DRAFT **August 1996**
DO NOT QUOTE OR CITE **Draft Report**

VOLUME I - GENERAL FACTORS

EXPOSURE FACTORS HANDBOOK

Update to Exposure Factors Handbook
EPA/600/8-89/043 - May 1989

NOTICE

THIS DOCUMENT IS A PRELIMINARY DRAFT. It has not been formally released by the U.S. Environmental Protection Agency and should not at this stage be construed to represent Agency policy. It is being circulated for comments on its technical accuracy and policy implications.

Office of Research and Development
National Center for Environmental Assessment
U.S. Environmental Protection Agency
Washington, DC 20460

DRAFT **August 1996**
DO NOT QUOTE OR CITE **Draft Report**

VOLUME II - FOOD INGESTION FACTORS

EXPOSURE FACTORS HANDBOOK

Update to Exposure Factors Handbook
EPA/600/8-89/043 - May 1989

NOTICE

THIS DOCUMENT IS A PRELIMINARY DRAFT. It has not been formally released by the U.S. Environmental Protection Agency and should not at this stage be construed to represent Agency policy. It is being circulated for comments on its technical accuracy and policy implications.

Office of Research and Development
National Center for Environmental Assessment
U.S. Environmental Protection Agency
Washington, DC 20460

DRAFT
DO NOT QUOTE OR CITE

August 1996
Draft Report

VOLUME III - ACTIVITY FACTORS

EXPOSURE FACTORS HANDBOOK

Update to Exposure Factors Handbook
EPA/600/8-89/043 - May 1989

NOTICE

THIS DOCUMENT IS A PRELIMINARY DRAFT. It has not been formally released by the U.S. Environmental Protection Agency and should not at this stage be construed to represent Agency policy. It is being circulated for comments on its technical accuracy and policy implications.

Office of Research and Development
National Center for Environmental Assessment
U.S. Environmental Protection Agency
Washington, DC 20460

DISCLAIMER

This document is a draft report subject to review by the Science Advisory Board. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

The National Center for Environmental Assessment (NCEA) of EPA's Office of Research and Development (ORD) has five main functions: (1) providing risk assessment research, methods, and guidelines; (2) performing health and ecological assessments; (3) developing, maintaining, and transferring risk assessment information and training; (4) helping ORD set research priorities; and (5) developing and maintaining resource support systems for NCEA. The activities under each of these functions are supported by and respond to the needs of the various program offices. In relation to the first function, NCEA sponsors projects aimed at developing or refining techniques used in exposure assessments.

This handbook was first published in 1989 to provide statistical data on the various factors used in assessing exposure. This revised version of the handbook provides the up-to-date data on these exposure factors. The recommended values are based solely on our interpretations of the available data. In many situations different values may be appropriate to use in consideration of policy, precedent or other factors.

Michael A. Callahan
Director
National Center for Environmental
Assessment, Washington Office

PREFACE

The National Center for Environmental Assessment has prepared this handbook to address factors commonly used in exposure assessments. This handbook was first published in 1989 in response to requests from many EPA Program and Regional offices for additional guidance on how to select values for exposure factors.

Several events sparked the efforts to revise the Exposure Factors Handbook. First, since its publication in 1989, new data have become available. Second, the Risk Assessment Council issued a memorandum titled, "Guidance on Risk Characterization for Risk Managers and Risk Assessors", dated February 26, 1992 which emphasized the use of multiple descriptors of risk (i.e., a measure of tendency such as average or mean central tendency, high end of individual risk, population risk, important subpopulations). Third, EPA published the revised Guidelines for Exposure Assessment.

As part of the efforts to revise the handbook, the EPA Risk Assessment Forum sponsored a two-day peer involvement workshop which was conducted during the summer of 1993. The workshop was attended by 57 scientists from academia, consulting firms, private industry, the states, and other Federal agencies. The purpose of the workshop was to identify new data sources, to discuss adequacy of the data and the feasibility of developing statistical distributions and to establish priorities.

As a result of the workshop, two new chapters have been added to the handbook. These chapters are: Consumer Product Use and the Reference Residence. This document also provides a summary of the available data on consumption of drinking water; consumption of fruits, vegetables, beef, dairy products, and fish; soil ingestion; inhalation rates; skin surface area; soil adherence; lifetime; activity patterns; and body weight.

AUTHORS, CONTRIBUTORS, AND REVIEWERS

The National Center for Environmental Assessment (NCEA), Office of Research and Development was responsible for the preparation of this handbook. The original document was prepared by Versar Inc. under EPA Contract No. 68-02-4254, Work Assignment No. 189. John Schaum, of NCEA-Washington Office, served as the EPA Work Assignment Manager, providing overall direction and coordination of the production effort as well as technical assistance and guidance. Revisions, updates, and additional preparation were provided by Versar Inc. under Contract Numbers 68-D0-0101, 68-D3-0013, and 68-D5-0051. Russell Kinerson and Greg Kew have served as EPA Work Assignment Managers during previous efforts of the update process. Jackie Moya served as Work Assignment Manager for the current updated version, providing overall direction, technical assistance, and serving as contributing author.

AUTHORS

Patricia Wood
Linda Phillips
Aderonke Adenuga
Mike Koontz
Harry Rector
Charles Wilkes
Margaret Wilson

Exposure Assessment Division
Versar Inc.
Springfield, VA

DESKTOP PUBLISHING

Susan Perry

WORD PROCESSING

Valerie Schwartz

GRAPHICS

Kathy Bowles
Jennifer Baker

CONTRIBUTORS AND REVIEWERS

The following EPA individuals have reviewed and/or have been contributing authors of this document.

Michael Dellarco
Robert McGaughy
Amy Mills
Jacqueline Moya
Susan Perlin
Paul Pinsky
John Schaum
Paul White
Amina Wilkins
Chieh Wu

An earlier draft of this document was peer reviewed by a panel of experts at a peer-review workshop held in 1995. Members of the Peer Review Panel were as follows:

Edward Avol
Department of Preventive Medicine
School of Medicine
University of Southern California

James Axley
School of Architecture
Yale University

David Burmaster
Alceon Corporation

Steven Colome
Integrated Environmental Services

Michael DiNovi
Chemistry Review Branch
U.S. Food & Drug Administration

Dennis Druck
Environmental Scientist
Center of Health Promotion & Preventive Medicine
U.S. Army

J. Mark Fly
Department of Forestry, Wildlife, & Fisheries
University of Tennessee

Larry Gephart
Exxon Biomedical Sciences, Inc.

Patricia Guenther
Beltsville Human Nutrition Research Center
U.S. Department of Agriculture

P.J. (Bert) Hakkinen
Paper Product Development & Paper Technology Divisions
The Proctor & Gamble Company

Mary Hama
Beltsville Human Nutrition Research Center
U.S. Department of Agriculture

Dennis Jones
Agency for Toxic Substances & Disease Registry

John Kissel
Department of Environmental Health
School of Public Health & Community Medicine

Neil Klepeis
Information Systems & Services, Inc.

Andrew Persily
National Institute of Standards & Technologies

Barbara Petersen
Technical Assessment Systems, Inc.

Thomas Phillips
Research Division
California Air Resources Board

Paul Price
ChemRisk

John Risher
Division of Toxicology
The Agency for Toxic Substances & Disease Registry

John Robinson
University of Maryland

Peter Robinson
The Proctor & Gamble Company

P. Barry Ryan
Department of Environmental & Occupational Health
Rollins School of Public Health
Emory University

Val Schaeffer
U.S. Consumer Product Safety Commission

Brad Shurdut
DowElanco

John Talbott
U.S. Department of Energy

Frances Vecchio
Beltsville Human Nutrition Research Center
U.S. Department of Agriculture

The following individuals within EPA have reviewed an earlier draft of this document and provided valuable comments:

OFFICE	REVIEWERS/CONTRIBUTORS
Office of Research and Development	Maurice Berry Jerry Blancato Elizabeth Bryan Curtis Dary Stan Durkee Manuel Gomez Wayne Marchant Sue Perlin James Quanckenboss Glen Rice Lance Wallace
Office of Emergency and Remedial Response	Jim Konz
Office of Pollution, Pesticides and Toxic Substances	Pat Kennedy Cathy Fehrenbacker
Office of Water	Denis Borum
Office of Air Quality Planning and Standards	Warren Peters
EPA Regions	Steve Ehlers - Reg. VI Maria Martinez - Reg. VI Mike Morton - Reg. VI Jeffrey Yurk - Reg. VI Youngmoo Kim - Reg. VI

In addition, the National Exposure Research Laboratory (NERL) of the Office of Research and Development of EPA made an important contribution to this handbook by conducting additional analysis of the National Human Activity Pattern Survey (NHAPS) data. EPA input to the NHAPS data analysis came from Karen A. Hammerstrom and Jacqueline Moya from NCEA-Washington Office; William C. Nelson from NERL-RTP, and Stephen C. Hern, Joseph V. Behar (retired), and William H. Englemann from NERL-Las Vegas.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

Page No.

APPENDIX 5A

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

Page No.

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

Page No.

LIST OF TABLES (continued)

Page No.

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF FIGURES

1. INTRODUCTION

1.1. PURPOSE

The purpose of the Exposure Factors Handbook is to: (1) summarize data on human behaviors and characteristics which affect exposure to environmental contaminants, and (2) recommend values to use for these factors. These recommendations are not legally binding on any EPA program and should be interpreted as suggestions which program offices or individual exposure assessors can consider and modify as needed. Most of these factors are best quantified on a site or situation-specific basis. The Handbook has strived to include full discussions of the issues which assessors should consider in deciding how to use these data and recommendations. The Handbook is intended to serve as a support document to EPA's Guidelines for Exposure Assessment (U.S. EPA, 1992). The Guidelines were developed to promote consistency among the various exposure assessment activities that are carried out by the various EPA program offices. This handbook assists in this goal by providing a consistent set of exposure factors to calculate dose.

Purpose

- Summarize data on human behaviors and characteristics affecting exposure
- Recommend exposure factor values

1.2. INTENDED AUDIENCE

The Exposure Factors Handbook is addressed to exposure assessors inside the Agency as well as outside, who need to obtain data on standard factors needed to calculate human exposure to toxic chemicals.

1.3. BACKGROUND

This handbook is the update of an earlier version prepared in 1989. Revisions have been made in the following areas:

- addition of drinking water rates for children;
- changes in soil ingestion rates for children;
- addition of soil ingestion rates for adults;
- addition of tapwater consumption for adults and children;
- addition of mean daily intake of food class and subclass by region, age and per capita rates;
- addition of mean moisture content of selected fruits, vegetables, grains, fish, meat, and dairy products;
- addition of food intake by class in dry weight per kg of body weight per day;
- update of homegrown food intake;
- expansion of data in the dermal chapter;
- update of fish intake data;
- expansion of data for time spent at residence;
- update of body weight data;
- update of population mobility data;
- addition of new data for average time spent in different locations and various microenvironments;
- addition of data for occupational mobility;
- addition of breast milk ingestion;
- addition of consumer product use; and
- addition of reference residence factors.

Variation Among Studies

This handbook is a compilation of available data from a variety of different sources. With very few exceptions, the data presented are the analyses of the individual study authors. Since the studies included in this handbook varied in terms of their objectives, design, scope, presentation of results, etc., the level of detail, statistics, and terminology may vary from study to study and from factor to factor. For example, some authors used geometric means to present their results, while others used arithmetic means or distributions. Authors have sometimes used different terms to describe the same racial populations. Within the constraint of presenting the original material as accurately as possible, EPA has made an effort to present discussions and results in a consistent manner. Further, the strengths and limitations of each study are discussed to provide the reader with a better understanding of the uncertainties associated with the values derived from the study.

1.3.1. Selection of Studies for the Handbook

Information in this handbook has been summarized from studies documented in the scientific literature and other available sources. Studies were chosen that were seen as useful and appropriate for estimating exposure factors.

General Considerations

Many scientific studies were reviewed for possible inclusion in this handbook. Studies were selected based on the following considerations:

- Level of peer review: Studies were selected predominantly from the peer-reviewed literature and final government reports. Internal or interim reports were therefore avoided.

- Accessibility: Studies were preferred that the user could access in their entirety if needed.

- Reproducibility: Studies were sought that contained sufficient information so that methods could be reproduced, or at least so the details of the author's work could be accessed and evaluated.

- Focus on exposure factor of interest: Studies were chosen that directly addressed the exposure factor of interest, or addressed related factors that have significance for the factor under consideration. As an example of the latter case, a selected study contained useful ancillary information concerning fat content in fish, although it did not directly address fish consumption.

- Data pertinent to the U.S.: Studies were selected that addressed the U.S. population. Data from populations outside the U.S. were sometimes included if behavioral patterns and other characteristics of exposure were similar.

- Primary data: Studies were deemed preferable if based on primary data, but studies based on secondary sources were also included where they offered an original analysis. For example, the Handbook cites studies of food consumption based on original data collected by the USDA National Food Consumption Survey.

- Current information: Studies were chosen only if they were sufficiently recent to represent current exposure conditions. This is an important consideration for those factors that change with time.

- Adequacy of data collection period: Because most users of the Handbook are primarily addressing chronic exposures, studies were sought that utilized the most appropriate techniques for collecting data to characterize long-term behavior.

- Validity of approach: Studies utilizing experimental procedures or approaches that more likely or closely capture the desired measurement were selected. In general, direct exposure data collection techniques, such as direct observation, personal monitoring devices, or other known methods were preferred where available. If studies utilizing direct measurement were not available, studies were selected that rely on validated indirect measurement methods such as surrogate measures (such as heart rate for inhalation rate), and use of questionnaires. If questionnaires or surveys were used, proper design and procedures include an adequate sample size for the population under consideration, a response rate large enough to avoid biases, and avoidance of bias in the design of the instrument and interpretation of the results.

- Representativeness of the population: Studies seeking to characterize the national population, a particular region, or sub-population were selected, if appropriately representative of that population. In cases where data were limited, studies with limitations in this area were included and limitations were noted in the handbook.

- Variability in the population: Studies were sought that characterized any variability within populations.

- Minimal (or defined) bias in study design: Studies were sought that were designed with minimal bias, or at least if biases were suspected to be present, the direction of the bias (i.e. an over or under estimate of the parameter) was either stated or apparent from the study design.

- Minimal (or defined) uncertainty in the data: Studies were sought with minimal uncertainty in the data, which was judged by evaluating all the considerations listed above. At least, studies were preferred that identified uncertainties, such as those due to inherent variability in environmental and exposure-related parameters or possible measurement error. Studies that documented Quality Assurance/Quality Control measures were preferable.

Key versus relevant studies

Certain studies described in this handbook are designated as "key," that is, the most useful for deriving exposure factors. The recommended values for most exposure factors are based on the results of the key studies. Other studies are designated "relevant," meaning applicable or pertinent, but not necessarily the most important. This distinction was made on the strength of the attributes listed in the "General Considerations." For example, in Chapter 14 of Volume III, one set of studies is deemed to best address the attributes listed and is designated as "key." Other applicable studies, including foreign data, believed to have value to Handbook users, but having fewer attributes, are designated "relevant."

1.3.2. Using the Handbook in an Exposure Assessment

Some of the steps for performing an exposure assessment are (1) determining the pathways of exposure, (2) identifying the environmental media which transports the contaminant, (3) determining the contaminant concentration, (4) determining the exposure time, frequency, and duration, and (5) identifying the exposed population. Many of the issues related to characterizing exposure from selected exposure pathways have been addressed in a number of existing EPA guidance documents. These include, but are not limited to the following:

- Guidelines for Exposure Assessment (U.S. EPA 1992a);
- Dermal Exposure Assessment: Principles and Applications (U.S. EPA 1992b);
- Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustion Emissions (U.S. EPA, 1990);
- Risk Assessment Guidance for Superfund (U.S. EPA, 1989);
- Estimating Exposures to Dioxin-Like Compounds (U.S. EPA, 1994);
- Superfund Exposure Assessment Manual (U.S. EPA, 1988a);
- Selection Criteria for Models Used in Exposure Assessments (U.S. EPA 1988b);
- Selection Criteria for Mathematical Models Used in Exposure Assessments (U.S. EPA 1987);
- Standard Scenarios for Estimating Exposure to Chemical Substances During Use of Consumer Products (U.S. EPA 1986a);
- Pesticide Assessment Guidelines, Subdivisions K and U (U.S. EPA, 1984, 1986b); and
- Methods for Assessing Exposure to Chemical Substances, Volumes 1-13 (U.S. EPA, 1983-1989).

These documents may serve as valuable information resources to assist in the assessment of exposure. The reader is encouraged to refer to them for more detailed discussion.

Key vs. Relevant Studies

- Key studies used to derive recommendations
- Relevant studies included to provide additional perspective

In addition to the references listed above, this handbook discusses the recommendations provided by the American Industrial Health Council (AIHC) - Exposure Factors Sourcebook (May 1994) for some of the major exposure factors. The AIHC Sourcebook summarizes and evaluates statistical data for various exposure factors used in risk assessments. Probability distributions for specific exposure factors were derived from the available scientific literature using @Risk simulation software. Each factor is described by a specific term, such as lognormal, normal, cumulative type, or triangular. Other distributions included Weibull, beta logistic, and gamma. Unlike this handbook, however, the Sourcebook does not provide a description and evaluation of every study available on each exposure factor.

Due to unique activity patterns, preferences, practices and biological differences, various segments of the population may experience exposures different from those of the general population, which, in many cases, may be greater. It is necessary for risk or exposure assessors characterizing a diverse population, to identify and enumerate certain groups within the general population who are at risk for greater contaminant exposures or exhibit a heightened sensitivity to particular chemicals. For further guidance on addressing susceptible populations, it is recommended to consult the EPA, National Center for Environmental Assessment document *Socio-demographic Data Used for Identifying Potentially Highly Exposed Subpopulations* (to be released as a final document December 1996).

Most users of the Handbook will be preparing estimates of exposure which are to be combined with dose-response factors to estimate risk. Some of the exposure factors (e.g., life time, body weight) presented in this document are also used in generating dose-response relationships. In order to develop risk estimates properly, assessors must use dose-response relationships in a manner consistent with exposure conditions. Although, it is beyond the scope of this document to explain in detail how assessors should address this issue, a discussion (see Appendix A of this chapter) has been included which describes how dose-response factors can be modified to be consistent with the exposure factors for a population of interest. This should serve as a guide for when this issue is a concern.

Recommendations and Confidence Ratings

- Recommendations based on data from single or multiple key studies
- Variability and uncertainty of recommended values evaluated
- Factors rated as low, medium, and high confidence

1.3.3. Approach Used to Develop Recommendations for Exposure Factors

As discussed above, EPA first reviewed all literature pertaining to a factor and determined relevant and key studies. The key studies were used to derive recommendations for the values of each factor. The recommended values were derived solely from EPA's interpretation of the available data. Different values may be appropriate for the user to select in consideration of policy, precedent, strategy, or other factors such as site-specific information. EPA's procedure for developing recommendations was as follows:

1. Key studies were evaluated in terms of both quality and relevance to specific populations (general U. S. population, age groups, gender, etc). The criteria for assessing the quality of studies is described in Section 1.3.1.

2. If only one study has been classified as key for a particular factor, the mean value from that study is selected as the recommended central value for that population. If there are multiple key studies, all with reasonably equal quality, relevance and study design are available, a weighted mean (if appropriate, considering sample size and other statistical factors) of the studies was chosen as the recommended mean value. If the key studies were judged to be unequal in quality, relevance, or study design, the range of means are presented and the user of this handbook must employ judgment in selecting the most appropriate value for the population of interest. In cases where the national population is of interest, the mid-point of the range would usually be judged to be the most appropriate value.

3. The variability of the factor across the population was discussed. If adequate data were available, the variability is described as either a series of percentiles or a distribution.

4. The uncertainty in each recommended value was discussed in terms of data limitations, the range of circumstances over which the estimates are (or are not) applicable, possible biases in the values themselves, a statement about parameter uncertainties (measurement error, sampling error) and model or scenario uncertainties if models or scenarios have been used in the derivation of the recommended value.

5. Finally, EPA assigned a confidence rating of low, medium or high to each recommended value. This rating is based on judgment using the guidelines shown in Table 1-1. Table 1-1 is an adaptation of the General Considerations discussed earlier in Section 1.3.1. Clearly this is a continuum from low to high and judgment was used to determine these ratings. Recommendations given in this handbook are accompanied by a discussion of the rationale for their rating.

Table 1-2 summarizes EPA's recommendations and confidence ratings for the various exposure factors.

1.3.4. Characterizing Variability

This document attempts to characterize variability of each of the factors. Variability is characterized in one or more of three ways: (1) as tables with various percentiles or ranges of values; (2) as analytical distributions with specified parameters; and/or (3) as a qualitative discussion. Analyses to fit standard or parametric distributions (e.g., normal, lognormal) to the exposure data have not been performed by the authors of this handbook, but have been reproduced in this document wherever they were found in the literature. Recommendations on the use of these distributions are made where appropriate based on the adequacy of the supporting data. The list of exposure factors and the way that variability has been characterized (i.e., average, upper percentiles, multiple percentiles, fitted distribution) are presented in Table 1-3.

The use of Monte Carlo or other probabilistic analysis require a selection of distributions or histograms for the input parameters. Although this handbook is not intended to provide a complete guidance on the use of Monte Carlo and other probabilistic analyses, the following should be considered when using such techniques:

- The exposure assessor should only consider using probabilistic analysis when there are credible distribution data (or ranges) for the factor under consideration. Even if these distributions are known, it may not be necessary to apply this technique. For example, if only average exposure values are needed, these can often be computed accurately by using average values for each of the input parameters. Probabilistic analysis is also not necessary when conducting assessments for screening purposes, i.e, to determine if unimportant pathways can be eliminated. In this case, bounding estimates can be calculated using maximum or near maximum values for each of the input parameters.

- It is important to note that the selection of distributions can be highly site specific and will always involve some degree of judgment. Distributions derived from national data may not represent local conditions. To the extent possible, an assessor should use distributions or frequency histograms derived from local surveys to assess risks locally. When distributional data are drawn from national or other surrogate population, it is important that the assessor address the extent to which local conditions may differ from the surrogate data. In addition to a qualitative statement of uncertainty, the representativeness assumption should be appropriately addressed as part of a sensitivity analysis.

- Distribution functions to be used in Monte Carlo analysis may be derived by fitting an appropriate function to empirical data. In doing this, it should be recognized that in the lower and upper tails of the distribution the data are scarce, so that several functions, with radically different shapes in the extreme tails, may be consistent with the data. To avoid introducing errors into the analysis by the arbitrary choice of an inappropriate function, several techniques can be used. One way is to avoid the problem by using the empirical data itself rather than an analytic function. Another is to do separate analyses with several functions which have adequate fit but form upper and lower bounds to the empirical data. A third way is to use truncated analytical distributions. Judgment must be used in choosing the appropriate goodness of fit test. Information on the theoretical basis for fitting distributions can be found in a standard statistics text such as Statistical Methods for Environmental Pollution Monitoring, Gilbert, R.O., 1987, Van Nostrand Reinhold; off-the-shelf computer software such as Best-Fit by Palisade Corporation can be used to

Table 1-1. Considerations Used to Rate Confidence in Recommended Values

CONSIDERATIONS	HIGH CONFIDENCE	LOW CONFIDENCE
Study Elements		
Level of peer review	Studies received high level of peer review (e.g., they appear in peer review journals)	Studies received limited peer review
Accessibility	Studies are widely available to the public	Studies are difficult to obtain (e.g., draft reports, unpublished data)
Reproducibility	Results can be reproduced or methodology can be followed and evaluated	Results cannot be reproduced, methodology is hard to follow, and author(s) cannot be located
Focus on factor of interest	Studies focused on the exposure factor of interest	Purpose of the studies were to characterize a related factor
Data pertinent to U.S.	Studies focused on the U.S. population	Studies focused on populations outside the U.S.
Primary data	Studies analyzed primary data	Studies are based on secondary sources
Currency	After 1990	Before 1980
Adequacy of data collection period	Study design captures the measurement of interest (e.g., usual consumption patterns of a population)	Study design does not very accurately captures the measurement of interest
Validity of approach	Studies used the best methodology available to capture the measurement of interest	There are serious limitations with the approach used
Study sizes	n > 100	n < 20
	The sample size depends on how the target population is defined. As the size of a sample relative to the total size of the target population increases, estimates are made with greater statistical assurance that the sample results reflect actual characteristics of the target population.	
Representativeness of the population	Study population same as population of interest	Study population very different from the population of interest
Variability in the population	Studies characterized variability in the population studied	Characterization of variability is limited
Lack of bias in study design (a high rating is desirable)	Potential bias in the studies are stated or can be determined from study design	Study design introduces biases in the results
Response rates		< 40%
In-person interviews	> 80%	< 40%
Telephone interviews	> 80%	< 40%
Mail surveys	> 70%	
Measurement error	Study design minimizes measurement errors	Uncertainties with the data exists due to measurement error
Other Elements		
Number of studies	> 3	1
Agreement between researchers	Results of studies from different researchers are in agreement	Results of studies from different researchers are in disagreement

[a] Differences include age, sex, race, income, or other demographic parameters.

Table 1-2. Summary of Exposure Factor Recommendations and Confidence Ratings

EXPOSURE FACTOR	RECOMMENDATION	CONFIDENCE RATING
Drinking water intake rate	21 ml/kg-day (average)	Medium
	34 ml/kg-day (90th percentile)	
	Percentiles and distribution also included	
Total fruit intake rate	3.4 g/kg-day (average)	Medium
	12.4 g/kg-day (95th percentile)	Low
	Percentiles also included	
	Means presented for individual fruits	
Total vegetable intake rate	4.3 g/kg-day (average)	Medium
	10 g/kg-day (95th percentile)	Low
	Percentiles also included	
	Means presented for individual vegetables	
Total meat intake rate	2.1 g/kg-day (average)	Medium
	5.1 g/kg-day (95th percentile)	Low
	Percentiles also included	
	Means presented for individual meats	
Total dairy intake rate	8.0 g/kg-day (average)	Medium
	29.7 g/kg-day (95th percentile)	Low
	Percentiles also included	
	Means presented for individual dairy products	
Breast milk intake rate	742 ml/day (average)	Medium
	1,033 ml/day (upper percentile)	Medium
Fish intake rate	General Population	
	20.1 g/day (total fish) average	Medium
	13.5 g/day (marine) average	Medium
	6.6 g/day (freshwater/estuarine)average	Medium
	63 g/day (total fish)95th percentile long-term	Medium
	Serving size	
	123 g (average)	High
	305 g (95th percentile)	High
	Recreational marine anglers	
	2 - 7 g/day (finfish only)	Medium
	Recreational freshwater	
	8 g/day (average)	Medium
	25 g/day (95th percentile)	Medium
	Native American Subsistence Population	
	70 g/day (average)	Medium
	170 g/day (95th percentile)	Low
Home produced food intake	Total Fruits	Medium (for means and short-term distributions)
	2.7 g/kg-day (average)	
	11.1 g/kg-day (95th percentile)	Low (for long-term distributions)
	Total vegetables	
	2.1 g/kg-day (average)	
	7.5 g/kg-day (95th percentile)	
	Total meats	
	2.2 g/kg-day (average)	
	6.8 g/kg-day (95th percentile)	
	Total dairy products	
	14 g/kg-day (average)	
	44 g/kg-day (95th percentile)	
	Percentiles also included	
	Means presented for individual food items	

Table 1-2. Summary of Exposure Factor Recommendations and Confidence Ratings (continued)

EXPOSURE FACTOR	RECOMMENDATION	CONFIDENCE RATING
Inhalation rate	Children (< 1 year) 4.5 m^3/day (average) Children (1-12 years) 8.7 m^3/day (average) Adult Females 11.3 m^3/day (average) Adult Males 15.2 m^3/day (average)	 High High High High
Surface area	Water contact (bathing and swimming) Use total body surface area for children in Tables 6-6 through 6-8; for adults use Tables 6-2 through 6-4 (percentiles are included) Soil contact (outdoor activities) Use whole body part area based on Table 6-6 through 6-8 for children and 6-2 through 6-4 for adults (percentiles are included)	 High
Soil adherence	Use values presented in Table 6-16 depending on activity and body part (central estimates only)	Low
Soil ingestion rate	Children 100 mg/day (average) 400 mg/day (upper percentile) Adults 50 mg/day (average) Pica child 10 g/day	 Medium Low Low
Life expectancy	75 years	High
Body weight	71.8 kg	High
Showering/Bathing	Showering time 8 min/day (average) 12 min/day (95th percentile) (percentiles are also included) Bathing time 20 min/event (median) 45 min/event (90th percentile) Bathing/showering frequency 1 shower event/day	 Medium High High
Swimming	Frequency 1 event/month Duration 60 min/event (median) 180 min/event (90th percentile)	 High High
Time indoors	Children (ages 3-11) 19 hr/day (weekdays) 17 hr/day (weekends) Adults (ages 12 and older) 21 hr/day Residential 16.4 hrs/day	Medium Medium High
Time outdoors	Children (ages 3-11) 5 hr/day (weekdays) 7 hr/day (weekends) Adults 1.5 hr/day Residential 2 hrs/day	Medium Medium High

Table 1-2. Summary of Exposure Factor Recommendations and Confidence Ratings (continued)

EXPOSURE FACTOR	RECOMMENDATION	CONFIDENCE RATING
Time spent inside vehicle	Adults 1 hr 20 min/day	Medium
Occupational tenure	6.6 years (16 years old and older)	High
Population mobility	9 years (average) 30 years (95th percentile)	Medium
Residence volume	369 m^3 (average) 217 m^3 (conservative)	Medium
Residential air exchange	0.45 (median) 0.18 (conservative)	Medium

Table 1-3. Characterization of Variability in Exposure Factors

Exposure Factors	Average	Upper percentile	Multiple Percentiles	Fitted Distributions
Drinking water intake rate	✓	✓	✓	✓
Total fruits and total vegetables intake rate	✓	✓ Qualitative discussion for long-term	✓	
Individual fruits and individual vegetables intake rate	✓			
Total meats and dairy products intake rate	✓	✓ Qualitative discussion for long-term	✓	
Individual meats and dairy products intake rate	✓			
Serving size for various food items	✓	✓	✓	
Breast milk intake rate	✓	✓		
Fish intake rate for general population, recreational marine, recreational freshwater, and native american	✓	✓		
Homeproduced food intake rates	✓	✓ Only provided for the total groups (i.e., total fruits, total vegetables and total meats and dairy)	✓ Long-term values only for the total groups (i.e., total fruits, total vegetables and total meats and dairy)	
Soil intake rate	✓	Qualitative discussion for long-term		
Inhalation rate	✓	✓		
Surface area	✓	✓	✓	
Soil adherence	✓			
Life expectancy	✓			
Body weight	✓	✓	✓	
Time indoors	✓			
Time outdoors	✓			
Showering time	✓	✓	✓	
Occupational tenure	✓			
Population mobility	✓	✓	✓	

statistically determine the distributions that fit the data.

- If only a range of values is known for an exposure factor, the assessor has several options.

  - keep that variable constant at its central value;
  - assume several values within the range of values for the exposure factor;
  - calculate a point estimate(s) instead of using probabilistic analysis; and
  - assume a distribution (The rationale for the selection of a distribution should be discussed at length.) There are, however, cases where assuming a distribution is not recommended. These include:

    -- data are missing or very limited for a key parameter - Examples include: soil ingestion by adults;

    -- data were collected over a short time period and may not represent long term trends (the respondent usual behavior). Examples include: food consumption surveys; activity pattern data;

    -- data are not representative of the population of interest because sample size was small or the population studied was selected from a local area and therefore not representative of the area of interest - Examples include: soil ingestion by children; and

    -- ranges for a key variable are uncertain due to experimental error or other limitations in the study design or methodology- Examples include: soil ingestion by children.

1.4. GENERAL EQUATION FOR CALCULATING DOSE

The definition of exposure as used in the Exposure Guidelines (U.S. EPA, 1992a) is "condition of a chemical contacting the outer boundary of a human." This means contact with the visible exterior of a person such as the skin, and openings such as the mouth, nostrils, and lesions. The process of a chemical entering the body can be described in two steps: contact (exposure), followed by entry (crossing the boundary). The magnitude of exposure (dose) is the amount of agent available at human exchange boundaries (skin, lungs, gut) where absorption takes place during some specified time. Starting with a general integral equation for exposure (U.S. EPA 1992a), several dose equations can be derived depending upon boundary assumptions. One of the more useful of these derived equations is the Average Daily Dose (ADD). The ADD, which is used for many noncancer effects, averages exposures or doses over the period of time over which exposure occurred. The ADD can be calculated by averaging the potential dose (D_{pot}) over body weight and an averaging time.

$$ADD_{pot} = \frac{\text{Total Potential Dose}}{\text{Body Weight x Averaging Time}} \qquad \text{(Eqn. 1-1)}$$

For cancer effects, where the biological response is usually described in terms of lifetime probabilities, even though exposure does not occur over the entire lifetime, doses are often presented as lifetime average daily doses (LADDs). The LADD takes the form of the Equation 1-1 with lifetime replacing averaging time. The LADD is a very common term used in carcinogen risk assessment where linear non-threshold models are employed.

The total exposure can be expressed as follows:

$$\text{Total Potential Dose} = CC \times IR \times ED \qquad \text{(Eqn. 1-2)}$$

Where:

CC = Contaminant Concentration

Contaminant concentration is the concentration of the contaminant in the medium (air, food, soil, etc.) contacting the body and has units of mass/volume or mass/mass.

The intake rate refers to the rates of inhalation, ingestion, and dermal contact depending on the route of exposure. For ingestion, the intake rate is simply the amount of food containing the contaminant of interest that an individual ingests during some specific time period (units of mass/time). Much of this handbook is devoted to rates of ingestion for some broad classes of food. For inhalation, the intake rate is the rate at which contaminated air is inhaled. Factors that affect dermal exposure are the amount of material that comes into contact with the skin, and the rate at which the contaminant is absorbed.

The exposure duration is the length of time that contaminant contact lasts. The time a person lives in an area, frequency of bathing, time spent indoors versus outdoors, etc. all affect the exposure duration. The Activity Factors Chapter (Volume III, Chapter 2) gives some examples of population behavior patterns, which may be useful for estimating exposure durations to be used in the exposure calculations.

When the above parameter values remain constant over time, they are substituted directly into the exposure equation. When they change with time, a summation approach is needed to calculate exposure. In either case, the exposure duration is the length of time exposure occurs at the concentration and intake rate specified by the other parameters in the equation.

Exposure can be expressed as a total amount (with units of mass, e.g., mg) or as an exposure rate in terms of mass/time (e.g., mg/day), or as a rate normalized to body mass (e.g., with units of mg of chemical per kg of body weight per day (mg/kg-day)). The LADD is usually expressed in terms of mg/kg-day or other mass/mass-time units.

In most cases (inhalation and ingestion exposure) the dose-response parameters for carcinogen risks have been adjusted for the difference in absorption across body barriers between humans and the experimental animals used to derive such parameters. Therefore, the exposure assessment in these cases is based on the potential dose with no explicit correction for the fraction absorbed. However, the exposure assessor needs to make such an adjustment when calculating dermal exposure and in other specific cases when current information indicates that the human absorption factor used in the derivation of the dose-response factor is inappropriate.

The lifetime value used in the LADD version of Equation 1-1 is the period of time over which the dose is averaged. For carcinogens, the derivation of the dose-response parameters usually assumes no explicit number of years as the duration of a lifetime, and the nominal value of 75 years is considered a reasonable approximation. For exposure estimates to be used for assessments other than carcinogenic risk, various averaging periods have been used. For acute exposures, the administered doses are usually averaged over a day or a single event. For nonchronic noncancer effects, the time period used is the actual period of exposure. The objective in selecting the exposure averaging time is to express the exposure in a way which can be combined with the dose-response relationship to calculate risk.

The body weight to be used in the exposure Equation (1-1) depends on the units of the exposure data presented in this handbook. For food ingestion, the body weights of the surveyed populations were known in the USDA surveys and they were explicitly factored into the food intake data in order to calculate the intake as grams per day per kilogram body weight. In this case, the body weight has already been included in the "intake rate" term in Equation (1-2) and the exposure assessor does not need to explicitly include body weight.

The units of intake in this handbook for the ingestion of fish, breast milk, and the inhalation of air are not normalized to body weight. In this case, the exposure assessor needs to use (in Equation 1-1) the average weight of the exposed population during the time when the exposure actually occurs. If the exposure occurs continuously throughout an individual's life or only during the adult ages, using an adult weight of 71.8 kg should provide sufficient accuracy. If the body weight of the individuals in the population whose risk is being evaluated is non-standard in some way, such as for children or for first-generation immigrants who may be smaller than the national population, and if reasonable values are not available in the literature, then a model of intake as a function of body weight must be used. One such model is discussed in Appendix 1A of this chapter. Some of the parameters (primarily concentrations) used in estimating exposure are exclusively site specific, and therefore default recommendations could not be used.

The link between the intake rate value and the exposure duration value is a common source of confusion in defining exposure scenarios. It is important to define the duration estimate so that it is consistent with the intake rate:

- The intake rate can be based on an individual event, such as 123 g of fish eaten per meal (Pao et al., 1982; CSFII, 1989-91). The duration should be based on the number of events or, in this case, meals.

- The intake rate also can be based on a long-term average, such as 10 g/day. In this case the duration should be based on the total time interval over which the exposure occurs.

The objective is to define the terms so that when multiplied, they give the appropriate estimate of mass of contaminant contacted. This can be accomplished by basing the intake rate on either a long-term average (chronic exposure) or an event (acute exposure) basis, as long as the duration value is selected appropriately. Consider the case in which a person eats a 123-g fish meal approximately five times per month (long-term average is 20 g/day) for 30 years; or 20 g/day of fish every day for 30 years.

(123 g/meal)(5 meals/mo)(mo/30 d)(365 d/yr)(30 yrs) = 219,000 g

(20 g/day)(365 d/yr)(30 yrs) = 219,000 g

Thus, a frequency of either 36.5 meals/year or a duration of 365 days/year could be used as long as it is matched with the appropriate intake rate.

1.5. RESEARCH NEEDS

In an earlier draft of this Handbook, reviewers were asked to identify factors or areas where further research is needed. The following list is a compilation of areas for future research identified by the peer reviewers and authors of this document:

- The data and information available with respect to occupational exposures are quite limited. Efforts need to be directed to identify data or references on occupational exposure.

- Further research is necessary to refine estimates of fish consumption, particularly by subpopulations of subsistence fishermen.

- Research is needed to better estimate soil intake rates, particularly how to extrapolate short-term data to chronic exposures. Data on soil intake rates by adults are very limited. Research in this area is also recommended. Research is also needed to refine methods to calculate soil intake rate (i.e., inconsistencies among tracers and input/output misalignment errors indicate a fundamental problem with the methods).

- In cases where several studies of equal quality and data collection procedures are available for an exposure factor, procedures need to be developed to combine the data in order to create a single distribution of likely values for that factor.

- Reviewers recommended that the Handbook be made available in CD ROM and that the data presented be made available in a format that will allow the users to conduct their own analysis. The intent is to provide a comprehensive factors tool with interactive menu to guide users to areas of interest, word searching features, and data base files.

- Reviewers recommended that EPA derive distribution functions using the empirical data for the various exposure factors to be used in Monte Carlo or other probabilistic analysis.

- Research is needed to derive a methodology to extrapolate from short-term data to long-term or chronic exposures.

- Reviewers recommended that the consumer products chapter be expanded to include more products. A comprehensive literature search needs to be conducted to investigate other sources of data.

1.6. ORGANIZATION

The Handbook is organized into three volumes as follows:

Volume I - General Factors

Chapter 1	Provides the overall introduction to the Handbook
Chapter 2	Presents an analysis of uncertainty and discusses methods that can be used to evaluate and present the uncertainty associated with exposure scenario estimates.
Chapter 3	Provides factors for estimating human exposure through ingestion of water.
Chapter 4	Provides factors for estimating exposure through ingestion of soil.

Chapter 5 Provides factors for estimating exposure as a result of inhalation of vapors and particulates.

Chapter 6 Presents factors for estimating dermal exposure to environmental contaminants that come in contact with the skin.

Chapter 7 Provides data on bodyweight.

Chapter 8 Provides data on life expectancy.

Volume II - Ingestion Factors

Chapter 9 Provides factors for estimating exposure through ingestion of fruits and vegetables.

Chapter 10 Provides factors for estimating exposure through ingestion of fish.

Chapter 11 Provides factors for estimating exposure through ingestion of meats and dairy products.

Chapter 12 Presents factors for estimating exposure through ingestion of home produced food.

Chapter 13 Presents data for estimating exposure through ingestion of breast milk.

Volume III - Activity Factors

Chapter 14 Presents data on activity factors (activity patterns, population mobility, and occupational mobility).

Chapter 15 Presents data on consumer product use.

Chapter 16 Presents factors used in estimating residential exposures.

Figure 1-1 provides a roadmap to assist users of this handbook in locating recommended values and confidence ratings for the various exposure factors presented in these chapters. A glossary is provided at the end of Volume III.

1.7. REFERENCES FOR CHAPTER 1

AIHC. (1994) Exposure factors sourcebook. Washington, DC: American Industrial Health Council.

U.S. EPA. (1983-1989) Methods for assessing exposure to chemical substances. Volumes 1-13. Washington, DC: Office of Toxic Substances, Exposure Evaluation Division.

U.S. EPA. (1984) Pesticide assessment guidelines subdivision K, exposure: reentry protection. Office of Pesticide Programs, Washington, DC. EPA/540/9-48/001. Available from NTIS, Springfield, VA; PB-85-120962.

U.S. EPA. (1985) Development of statistical distributions or ranges of standard factors used in exposure assessments. Washington, DC: Office of Health and Environmental Assessment. EPA No. 600/8-85-010. Available from: NTIS, Springfield, VA. PB85-242667.

U.S. EPA. (1986a) Standard scenarios for estimating exposure to chemical substances during use of consumer products. Volumes I and II. Washington, DC: Office of Toxic Substance, Exposure Evaluation Division.

U.S. EPA. (1986b) Pesticide assessment guidelines subdivision U, applicator exposure monitoring. Office of Pesticide Programs, Washington, DC. EPA/540/9-87/127. Available from NTIS, Springfield, VA; PB-85-133286.

U.S. EPA. (1987) Selection criteria for mathematical models used in exposure assessments: surface water models. Exposure Assessment Group, Office of Health and Environmental Assessment, Washington, DC. WPA/600/8-87/042. Available from NTIS, Springfield, VA; PB-88-139928/AS.

U.S. EPA. (1988a) Superfund exposure assessment manual. Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-88/001. Available from NTIS, Springfield, VA; PB-89-135859.

U.S. EPA. (1988b) Selection criteria for mathematical models used in exposure assessments: groundwater models. Exposure Assessment Group, Office of Health and Environmental Assessment, Washington, DC. EPA/600/8-88/075. Available from NTIS, Springfield, VA; PB-88-248752/AS.

U.S. EPA. (1989) Risk assessment guidance for superfund. Human health evaluation manual: part A. Interim Final. Office of Solid Waste and Emergency Response, Washington, DC. Available from NTIS, Springfield, VA; PB-90-155581.

U.S. EPA. (1990) Methodology for assessing health risks associated with indirect exposure to combustor emissions. EPA 600/6-90/003. Available from NTIS, Springfield, VA; PB-90-187055/AS.

U.S. EPA. (1992a) Guidelines for exposure assessment. Washington, DC: Office of Research and Development, Office of Health and Environmental Assessment. EPA/600/Z-92/001.

U.S. EPA. (1992b) Dermal exposure assessment: principles and applications. Washington, DC: Office of Health and Environmental Assessments. EPA/600/8-9/011F.

U.S. EPA. (1994) Estimating exposures to dioxin-like compounds. (Draft Report). Office of Health and Environmental Assessment, Washington, DC. EPA/600/6-88/005Cb.

Figure 1-1. Road Map to Exposure Factor Recommendations

EXPOSURE ROUTE	EXPOSURE FACTOR	POPULATION	VOLUME	CHAPTER	RECOMMENDATIONS/ RATINGS TABLE PAGE NOS.
Ingestion	Drinking Water Intake Rate	Adults Children Pregnant Women High Activity	I	3.	3-25/3-31
	Fruit and Vegetable Intake Rate	Various Demographic Groups — Age, Region, Season, Urbanization, Race	II	9.	9-8/9-40,9-41
	Meat and Dairy Intake Rate	Various Demographic Groups — Age, Region, Season, Urbanization, Race	II	11.	11-6/11-26,11-27
	Homegrown Foods	Various Demographic Groups — Age, Region, Season, Urbanization, Race	II	12.	12-9/12-77
	Breast milk Intake Rate	Nursing Infants	II	13.	13-8/13-14
	Fish and Shellfish Intake Rate	General Population	II	10.	10-49/10-57
		Freshwater Recreational	II	10.	10-51/10-59
		Marine Recreational	II	10.	10-50/10-58
		Subsistence	II	10.	10-51/10-60
	Soil Intake Rate	Typical Children Adults Pica Children	I	4.	4-19/4-23
Inhalation	Inhalation Rate	Adults Children High Activity	I	5.	5-21/5-21
Dermal	Skin Surface Area	Adults Children	I	6.	6-8/6-23
	Soil Adherence	General Population	I	6.	6-8/6-24
(All Routes) Human Characteristics	Body Weight	Adults Children	I	7.	7-7/7-9
	Lifetime	Adults Children	I	8.	8-1/8-3
(All Routes) Activity Factors	Activity Patterns	Adults Children	III	14.	1-69/1-72
	Occupational Mobility	Adults	III	14.	1-71/1-75
	Population Mobility	Adults Children	III	14.	1-71/1-44
(All Routes) Consumer Product Use	Frequency of Use	Adults	III	15.	15-5
	Amount Used	Adults			
(All Routes) Reference House	Water Use Air Exchange Rates House Volumes Building Characteristics	General Population	III	16.	16-25/16-32,16-33

APPENDIX 1A

RISK CALCULATIONS USING EXPOSURE HANDBOOK DATA AND DOSE-RESPONSE INFORMATION FROM THE INTEGRATED RISK INFORMATION SYSTEM (IRIS)

APPENDIX A
RISK CALCULATIONS USING EXPOSURE HANDBOOK DATA AND DOSE-RESPONSE INFORMATION FROM IRIS

1. INTRODUCTION

When calculating risk estimates for a specific population, whether the entire national population or some sub-population, the exposure information (either from this handbook or from other data) must be combined with dose-response information. The latter typically comes from the IRIS data base, which summarizes toxicity data for each agent separately. Care must be taken that the assumptions about population parameters in the dose-response analysis are consistent with the population parameters used in the exposure analysis. This Appendix discusses procedures for insuring this consistency.

In the IRIS derivation of threshold based dose-response relationships (U.S. EPA, 1996), such as the RfD and the RfCs based on adverse systemic effects, there has generally been no explicit use of human exposure factors. In these cases the numerical value of the RfD and RfC comes directly from animal dosing experiments (and occasionally from human studies) and from the application of uncertainty factors to reflect issues such as the duration of the experiment, the fact that animals are being used to represent humans and the quality of the study. However in developing cancer dose-response (D-R) assessments, a standard exposure scenario is assumed in calculating the slope factor (i.e. human cancer risk per unit dose) on the basis of either animal bioassay data or human data. This standard scenario has traditionally been assumed to be typical of the U.S. population: 1) body weight = 70 kg; 2) air intake rate = 20 m^3/day; 3) drinking water intake = 2 liters/day; 4) lifetime = 70 years. In RfC derivations for cases involving an adverse effect on the respiratory tract, the air intake rate of 20 m^3/day is assumed. The use of these specific values has depended on whether the slope factor was derived from animal or human epidemiologic data:

- Animal Data: For dose-resopnse (D-R) studies based on animal data scale animal doses to human equivalent doses using a human body weight assumption of 70 kg. No explicit lifetime adjustment is necessary because the assumption is made that events occurring in the lifetime animal bioassay will occur with equal probability in a human lifetime, whatever that might happen to be.

- Human Data - In the analysis of human studies (either occupational or general population) the Agency has usually made no explicit assumption of body weight or human lifetime. For both of these parameters there is an implicit assumption that the population usually of interest has the same descriptive parameters as the population analyzed by the Agency. In the rare situation where this assumption is known to be wrong, the Agency has made appropriate corrections so that the dose-response parameters represent the national average population.

When the population of interest is different than the national average (standard) population, the dose-response parameter needs to be adjusted. In addition, when the population of interest is different than the population from which the exposure factors in this handbook were derived, the exposure factor needs to be adjusted. Two generic examples of situations where these adjustments are needed are as follows:

. A) Detailed study of recent data, such as are presented in this handbook, show that EPA's standard assumptions (i.e., 70 kg body weight, 20 m^3/day air inhaled, and 2 L/day water intake) are inaccurate for the national population and may be inappropriate for sub-populations under consideration. The Handbook addresses most of these situations by providing gender- and age-specific values and by normalizing the intake values to body weight when the data are available, but it may not have covered all possible situations. An example of a sub-population with different mean body weight would be females, with an average body weight of 60 kg or children with a body weight dependent on age.

Another example of a non-standard sub-population would be a sedentary hospital population with lower than 20 m^3/day air intake rates.

B) The population variability of these parameters is of interest and it is desired to estimate percentile limits of the population variation. Although the detailed methods for estimating percentile limits of exposure and risk in a population are beyond the scope of this document, one would treat the body weight and the intake rates discussed in Sections 2 to 4 of this appendix as distributions, rather than constants.

2. CORRECTIONS FOR DOSE-RESPONSE PARAMETERS

The correction factors for the dose-response values tabulated in the IRIS data base for carcinogens are summarized in Table 1A-1. Use of these correction parameters is necessary to avoid introducing errors into the risk analysis. The second column of Table 1A-1 shows the dependencies that have been assumed in the typical situation where the human dose-response factors have been derived from the administered dose in animal studies. This table is applicable in most cases that will be encountered, but it is not applicable when: a) the effective dose has been derived with a pharmacokinetic model and b) the dose-response data has been derived from human data. In the former case, the subpopulation parameters need to be incorporated into the model. In the latter case the correction factor for the dose-response parameter must be evaluated on a case-by case basis by examining the specific data and assumptions in the derivation of the parameter.

Table 1A-1. Procedures for Modifying IRIS Risk Values for Non-standard Populations[a,b]

IRIS Risk Measure [Units]	IRIS Risk Measure is Proportional to:[b]	Correction Factor (CF) for modifying IRIS Risk Measures:[c]
Slope Factor [per mg/(kg/day)]	$(W^S)^{1/3} = (70)^{1/3}$	$(W^P/70)^{1/3}$
Water Unit Risk [per µg/l]	$I_W^S/[(W^S)^{2/3}] = 2/[(70)^{2/3}]$	$(I_W^P)/2 \times [70/(W^P)]^{2/3}$
Air Unit Risk: A. Particles or aerosols [per µg/m^3], air concentration by weight	$I_A^S/[(W^S)^{2/3}] = 20/[(70)^{2/3}]$	$(I_A^P)/20 \times [70/(W^P)]^{2/3}$
Air Unit Risk: B. Gases [per parts per million], air concentration by volume,	No explicit proportionality to body weight or air intake is assumed.	1.0 Ppm by volume is assumed to be the effective dose in both animals and humans.

[a] W = Body weight (kg)
I_W = Drinking water intake (liters per day)
I_A = Air intake (cubic meters per day)

[b] W^S, I_W^S, I_A^S denote standard parameters assumed by IRIS

[c] Modified risk measure = (CF) x IRIS value
W^P, I_W^P, I_A^P denote non-standard parameters of the actual population

As one example of the use of Table 1A-1, the recommended value for the average consumption of tap water for adults in the U. S. population derived in this document (Chapter 3), is 1.4 liters per day. The drinking water unit risk for dichlorvos, as given in the IRIS information data base is 8.3 x 10^{-6} per µg/l, and was calculated from the slope factor assuming the standard intake, I_W^S, of 2 liters per day. For the United States population drinking 1.4 liters of tap water per day the corrected drinking water unit risk should be 8.3 x 10^{-6} x (1.4/2) = 5.8 x 10^{-6} per μg/l. The risk to the average individual is then estimated by multiplying this by the average concentration in units of μg/l.

Another example is when the risk for women drinking water contaminated with dichlorvos is to be estimated. If the women have an average body weight of 60 kg, the correction factor for the drinking water unit risk is (disregarding the correction discussed in the above paragraph), from Table 1A-1, is $(70/60)^{2/3}$ = 1.11. Here the ratio of 70 to 60 is raised to the power of 2/3. The corrected water unit risk for dichlorvos is 8.3 x 10^{-6} x 1.11 = 9.2 x 10^{-6} per μg/l. As before, the risk to the average individual is estimated by multiplying this by the water concentration.

When human data are used to derive the risk measure, there is a large variation in the different data sets encountered in IRIS, so no generalizations can be made about global corrections. However, the typical default exposure values used for the air intake of an air pollutant over an occupational lifetime are: air intake is 10 m^3/day for an 8-hour shift, 240 days per year with 40 years on the job. If there is continuous exposure to an ambient air pollutant, the lifetime dose is usually calculated assuming a 70-year lifetime.

3. CORRECTIONS FOR INTAKE DATA

When the body weight, W^P, of the population of interest differs from the body weight, W^E, of the population from which the exposure values in this handbook were derived, the following model furnishes a reasonable basis for estimating the intake of food and air (and probably water also) in the population of interest. Such a model is needed in the absence of data on the dependency of intake on body size. This occurs for inhalation data, where the intake data is not normalized to body weight, whereas the model is not needed for food and tap water intakes if they are given in units of intake per kg body weight.

The model is based on the dependency of metabolic oxygen consumption on body size. Oxygen consumption is directly related to food (calorie) consumption and air intake and indirectly to water intake. For mammals of a wide range of species sizes *(Prosser and Brown, 1961)*, and also for individuals of various sizes within a species, the oxygen consumption and calorie (food) intake varies as the body weight raised to a power between 0.65 and 0.75. A value of 0.667 = 2/3 has been used *in EPA* as the default value for adjusting cross-species intakes, and the same factor has been used for intra-species intake adjustments.

[NOTE: Following discussions by an interagency task force *(Federal Register, 1992)*, the agreement was that a more accurate and defensible default value would be to choose the power to 3/4 rather than 2/3. This will be the standard value to be used in future assessments, and all equations in this Appendix will be modified in future risk assessments. However, because risk assessors now use the current IRIS information, this discussion is presented with the previous default assumption of 2/3].

With this model, the relation between the daily air intake in the population of interest, $I_A^P = (m^3/day)^P$, and the intake in the population described in this handbook, $I_A^E = (m^3/day)^E$ is:

$$I_A^P = I_A^E \times (W^P/W^E)^{2/3}.$$

4. CALCULATION OF RISKS FOR AIR CONTAMINANTS

The risk is calculated by multiplying the IRIS air unit risk, corrected as described in Table 1A-1, by the air concentration. But since the correction factor involves the intake in the population of interest (I_A^P), that quantity must be included in the equation, as follows:

$$
\begin{aligned}
(\text{Risk})^P &= (\text{air unit risk})^P \times (\text{air concentration})\\
&= (\text{air unit risk})^S \times (I_A{}^P/20) \times (70/W^P)^{2/3} \times (\text{air concentration})\\
&= (\text{air unit risk})^S \times [(\,I_A{}^E \times (W^P/W^E)^{2/3}/20)] \times (70/W^P)^{2/3} \times (\text{air concentration})\\
&= (\text{air unit risk})^S \times (I_A{}^E/20) \times (70/W^E)^{2/3} \times (\text{air concentration})
\end{aligned}
$$

In this equation the air unit risk from the IRIS data base (air unit risk)^S, the air intake data in the Handbook for the populations where it is available ($I_A{}^E$) and the body weight of that population (W^E) are included along with the standard IRIS values of the air intake (20 m^3/day) and body weight (70kg).

For food ingestion and tap water intake, the intake values are empirically normalized to body weight and therefore the intake data do not have to be corrected as in section 3 above. In these cases corrections to the dose-response parameters in Table 1A-1 are sufficient.

5. REFERENCES

Federal Register. (1992) Cross-species scaling factor for carcinogen risk assessments based on equivalence of (mg/kg-day)$^{3/4}$. Draft report. Federal Register, 57(109): 24152-24173, June 5, 1992.

Prosser, C.L.; Brown, F.A. (1961) Comparative Animal physiology, 2nd edition. WB Saunders Co. p. 161.

U.S. EPA. (1996) Background Documentation. Integrated Risk Information System (IRIS). Online. National Center for Environmental Assessment, Cincinnati, Ohio. Background Documentation available from: Risk Information Hotline, National Center for Environmental Assessment, U.S. EPA, 26 W. Martin Luther King Dr. Cincinnati, OH 45268. (513) 569-7254

TABLE OF CONTENTS

Page No.

2. ANALYSIS OF UNCERTAINTY

The chapters that follow will discuss exposure factors and algorithms for estimating exposure. Exposure factor values can be used to obtain a range of exposure estimates such as average, high-end and bounding estimates. It is instructive here to return to the general equation for potential Average Daily Dose (ADD_{pot}) that was introduced in the opening chapter of this handbook:

$$ADDpot = \frac{\text{Contaminant Concentration x Intake Rate x Exposure Dura}}{\text{Body Weight x Averaging Time}} \quad \text{(Eqn. 2-1)}$$

With the exception of the contaminant concentration, all parameters in the above equation are considered exposure factors and, thus, are treated in fair detail in other chapters of this handbook. Each of the exposure factors involves humans, either in terms of their characteristics (e.g., body weight) or behaviors (e.g., amount of time spent in a specific location, which affects exposure duration). While the topic of uncertainty applies equally to contaminant concentrations and exposure factors, the focus of this chapter is on uncertainty as it relates to exposure factors. Consequently, examples provided in this chapter relate primarily to exposure factors, although contaminant concentrations may be used when they better illustrate the point under discussion.

This chapter also is intended to acquaint the exposure assessor with some of the fundamental concepts and precepts related to uncertainty, together with methods and considerations for evaluating and presenting the uncertainty associated with exposure estimates. Subsequent sections in this chapter are devoted to the following topics:

- Reasons for concern about uncertainty
- Distinction between uncertainty and variability
- Types and sources of uncertainty
- Types and sources of variability
- Methods of analyzing uncertainty and variability
- Presenting results of uncertainty analysis.

Fairly extensive treatises on the topic of uncertainty have been provided, for example, by Morgan and Henrion (1990), the National Research Council (NRC, 1994) and, to a lesser extent, the U.S. EPA (1992, 1995). The topic commonly has been treated as it relates to the overall process of conducting risk assessments; because exposure assessment is a component of risk-assessment process, the general concepts apply equally to the exposure-assessment component.

2.1. CONCERN ABOUT UNCERTAINTY

Why should the exposure assessor be concerned with uncertainty? As noted by the U.S. EPA (1992), exposure assessment utilizes a broad array of information sources and analysis techniques. Even in situations where actual exposure-related measurements exist, assumptions or inferences will still be required because data are not likely to be available for all aspects of the exposure assessment. Moreover, the data that are available may be of questionable or unknown quality. Thus, exposure assessors have a responsibility to present not just numbers, but also a clear and explicit explanation of the implications and limitations of their analyses.

Morgan and Henrion (1990) provide an argument by analogy. When scientists report quantities that they have measured, they are expected to routinely report an estimate of the probable error associated with such measurements. Because uncertainties inherent in policy analysis (of which exposure assessment is a part) tend to be even greater than those in the natural sciences, exposure assessors also should be expected to report or comment on the uncertainties associated with their estimates.

Additional reasons for addressing uncertainty in exposure or risk assessments (U.S. EPA, 1992, Morgan and Henrion, 1990) include the following:

- Uncertain information from different sources of different quality often must be combined for the assessment
- Decisions need to be made about whether or how to expend resources to acquire additional information
- Biases may result in so-called "best estimates" that in actuality are not very accurate
- Important factors and potential sources of disagreement in a problem can be identified.

Addressing uncertainty will increase the likelihood that results of an assessment or analysis will be used in an appropriate manner. Problems rarely are solved to everyone's satisfaction, and decisions rarely are reached on the basis of a single piece of evidence. Results of prior analyses can shed light on current assessments, particularly if they are couched in the context of prevailing uncertainty at the time of analysis. Exposure assessment tends to be an iterative process, beginning with a screening-level assessment that may identify the need for more in-depth assessment. One of the primary goals of the more detailed assessment is to reduce uncertainty in estimated exposures. This objective can be achieved more efficiently if guided by presentation and discussion of factors thought to be primarily responsible for uncertainty in prior estimates.

2.2. UNCERTAINTY VERSUS VARIABILITY

While some authors have treated variability as a specific type or component of uncertainty, the U.S. EPA (1995) has advised the risk assessor (and, by analogy, the exposure assessor) to distinguish between uncertainty and variability. Uncertainty represents a lack of knowledge about factors affecting exposure or risk, whereas variability arises from true heterogeneity across people, places or time. In other words, uncertainty can lead to inaccurate or biased estimates, whereas variability can affect the precision of the estimates and the degree to which they can be generalized.

Uncertainty and variability can complement or confound one another. An instructive analogy has been drawn by National Research Council (NRC 1994, Chapter 10), based on the objective of estimating the distance between the earth and the moon. Prior to fairly recent technology developments, it was difficult to make accurate measurements of this distance, resulting in measurement uncertainty. Because the moon's orbit is elliptical, the distance is a variable quantity. If only a few measurements were to be taken without knowledge of the elliptical pattern, then either of the following incorrect conclusions might be reached:

- That the measurements were faulty, thereby ascribing to uncertainty what was actually caused by variability
- That the moon's orbit was random, thereby not allowing uncertainty to shed light on seemingly unexplainable differences that are in fact variable and predictable.

A more fundamental error in the above situation would be to incorrectly estimate the true distance, by assuming that a few observations were sufficient. This latter pitfall -- treating a highly variable quantity as if it were invariant or only uncertain -- is probably the most relevant to the exposure or risk assessor.

Now consider a situation that relates to exposure, such as estimating the average daily dose by one exposure route -- ingestion of contaminated drinking water. Suppose that it is possible to measure an individual's daily water consumption (and concentration of the contaminant) exactly, thereby eliminating uncertainty in the measured daily dose. The daily dose still has an inherent day-to-day variability, however, due to changes in the individual's daily water intake.

It is impractical to measure the individual's dose every day. For this reason, the exposure assessor may estimate the average daily dose (ADD) based on a finite number of measurements, in an attempt to "average out" the day-to-day variability. The individual has a true (but unknown) ADD, which has now been estimated based on a sample of measurements. Because the individual's true average is unknown, it is uncertain how close the estimate is to the true value. Thus, the variability across daily doses has been translated into uncertainty in the ADD. Although the individual's true ADD has no variability, the estimate of the ADD has some uncertainty.

The above discussion pertains to the ADD for one person. Now consider a distribution of ADDs across individuals in a defined population (e.g., the general U.S. population). In this case, variability refers to the range and distribution of ADDs across individuals in the population. By comparison, uncertainty refers to the exposure assessor's state of knowledge about that distribution, or about parameters describing the distribution (e.g., mean, standard deviation, general shape, various percentiles).

As noted by the National Research Council, the realms of uncertainty and variability have fundamentally different ramifications for science and judgment. For example, uncertainty may force decision-makers to judge how probable it is that exposures have been overestimated or underestimated for every member of the exposed population, whereas variability forces them to cope with the certainty that different individuals are subject to exposures both above and below any of the exposure levels chosen as a reference point.

2.3. TYPES OF UNCERTAINTY

The problem of uncertainty in exposure or risk assessment is relatively large, and can quickly become too complex for facile treatment unless it is divided into smaller and more manageable topics. One method of division (Bogen, 1990) involves classifying sources of uncertainty according to the step in the risk assessment process (hazard identification, dose-response assessment, exposure assessment or risk characterization) at which they can occur. A more abstract and generalized approach preferred by some scientists is to partition all uncertainties among the three categories of bias, randomness and true variability. These ideas are discussed later in some examples.

The U.S. EPA (1992) has classified uncertainty in exposure assessment into three broad categories:

1. Uncertainty regarding missing or incomplete information needed to fully define exposure and dose (Scenario Uncertainty).

2. Uncertainty regarding some parameter (Parameter Uncertainty).

3. Uncertainty regarding gaps in scientific theory required to make predictions on the basis of causal inferences (Model Uncertainty).

Identification of the sources of uncertainty in an exposure assessment is the first step in determining how to reduce that uncertainty. The types of uncertainty listed above can be further defined by examining their principal causes. Sources and examples for each type of uncertainty are summarized in Table 2-1 and discussed in further detail below.

The sources of **scenario uncertainty** include descriptive errors, aggregation errors, errors in professional judgment, and incomplete analysis. Descriptive errors include information errors such as the current producers of the chemical and its industrial, commercial, and consumer uses. Information of this type is the foundation for fate-and-transport analysis and the eventual development of exposure pathways, scenarios, exposed populations, and exposure estimates.

Aggregation errors arise as a result of lumping approximations. Included among these are assumptions of homogeneous populations, temporal approximations such as assuming steady-state conditions for a dynamic process, and spatial approximations such as using a 2-dimensional mathematical model to represent a 3-dimensional aquifer.

Errors in professional judgment can come into play in virtually every aspect of the exposure assessment process, including defining appropriate exposure scenarios, selecting environmental fate models, determining representative environmental conditions, etc. Judgment errors can be the result of limited experience, or can arise when the assessor has difficulty separating opinion from fact.

.

Table 2-1. Three Types of Uncertainty and Associated Sources and Examples

Type of Uncertainty	Sources	Examples
Scenario Uncertainty	Descriptive errors	Incorrect or insufficient information
	Aggregation errors	Spatial or temporal approximations
	Judgment errors	Selection of an incorrect model
	Incomplete analysis	Overlooking an important pathway
Parameter Uncertainty	Measurement errors	Imprecise or biased measurements
	Sampling errors	Small or unrepresentative samples
	Variability	In time, space or activities
	Surrogate data	Structurally-related chemicals
Model Uncertainty	Relationship errors	Incorrect inference on the basis for correlations
	Modeling errors	Excluding relevant variables

A potentially serious source of uncertainty in exposure assessments arises from incomplete analysis. For example, the exposure assessor may overlook an important exposure pathway due to lack of information regarding the use of a chemical in a consumer product, or may fail to include an important population subgroup that has increased susceptibility to adverse health effects of exposure.

Sources of **parameter uncertainty** include measurement errors, sampling errors, variability, and use of generic or surrogate data. Measurement errors may be random or systematic. Random errors result from imprecise measurements. For example, two observers who time an individual's activity may record different durations. Similarly, the second analysis of a split sample will not necessarily yield the same result as the first analysis. Systematic errors reflect a bias or tendency to measure something other than what was intended, as could occur if an ambient monitoring design inadvertently over-represented heavily industrialized areas. Similarly, body weight would be systematically overestimated if all measurements were made using fully clothed individuals.

Sampling errors tend to reduce sample representativeness. The general purpose of sampling is to collect information on some fraction of a population in order to make an inference about the entire group. If the sample size for a given data collection effort is relatively small, then the random sampling error associated with that effort will tend to be correspondingly large. If the exposure assessment uses data that were generated for another purpose, then uncertainty will arise if the data do not represent the exposure scenario being analyzed. For example, use of product sales information to infer residential usage patterns may be misleading if residential and commercial sales cannot be reliably distinguished.

The inherent variability in environmental and exposure-related parameters is a major source of uncertainty. For example, meteorological and hydrological conditions change seasonally at a given location, soil characteristics exhibit large spatial variability, and human activity patterns depend on the age, sex, and geographic location of specific individuals in the population. Although uncertainty and variability are treated in this chapter as different entities, it is noteworthy that variation in one quantity can contribute to uncertainty in another (NRC, 1994). The most relevant example involves the influence of the variability in a quantity on the uncertainty of its mean -- when the quantity varies by orders of magnitude, even relatively large data sets may be insufficient to pin down the mean with the desired degree of precision.

Generic data are commonly used when site-specific data are not available. Examples include standard emission factors for industrial processes and generalized descriptions of environmental settings. Surrogate data are commonly used when chemical-specific data are not available. One example is the use of structurally-related chemicals as surrogates for the chemical of interest. An example of surrogate data not pertaining to chemicals is the use of an individual's heart rate to infer his/her breathing rate. Since surrogate data introduce additional uncertainty, they should be avoided if actual data can be obtained.

Relationship and modeling errors are the primary sources of **model uncertainty**. Relationship errors include flaws in environmental fate models and poor correlations between chemical properties or between structure and reactivity. Modeling errors arise because models tend to be simplified representations of physical and chemical processes. Even after the exposure assessor has selected the most appropriate model, he or she still faces the question of how well the model represents actual conditions. This question is compounded by the overlap between modeling uncertainties and other uncertainties (e.g., natural variability in environmental inputs, model representativeness, aggregation errors). The dilemma facing exposure assessors is that many existing models (particularly the very complex ones) and the hypotheses contained within them cannot be fully tested (Beck, 1987), although certain components of the model may be testable. Even if a model has been validated under a particular set of conditions, its application in cases beyond the test conditions will introduce uncertainty.

Because uncertainty in exposure assessments is fundamentally tied to a lack of knowledge concerning important exposure factors, strategies for reducing uncertainty necessarily involve reduction or elimination of knowledge gaps. Example strategies to reduce uncertainty include (1) collection of new data using a larger sample size, an unbiased sample design, a more direct measurement method or a more appropriate target population, and (2) use of more sophisticated modeling and analysis tools.

2.4. TYPES OF VARIABILITY

Variability in exposure is related to an individual's location, activity, and behavior or preferences at a particular point in time, as well as pollutant emission rates and physical/chemical processes that affect concentrations in various media (e.g., air, soil, food and water). The variations in pollutant-specific emissions or processes, and in individual locations, activities or behaviors, are not necessarily independent of one another. For example, both personal activities and pollutant concentrations at a specific location might vary in response to weather conditions, or between weekdays and weekends.

At a more fundamental level, three types of variability can be distinguished:

- Variability across locations (Spatial Variability)
- Variability over time (Temporal Variability)
- Variability among individuals (Inter-individual Variability).

Spatial variability can occur both at regional (macroscale) and local (microscale) levels. For example, fish intake rates can vary depending on the region of the country. Higher consumption may occur among populations located near large bodies of water such as the Great Lakes or coastal areas. As another example, outdoor pollutant levels can be affected at the regional level by industrial activities and at the local level by activities of individuals. In general, higher exposures tend to be associated with closer proximity to the pollutant source, whether it be an industrial plant or related to a personal activity such as showering or gardening. In the context of exposure to airborne pollutants, the concept of a "microenvironment" has been introduced (Duan 1982) to denote a specific locality (e.g., a residential lot or a room in a specific building) where the airborne concentration can be treated as homogeneous (i.e., invariant) at a particular point in time.

Temporal variability refers to variations over time, whether long- or short-term. Seasonal fluctuations in weather, pesticide applications, use of woodburning appliances and fraction of time spent outdoors are examples of longer-term variability. Examples of shorter-term variability are differences in industrial or personal activities on weekdays versus weekends or at different times of the day.

Inter-individual variability can be either of two types: (1) human characteristics such as age or body weight, and (2) human behaviors such as location and activity patterns. Each of these variabilities, in turn, may be related to several underlying phenomena that vary. For example, the natural variability in human weight is due to a combination of genetic, nutritional, and other lifestyle or environmental factors. According to the central limit theorem, variability arising from independent factors that combine multiplicatively generally will lead to an approximately lognormal distribution across the population, or across spatial/temporal dimensions.

According to the National Research Council (NRC 1994), variability can be confronted in four basic ways when dealing with science-policy questions surrounding issues such as exposure or risk assessment. The first is to ignore the variability and hope for the best. This strategy tends to work best when the variability is relatively small. For example, the assumption that all adults weigh 70 kg is likely to be correct within ±25% for most adults.

The second strategy involves disaggregating the variability in some explicit way, in order to better understand it or reduce it. Mathematical models are appropriate in some cases, as in fitting a sine wave to the annual outdoor concentration cycle for a particular pollutant and location. In other cases, particularly those involving human characteristics or behaviors, it is easier to disaggregate the data by considering all the relevant subgroups or subpopulations. For example, distributions of body weight could be developed separately for adults, adolescents and children, and even for males and females within each of these subgroups. Temporal and spatial analogies for this concept involve measurements on appropriate time scales and choosing appropriate subregions or microenvironments.

The third strategy is to use the average value of a quantity that varies. Although this strategy might appear as tantamount to ignoring variability, it needs to be based on a decision that the average value can be estimated reliably in light of the variability (e.g., when the variability is known to be relatively small, as in the case of adult body weight).

The fourth strategy involves using the maximum or minimum value for an exposure factor. This is perhaps the most common method of dealing with variability in exposure or risk assessment -- to focus on one time period (e.g., the period of peak exposure), one spatial region (e.g., in close proximity to the pollutant source of concern), or one subpopulation (e.g., exercising asthmatics).

2.5. METHODS OF ANALYZING UNCERTAINTY AND VARIABILITY

Exposure assessments often are developed in a phased approach. The initial phase usually screens out the scenarios that are not expected to pose much risk, to eliminate them from more detailed, resource-intensive review. Screening-level assessments typically examine exposures that would fall on or beyond the high end of the expected exposure distribution. Because screening-level analyses are usually included in the final exposure assessment, the final document may contain scenarios that differ quite markedly in sophistication, data quality, and amenability to quantitative expressions of uncertainty.

According to the U.S. EPA (1992), uncertainty characterization and uncertainty assessment are two ways of describing uncertainty at different degrees of sophistication. Uncertainty characterization usually involves a qualitative discussion of the thought processes used to select or reject specific data, estimates, scenarios, etc. Uncertainty assessment is a more quantitative process that may range from simpler measures (e.g., ranges) and simpler analytical techniques (e.g., sensitivity analysis) to more complex measures and techniques. Its goal is to provide decision makers with information concerning the quality of an assessment, including the potential variability in the estimated exposures, major data gaps, and the effect that these data gaps have on the exposure estimates developed.

A distinction between uncertainty and variability was made in Section 2.2. Although the qualitative approach mentioned above applies more directly to uncertainty and the quantitative process more so to variability, there is some degree of overlap. In general, either method provides the assessor or decision-maker with insights to better evaluate the assessment in the context of available data and assumptions. The following paragraphs briefly describe some of the more common procedures for analyzing uncertainty and variability in exposure assessments. Principles that pertain to presenting the results of uncertainty analysis are discussed in the next section.

Several approaches can be used to characterize uncertainty in parameter values. When uncertainty is high, the assessor may use order-of-magnitude bounding estimates of parameter ranges (e.g., from 0.1 to 10 liters for daily water intake). Another method describes the range for each parameter including the lower and upper bounds as well as a "best estimate" (e.g., 1.4 liters per day) determined by available data or professional judgement. When sensitivity analysis (discussed below) indicates that a parameter profoundly influences exposure estimates, the assessor should develop a probabilistic description of its range. If there are enough data to support their use, standard statistical methods are preferred. If the data are inadequate, expert judgment can be used to generate a subjective probabilistic representation. Such judgments should be developed in a consistent, well-documented manner. Morgan and Henrion (1990) and Rish (1988) describe techniques to solicit expert judgment.

Most approaches to quantitative analysis examine how uncertainties in values of specific parameters translate into the overall uncertainty of the assessment. Details may be found in reviews such as Cox and Baybutt (1981), Whitmore (1985), Inman and Helton (1988), Seller (1987), and Rish and Marnicio (1988). These approaches can generally be described (in order of increasing complexity and data needs) as: (1) sensitivity analysis; (2) analytical uncertainty propagation; (3) probabilistic uncertainty analysis; or (4) classical statistical methods (U.S. EPA 1992). The four approaches are summarized in Table 2-2 and described in greater detail below.

Table 2-2. Approaches to Quantitative Analysis of Uncertainty

Approach	Description	Example
Sensitivity Analysis	Changing one input variable at a time while leaving others constant, to examine effect on output	Fix each input at lower (then upper) bound while holding others at nominal values (e.g., medians)
Analytical Uncertainty Propagation	Examining how uncertainty in individual parameters affects the overall uncertainty of the exposure assessment	Analytically or numerically obtain a partial derivative of the exposure equation with respect to each input parameter
Probabilistic Uncertainty Analysis	Varying each of the input variables over various values of their respective probability distributions	Assign probability density function to each parameter; randomly sample values from each distribution and insert them in the exposure equation (Monte Carlo)
Classical Statistical Methods	Estimating the population exposure distribution directly, based on measured values from a representative sample	Compute confidence interval estimates for various percentiles of the exposure distribution

Sensitivity analysis is the process of changing one variable while leaving the others constant to determine its effect on the output. This procedure fixes each uncertain quantity at its credible lower and upper bounds (holding all others at their nominal values, such as medians) and computes the results of each combination of values. The results help to identify the variables that have the greatest effect on exposure estimates and help focus further information-gathering efforts. However, the results themselves can be sensitive to the choices of nominal values and lower/upper bounds, and do not indicate the probability of a variable being at any point within its range; therefore, this approach is most useful at the screening level, to determine the need for and direction of further analyses.

Analytical uncertainty propagation examines how uncertainty in individual parameters affects the overall uncertainty of the exposure assessment. The uncertainties associated with various parameters may propagate through a model very differently, even if they have approximately the same uncertainty. Since uncertainty propagation is a function of both the data and the model structure, this procedure evaluates both input variances and model sensitivity. Application of this approach to exposure assessment requires explicit mathematical expressions of exposure, estimates of variance for each variable of interest, and the ability to obtain a mathematical (analytical or numerical) derivative of the exposure equation.

Although uncertainty propagation is a powerful tool, it should be applied with caution: It is difficult to generate and solve the equations for the sensitivity coefficients. The technique is most accurate for linear equations, so any departure from linearity must be carefully evaluated. In addition, assumptions such as variable independence and error normality must be verified. Finally, the information to support required parameter variance estimates may not be readily available. In some cases, analytical uncertainty propagation may be more difficult than probabilistic uncertainty analyses, discussed below.

The most common example of **probabilistic uncertainty analysis** is the Monte Carlo method. This simulation technique assigns a probability density function to each input parameter, then randomly selects values from each of the distributions and inserts them into the exposure equation. Repeated calculations produce a distribution of predicted values, reflecting the combined impact of variability in each input to the calculation.

The principal advantage of Monte Carlo simulation is its very general applicability. There is no restriction on the form of the input distributions or the relationship between input and output. Correlations among input parameters can be expressed and taken into account, and computations are straightforward. However, Monte Carlo analysis does have its disadvantages -- the exposure assessor should only consider using it when there are credible distribution data (or ranges) for most key variables. Even if these distributions are known, it may not be necessary to apply this technique. For example, one could use central-tendency values (e.g., means, medians) for each input parameter to develop a preliminary estimate of "typical exposure," recognizing that this combination of parameters will not necessarily yield the average obtained through Monte Carlo simulation. In addition, it is not necessary to use this technique if a bounding exposure estimate indicates that the particular pathway or chemical being assessed does not present a significant risk.

As noted by Morgan and Henrion (1990), analysis of Monte Carlo inputs and outputs also can shed light on the attribution of uncertainty to specific input parameters. For example, the correlation between any input and the output provides an indication of the linear contribution of each input to output uncertainty, and is therefore a global measure of uncertainty importance. In a similar vein, multiple regression analysis indicates the relative linear contribution of each input to output uncertainty, after statistically removing the effects attributable to other inputs, provided that standardized regression coefficients are examined. Rank-order correlations and scatterplots of each input against the output offer the means to investigate nonlinear relationships that may be important.

Classical statistical methods can be used to analyze variability and uncertainty in measured exposures. Given a data set of measured exposure values for a series of individuals, the population distribution may be estimated directly, provided that the sample design captures a representative sample. Measured exposure values can also be used to directly compute confidence intervals for percentiles of the exposure distribution (ACS, 1989). When the exposure distribution is estimated from measured exposures for a probability sample of population members, confidence interval estimates for percentiles of the exposure distribution are the primary uncertainty characterization. Data collection, survey design, and the accuracy and precision of measurement techniques should also be discussed.

Often the observed exposure distribution is skewed because many points within the sample distribution fall at or below the detection limit, in the case of concentrations, or because few points fall at the upper end of the distribution. Fitting the data to a distribution type can be problematic in these situations because (1) there is no way to determine the distribution of values below the detection limit and (2) data are usually scant in low-probability areas (such as upper-end tails) where numerical values may vary widely. Thus, for many data sets, means and standard deviations may be good approximations, but the tails of the distribution will be much less well-characterized. For data sets where sampling is still practical, the sample may be stratified in order to over sample the tail, thereby increasing the precision with which that portion of the distribution can be estimated.

A variety of approaches can be used to quantitatively characterize the uncertainty associated with model constructs. One approach uses different modeling formulations (including the preferred and plausible alternatives) and assumes that the range of outputs represents the range of uncertainty. This strategy is most useful when available data do not support any "best" approach, or when a model must be used to extrapolate beyond the conditions for which it was designed.

The issues of verifying computer code and verifying the model are not the same, and should be performed in separate steps. Often there may be simplifications in the programming that lead to errors, even though the model formulation is correct. Once the computer code is verified, the model output can be compared with real data to evaluate the model itself.

Where the data base is sufficient, the exposure assessor should characterize the uncertainty in the selected model by describing the validation and verification efforts. The validation process compares the performance of the model to actual observations under situations representative of those being assessed. Burns (1985) discusses approaches for model validation. The verification process confirms that the model computer code produces the correct numerical output. In most situations, only partial validation is possible due to data deficiencies or model complexity.

2.6. PRESENTING RESULTS OF UNCERTAINTY ANALYSIS

Comprehensive qualitative analysis and rigorous quantitative analysis are of little value for use in the decision-making process, if their results are not clearly presented. In this chapter, variability (the receipt of different levels of exposure by different individuals) has been distinguished from uncertainty (the lack of knowledge about the correct value for a specific exposure measure or estimate). Most of the data that are presented in this handbook deal with variability directly, through inclusion of statistics that pertain to the distributions for various exposure factors. The uncertainty surrounding data for the exposure factors has been discussed qualitatively, by describing the limitations and assumptions of each study or data set.

Any exposure estimate developed by an assessor will have associated assumptions about the setting, chemical, population characteristics, and how contact with the chemical occurs through various exposure routes and pathways. The exposure assessor will need to examine many sources of information that bear either directly or indirectly on these components of the exposure assessment. In addition, the assessor will be required to make many decisions regarding the use of existing information in constructing scenarios and setting up the exposure equations. In presenting the scenario results, the assessor should strive for a balanced and impartial treatment of the evidence bearing on the conclusions with the key assumptions highlighted. For these key assumptions, one should cite data sources and explain any adjustments of the data.

It is not sufficient to merely present the results of these many decisions using different exposure descriptors. A discussion also must be included that describes key assumptions and indicates the parameters that are believed to have the greatest impact on the exposure estimate(s). The exposure assessor should strive to address questions such as:

- What is the basis or rationale for selecting these assumptions/parameters, such as data, modeling, scientific judgment, Agency policy, "what if" considerations, etc.?

- What is the range or variability of the key parameters? How were the parameter values selected for use in the assessment? Were average, median, or upper-percentile values chosen? If other choices had been made, how would the results have differed?

- What is the assessor's confidence (including qualitative confidence aspects) in the key parameters and the overall assessment? What are the quality and the extent of the data base supporting the selection of the chosen values?

The exposure assessor also should qualitatively describe the rationale for selection of conceptual and mathematical models. This discussion should address their verification and validation status, how well they represent the situation being assessed (e.g., average or high-end estimates), and any plausible alternatives in terms of their acceptance by the scientific community.

Although incomplete analysis is essentially unquantifiable as a source of uncertainty, it should not be ignored. At a minimum, the assessor should describe the rationale for excluding particular exposure scenarios; characterize the uncertainty in these decisions as high, medium, or low; and state whether they were based on data, analogy, or professional judgment. Where uncertainty is high, a sensitivity analysis can be used to establish credible upper limits on exposure by way of a series of "what if" questions.

Although assessors have always used descriptors to communicate the kind of scenario being addressed, the 1992 Exposure Guidelines establish clear quantitative definitions for these risk descriptors. These definitions were established to ensure that consistent terminology is used throughout the Agency. The risk descriptors defined in the Guidelines include descriptors of individual risk and population risk. Individual risk descriptors are intended to address questions dealing with risks borne by individuals within a population, including not only measures of central tendency (e.g., average or median), but also those risks at the high end of the distribution. Population risk descriptors refer to an assessment of the extent of harm to the population being addressed. It can be either an estimate of the number of cases of a particular effect that might occur in a population (or population segment), or a description of what fraction of the population receives exposures, doses, or risks greater than a specified value. The data presented in the Exposure Factors Handbook is one of the tools available to exposure assessors to construct the various risk descriptors.

2.7. REFERENCES FOR CHAPTER 2

American Chemical Society (ACS). (1989) Principles of environmental sampling. ACS Professional Reference Book, Laurence H. Keith, ed. Washington, DC.

Beck, M.B. (1987) Water quality modeling: A review of the analysis of uncertainty. Water Resour. Res. 23(8):1393-1442.

Bogen, K.T. (1990) Uncertainty in environmental health risk assessment. Garland Publishing, New York, NY.

Burns, L.A. (1985) Validation methods for chemical exposure and hazard assessment models. EPA/600/D-85/297.

Cox, D.C.; Baybutt, P.C. (1981) Methods for uncertainty analysis. A comparative survey. Risk Anal. 1(4):251-258.

Duan, N. (1982) Microenvironment types: A model for human exposure to air pollution. Environ. Intl. 8:305-309.

Inman, R.L.; Helton, J.C. (1988) An investigation of uncertainty and sensitivity analysis techniques for computer models. Risk Anal. 8(1):71-91.

Morgan, M.G.; Henrion, M. (1990) Uncertainty: A guide to dealing with uncertainty in quantitative risk and policy analysis. Cambridge University Press, New York, NY.

National Research Council (NRC). (1994) Science and judgment in risk assessment. National Academy Press, Washington, DC.

Rish, W.R. (1988) Approach to uncertainty in risk analysis. Oak Ridge National Laboratory. ORNL/TM-10746.

Rish, W.R.; Marnicio, R.J. (1988) Review of studies related to uncertainty in risk analysis. Oak Ridge National Laboratory. ORNL/TM-10776.

Seller, F.A. (1987) Error propagation for large errors. Risk Anal. 7(4):509-518.

U.S. EPA (1992) Guidelines for exposure assessment notice. 57FR11888, May 29, 1992.

U.S. EPA (1995) Guidance for risk characterization. Science Policy Council, Washington, DC.

Whitmore, R.W. (1985) Methodology for characterization of uncertainty in exposure assessments. EPA/600/8-86/009.

3. DRINKING WATER INTAKE

3.1. BACKGROUND

Drinking water is a potential source of human exposure to toxic substances. Contamination of drinking water may occur by, for example, percolation of toxics through the soil to ground water that is used as a source of drinking water; runoff or discharge to surface water that is used as a source of drinking water; intentional or unintentional addition of substances to treat water (e.g., chlorination); and leaching of materials from plumbing systems (e.g., lead). Estimating the magnitude of the potential dose of toxics from drinking water requires information on the quantity of water consumed. The purpose of this section is to describe key published studies that provide information on drinking water consumption (Section 3.2) and to provide recommendations of consumption rate values that should be used in exposure assessments (Section 3.6).

Currently, the U.S. EPA uses the quantity of 2 L per day for adults and 1 L per day for infants (individuals of 10 kg body mass or less) as default drinking water intake rates (U.S. EPA, 1980). These rates include drinking water consumed in the form of juices and other beverages containing tapwater (e.g., coffee). The National Academy of Sciences (NAS, 1977) estimated that daily consumption of water may vary with levels of physical activity and fluctuations in temperature and humidity. It is reasonable to assume that some individuals in physically-demanding occupations or living in warmer regions may have high levels of water intake.

Numerous studies cited in this chapter have generated data on drinking water intake rates. In general, these sources support EPA's use of 2 L/day for adults and 1 L/day for children as upper-percentile tapwater intake rates. Many of the studies have reported fluid intake rates for both total fluids and tapwater. *Total fluid intake* is defined as consumption of all types of fluids including tapwater, milk, soft drinks, alcoholic beverages, and water intrinsic to purchased foods. *Total tapwater* is defined as water consumed directly from the tap as a beverage or used in the preparation of foods and beverages (i.e., coffee, tea, frozen juices, soups, etc.). Data for both consumption categories are presented in the sections that follow. However, for the purposes of exposure assessments involving source-specific contaminated drinking water, intake rates based on total tapwater are more representative of source-specific tapwater intake. Given the assumption that purchased foods and beverages are widely distributed and less likely to contain source-specific water, the use of total fluid intake rates may overestimate the potential exposure to toxic substances present only in local water supplies; therefore tapwater intake, rather than total fluid intake, is emphasized in this section.

All studies on drinking water intake that are currently available are based on short-term survey data. Although short-term data may be suitable for obtaining mean intake values that are representative of both short- and long-term consumption patterns, upper-percentile values may be different for short-term and long-term data because more variability generally occurs in short-term surveys. It should also be noted that most drinking water surveys currently available are based on recall. This may be a source of uncertainty in the estimated intake rates because of the subjective nature of this type of survey technique.

The distribution of water intakes is usually, but not always, lognormal. Instead of presenting only the lognormal parameters, the actual percentile distributions are presented in this handbook, usually with a comment on whether or not it is lognormal. To facilitate comparisons between studies, the mean and the 90th percentiles are given for all studies where the distribution data are available. With these two parameters, along with information about which distribution is being followed, one can calculate, using standard formulas, the geometric mean and geometric standard deviation and hence any desired percentile of the distribution. Before doing such a calculation one must be sure that one of these distributions adequately fits the data.

The available studies on drinking water consumption are summarized in the following sections. They have been classified as either key studies or relevant studies based on the applicability of their survey designs to exposure assessment of the entire United States population. Recommended intake rates are based on the results of key studies, but relevant studies are also presented to provide the reader with added perspective on the current state-of-knowledge pertaining to drinking water intake.

3.2. KEY GENERAL POPULATION STUDIES ON DRINKING WATER INTAKE

Canada Department of Health and Welfare - Tapwater Consumption in Canada - In a study conducted by the Canadian Department of Health and Welfare, 970 individuals from 295 households were surveyed to determine the per capita total tapwater intake rates for various age/sex groups during winter and summer seasons

(Canadian Ministry of National Health and Welfare, 1981). Intake rate was also evaluated as a function of physical activity. The population that was surveyed matched the Canadian 1976 census with respect to the proportion in different age, regional, community size and dwelling type groups. Participants monitored water intake for a 2-day period (1 weekday, and 1 weekend day) in both late summer of 1977 and winter of 1978. All 970 individuals participated in both the summer and winter surveys. The amount of tapwater consumed was estimated based on the respondents' identification of the type and size of beverage container used, compared to standard sized vessels. The survey questionnaires included a pictorial guide to help participants in classifying the sizes of the vessels. For example, a small glass of water was assumed to be equivalent to 4.0 ounces of water, and a large glass was assumed to contain 9.0 ounces of water. The study also accounted for water derived from ice cubes and popsicles, and water in soups, infant formula, and juices. The survey did not attempt to differentiate between tapwater consumed at home and tapwater consumed away from home. The survey also did not attempt to estimate intake rates for fluids other than tapwater. Consequently, no intake rates for total fluids were reported.

Daily consumption distribution patterns for various age groups are presented in Table 3-1. For adults (over 18 years of age) only, the average total tapwater intake rate was 1.38 L/day, and the 90th percentile rate was 2.41 L/day as determined by graphical interpolation. These

Table 3-1. Daily Total Tapwater Intake Distribution for Canadians, by Age Group
(Approx. 0.20 L Increments, Both Sexes, Combined Seasons)

	Age Group (years)					
Amount Consumed[a]	5 and under		6-17		18 and over	
L/day	%	Number	%	Number	%	Number
0.00 - 0.21	11.1	9	2.8	7	0.5	3
0.22 - 0.43	17.3	14	10.0	25	1.9	12
0.44 - 0.65	24.8	20	13.2	33	5.9	38
0.66 - 0.86	9.9	8	13.6	34	8.5	54
0.87 - 1.07	11.1	9	14.4	36	13.1	84
1.08 - 1.29	11.1	9	14.8	37	14.8	94
1.30 - 1.50	4.9	4	9.6	24	15.3	98
1.51 - 1.71	6.2	5	6.8	17	12.1	77
1.72 - 1.93	1.2	1	2.4	6	6.9	44
1.94 - 2.14	1.2	1	1.2	3	5.6	36
2.15 - 2.36	1.2	1	4.0	10	3.4	22
2.37 - 2.57	-	0	0.4	1	3.1	20
2.58 - 2.79	-	0	2.4	6	2.7	17
2.80 - 3.00	-	0	2.4	6	1.4	9
3.01 - 3.21	-	0	0.4	1	1.1	7
3.22 - 3.43	-	0	-	0	0.9	6
3.44 - 3.64	-	0	-	0	0.8	5
3.65 - 3.86	-	0	-	0	-	0
>3.86	-	0	1.6	4	2.0	13
TOTAL	100.0	81	100.0	250	100.0	639

[a] Includes tapwater and foods and beverages derived from tapwater.
Source: Canadian Ministry of National Health and Welfare, 1981.

data follow a lognormal distribution. The intake data for males, females, and both sexes combined as a function of age and expressed in the units of milliliters (grams) per kilogram body weight are presented in Table 3-2. The tapwater survey did not include body weights of the participants, but the body weight information was taken from a Canadian health survey dated 1981; it averaged 65.1 kg for males and 55.6 kg for females. Intake rates for specific age groups and seasons are presented in Table 3-3. The average daily total tapwater intake rates for all ages and seasons combined was 1.34 L/day, and the 90th percentile rate was 2.36 L/day. The summer intake rates are nearly the same as the winter intake rates. The authors speculate that the reason for the small seasonal variation here is that in Canada, even in the summer, the ambient temperature seldom exceeded 20 degrees C and marked increase in water consumption with high activity levels has been observed in other studies only when the ambient temperature has been higher than 20 degrees. Average daily total tapwater intake rates as a function of the level of physical activity, as estimated subjectively, are presented in Table 3-4. The amounts of tapwater consumed that are derived from various foods and beverages are presented in Table 3-5. Note that the consumption of direct “raw” tapwater is almost constant across all age groups from school-age children through the oldest ages. The increase in total tapwater consumption beyond school age is due to coffee and tea consumption.

Table 3-2. Average Daily Tapwater Intake of Canadians (expressed as milliliters per kilogram body weight)

	Average Daily Intake (mL/kg)		
Age Group (years)	Fema les	Males	Both Sexes
< 3	53	35	45
3-5	49	48	48
6-17	24	27	26
18-34	23	19	21
35-54	25	19	22
55+	24	21	22
Total Population	24	21	22

Source: Canadian Ministry of National Health and Welfare, 1981.

Data concerning the source of tapwater (municipal, well, or lake) was presented in one table of the study. This categorization is not appropriate for making conclusions about consumption of ground versus surface water.

This survey may be more representative of total tapwater consumption than some other less comprehensive surveys because it included data for some tapwater-containing items not covered by other studies (i.e., ice cubes, popsicles, and infant formula). One potential source of error in the study is that estimated intake rates were based on identification of standard vessel sizes; the accuracy of this type of survey data is not known. The cooler climate of Canada may have reduced the importance of large tapwater intakes resulting from high activity levels, therefore making the study less applicable to the United States. The authors were not able to explain the surprisingly large variations between regional tapwater intakes; the largest regional difference was between Ontario (1.18 liters/day) and Quebec (1.55 liters/day).

Ershow and Cantor - Total Water and Tapwater Intake - Ershow and Cantor (1989) estimated water intake rates based on data collected by the USDA 1977-1978 Nationwide Food Consumption Survey (NFCS). Daily intake rates for tapwater and total water were calculated for various age groups for males, females, and both sexes combined. Tapwater was defined as "all water from the household tap consumed directly as a beverage or used to prepare foods and beverages." Total water was defined as tapwater plus "water intrinsic to foods and beverages" (i.e., water contained in purchased food and beverages). The authors showed that the age, sex, and racial distribution of the surveyed population closely matched the estimated 1977 U. S. population.

Daily total tapwater intake rates, expressed as mL (grams) per day by age group are presented in Table 3-6. These data follow a lognormal distribution. The same data, expressed as mL (grams) per kg body weight per day are presented in Table 3-7. A summary of these tables, showing the mean, the 10th and 90th percentile intakes, expressed as both mL/day and mL/kg-day as a function of age, is presented in Table 3-8. This shows that the mean and 90th percentile intake for adults (ages 20 to 65+) is approximately 1,410 mL/day and 2,280 mL/day and for all ages the mean and 90th percentile is 1,190 mL/day and 2,090 mL/day. Note that older adults have greater intakes than do adults between age 20 and 65, an observation bearing on the interpretation of the Cantor, et al. (1987)

Table 3-3. Average Daily Total Tapwater Intake of Canadians, by Age and Season (L/day)[a]

	Age (years)						
	< 3	3-5	6-17	18-34	35-54	≤ 55	All Ages
Average							
Summer	0.57	0.86	1.14	1.33	1.52	1.53	1.31
Winter	0.66	0.88	1.13	1.42	1.59	1.62	1.37
Summer/Winter	0.61	0.87	1.14	1.38	1.55	1.57	1.34
90th Percentile							
Summer/Winter	1.50	1.50	2.21	2.57	2.57	2.29	2.36

[a] Includes tapwater and foods and beverages derived from tapwater.

Source: Canadian Ministry of National Health and Welfare, 1981.

Table 3-4. Average Daily Total Tapwater Intake of Canadians as a Function of Level of Physical Activity at Work and in Spare Time (16 Years and Older, Combined Seasons, L/day)

	Work		Spare Time	
Activity Level[a]	Consumption[b] L/day	Number of Respondents	Consumption[b] L/day	Number of Respondents
Extremely Active	1.72	99	1.57	52
Very Active	1.47	244	1.51	151
Somewhat Active	1.47	217	1.44	302
Not Very Active	1.27	67	1.52	131
Not At All Active	1.30	16	1.35	26
Did Not State	1.30	45	1.31	26
TOTAL		688		688

[a] The levels of physical activity listed here were not defined any further by the survey report, and categorization of activity level by survey participants is assumed to be subjective.
[b] Includes tapwater and foods and beverages derived from tapwater.

Source: Canadian Ministry of National Health and Welfare, 1981.

Table 3-5. Average Daily Tapwater Intake Apportioned Among Various Beverages (Both Sexes, by Age, Combined Seasons, L/day)[a]

	Age Group (years)					
	Under 3	3-5	6-17	18-34	35-54	55 and Over
Total Number in Group 34	47	250	232	254	153	
Water	0.14	0.31	0.42	0.39	0.38	0.38
Ice/Mix	0.01	0.01	0.02	0.04	0.03	0.02
Tea	*	0.01	0.05	0.21	0.31	0.42
Coffee	0.01	*	0.06	0.37	0.50	0.42
"Other Type of Drink"	0.21	0.34	0.34	0.20	0.14	0.11
Reconstituted Milk	0.10	0.08	0.12	0.05	0.04	0.08
Soup	0.04	0.08	0.07	0.06	0.08	0.11
Homemade Beer/Wine	*	*	0.02	0.04	0.07	0.03
Homemade Popsicles	0.01	0.03	0.03	0.01	*	*
Baby Formula, etc.	0.09	*	*	*	*	*
TOTAL	0.61	0.86	1.14	1.38	1.55	1.57

[a] Includes tapwater and foods and beverages derived from tapwater.
* Less than 0.01 L/day

Source: Canadian Ministry of National Health and Welfare, 1981.

study which surveyed a population that was older than the national average (see Section 3.3).

Ershow and Cantor (1989) also measured total water intake for the same age groups and concluded that it averaged 2,070 mL/day for all groups combined and that tapwater intake (1,190 mL/day) is 55 percent of the total water intake. (The detailed intake data for various age groups are presented in Table 3-9). They also concluded that, for all age groups combined, the proportion of tapwater consumed as drinking water, foods, and beverages is 54 percent, 10 percent and 36 percent, respectively. (The detailed data on proportion of tapwater consumed for various age groups are presented in Table 3-10). They found that males of all age groups had higher total water and tapwater consumption rates than females; the variation of each from the combined-sexes mean was about 8 percent.

Table 3-6. Total Tapwater Intake (mL/day) for Both Sexes Combined[a]

Age (yr)	Number of Observations	Mean	SD	S.E. of Mean	Percentile Distribution								
					1	5	10	25	50	75	90	95	99
< 0.5	182	272	247	18	*	0	0	80	240	332	640	800	*
0.5 - 0.9	221	328	265	18	*	0	0	117	268	480	688	764	*
1 - 3	1498	646	390	10	33	169	240	374	567	820	1162	1419	1899
4 - 6	1702	742	406	10	68	204	303	459	660	972	1302	1520	1932
7 - 10	2405	787	417	9	68	241	318	484	731	1016	1338	1556	1998
11 - 14	2803	925	521	10	76	244	360	561	838	1196	1621	1924	2503
15 - 19	2998	999	593	11	55	239	348	587	897	1294	1763	2134	2871
20 - 44	7171	1255	709	8	105	337	483	766	1144	1610	2121	2559	3634
45 - 64	4560	1546	723	11	335	591	745	1057	1439	1898	2451	2870	3994
65 - 74	1663	1500	660	16	301	611	766	1044	1394	1873	2333	2693	3479
75 +	878	1381	600	20	279	568	728	961	1302	1706	2170	2476	3087
Infants (ages < 1)	403	302	258	13	0	0	0	113	240	424	649	775	1102
Children (ages 1-10)	5605	736	410	5	56	192	286	442	665	960	1294	1516	1954
Teens (ages 11-19)	5801	965	562	7	67	240	353	574	867	1246	1701	2026	2748
Adults (ages 20-64)	11731	1366	728	7	148	416	559	870	1252	1737	2268	2707	3780
Adults (ages 65 +)	2541	1459	643	13	299	598	751	1019	1367	1806	2287	2636	3338
All	26081	1193	702	4	80	286	423	690	1081	1561	2092	2477	3415

[a] Total tapwater is defined as "all water from the household tap consumed directly as a beverage or used to prepare foods and beverages."
* Value not reported due to insufficient number of observations.

Source: Ershow and Cantor, 1989.

Table 3-7. Total Tapwater Intake (mL/kg-day) for Both Sexes Combined[a]

Age (yr)	Number of Observations: Actual Count	Number of Observations: Weighted Count	Mean	SD	S.E. of Mean	1	5	10	25	50	75	90	95	99
< 0.5	182	201.2	52.4	53.2	3.9	*	0.0	0.0	14.8	37.8	66.1	128.3	155.6	*
0.5 - 0.9	221	243.2	36.2	29.2	2.0	*	0.0	0.0	15.3	32.2	48.1	69.4	102.9	*
1 - 3	1498	1687.7	46.8	28.1	0.7	2.7	11.8	17.8	27.2	41.4	60.4	82.1	101.6	140.6
4 - 6	1702	1923.9	37.9	21.8	0.5	3.4	10.3	14.9	21.9	33.3	48.7	69.3	81.1	103.4
7 - 10	2405	2742.4	26.9	15.3	0.3	2.2	7.4	10.3	16.0	24.0	35.5	47.3	55.2	70.5
11 - 14	2803	3146.9	20.2	11.6	0.2	1.5	4.9	7.5	11.9	18.1	26.2	35.7	41.9	55.0
15 - 19	2998	3677.9	16.4	9.6	0.2	1.0	3.9	5.7	9.6	14.8	21.5	29.0	35.0	46.3
20 - 44	7171	13444.5	18.6	10.7	0.1	1.6	4.9	7.1	11.2	16.8	23.7	32.2	38.4	53.4
45 - 64	4560	8300.4	22.0	10.8	0.2	4.4	8.0	10.3	14.7	20.2	27.2	35.5	42.1	57.8
65 - 74	1663	2740.2	21.9	9.9	0.2	4.6	8.7	10.9	15.1	20.2	27.2	35.2	40.6	51.6
75+	878	1401.8	21.6	9.5	0.3	3.8	8.8	10.7	15.0	20.5	27.1	33.9	38.6	47.2
Infants (ages < 1)	403	444.3	43.5	42.5	2.1	0.0	0.0	0.0	15.3	35.3	54.7	101.8	126.5	220.5
Children (ages 1-10)	5605	6354.1	35.5	22.9	0.3	2.7	8.3	12.5	19.6	30.5	46.0	64.4	79.4	113.9
Teens (ages 11-19)	5801	6824.9	18.2	10.8	0.1	1.2	4.3	6.5	10.6	16.3	23.6	32.3	38.9	52.6
Adults (ages 20-64)	11731	21744.9	19.9	10.8	0.1	2.2	5.9	8.0	12.4	18.2	25.3	33.7	40.0	54.8
Adults (ages 65+)	2541	4142.0	21.8	9.8	0.2	4.5	8.7	10.9	15.0	20.3	27.1	34.7	40.0	51.3
All	26081	39510.2	22.6	15.4	0.1	1.7	5.8	8.2	13.0	19.4	28.0	39.8	50.0	79.8

[a] Total tapwater is defined as "all water from the household tap consumed directly as a beverage or used to prepare foods and beverages."
* Value not reported due to insufficient number of observations.

Source: Ershow and Cantor, 1989.

Table 3-8. Summary of Tapwater Intake by Age

Age Group	Intake (mL/day)		Intake (mL/kg-day)	
	Mean	10th-90th Percentiles	Mean	10th-90th Percentiles
Infants (< 1 year)	302	0-649	43.5	0 - 100
Children (1-10)	736	286-1,294	35.5	12.5 - 64.4
Teens (11-19)	965	353-1,701	18.2	6.5 - 32.3
Adults (20 -64)	1,366	559-2,268	19.9	8.0 - 33.7
Adults (65+)	1,459	751-2,287	21.8	10.9 - 34.7
All ages	1,193	423-2,092	22.6	8.2 - 39.8

Source: Ershow and Cantor (1989)

Table 3-9. Total Tapwater Intake (as Percent of Total Water Intake) by Broad Age Category[a,b]

Age (yr)	Mean	Percentile Distribution								
		1	5	10	25	50	75	90	95	99
< 1	26	0	0	0	12	22	37	55	62	82
1-10	45	6	19	24	34	45	57	67	72	81
11-19	47	6	18	24	35	47	59	69	74	83
20-64	59	12	27	35	49	61	72	79	83	90
65+	65	25	41	47	58	67	74	81	84	90

[a] Does not include pregnant women, lactating women, or breast-fed children.
[b] Total tapwater is defined as "all water from the household tap consumed directly as a beverage or used to prepare foods and beverages."
0 = Less than 0.5 percent.

Source: Ershow and Cantor, 1989.

Table 3-10. General Dietary Sources of Tapwater for Both Sexes[a,b]

Age (yr)	Source	% of Tapwater							
		Mean	Standard Deviation	5	25	50	75	95	99
< 1	Food[c]	11	24	0	0	0	10	70	100
	Drinking Water	69	37	0	39	87	100	100	100
	Other Beverages	20	33	0	0	0	22	100	100
	All Sources	100							
1-10	Food[c]	15	16	0	5	10	19	44	100
	Drinking Water	65	25	0	52	70	84	96	100
	Other Beverages	20	21	0	0	15	32	63	93
	All Sources	100							
11-19	Food[c]	13	15	0	3	8	17	38	100
	Drinking Water	65	25	0	52	70	85	98	100
	Other Beverages	22	23	0	0	16	34	68	96
	All Sources	100							
20-64	Food[c]	8	10	0	2	5	11	25	49
	Drinking Water	47	26	0	29	48	67	91	100
	Other Beverages	45	26	0	25	44	63	91	100
	All Sources	100							
65+	Food[c]	8	9	0	2	5	11	23	38
	Drinking Water	50	23	0	36	52	66	87	99
	Other Beverages	42	23	3	27	40	57	85	100
	All Sources	100							
All	Food[c]	10	13	0	2	6	13	31	64
	Drinking Water	54	27	0	36	56	75	95	100
	Other Beverages	36	27	0	14	34	55	87	100
	All Sources	100							

[a] Does not include pregnant women, lactating women, or breast-fed children.
[b] Individual values may not add to totals due to rounding.
[c] Food category includes soups.
0 = Less than 0.5 percent.
Source: Ershow and Cantor, 1989.

Ershow and Cantor (1989) also presented data on total water intake and tapwater intake for children of various ages. They found, for infants and children between the ages of 6 months and 15 years, that the total water intake per unit body weight increased smoothly and sharply from 30 mL/kg-day above age 15 years to 190 mL/kg-day for ages less than 6 months. This probably represents metabolic requirements for water as a dietary constituent. However, they found that the intake of tapwater alone went up only slightly with decreasing age (from 20 to 45 mL/kg-day as age decreases from 11 years to less than 6 months). They attributed this small effect of age on tapwater intake to the large number of alternative water sources (besides tapwater) used for the younger age groups.

With respect to region of the country, the northeast states had slightly lower average tapwater intake (1,200 mL/day) than the three other regions (which were approximately equal at 1,400 mL/day).

This survey has an adequately large size (26,446 individuals) and it is a representative sample of the United States population with respect to age distribution, sex, racial composition, and residential location. It is therefore suitable as a description of national tapwater consumption.

The chief limitation of the study is that the data were collected in 1978 and do not reflect the expected increase in the consumption of soft drinks and bottled water or changes in the diet within the last 18 years. Since the data were collected for only a three-day period, the extrapolation to chronic intake is uncertain.

Roseberry and Burmaster - Lognormal Distributions for Water Intake - Roseberry and Burmaster (1992) fit lognormal distributions to the water intake data reported by Ershow and Cantor (1989) and estimated population-wide distributions for total fluid and total tapwater intake based on proportions of the population in each age group. Their publication shows the data and the fitted log-normal distributions graphically. The mean was estimated as the zero intercept, and the standard deviation was estimated as the slope of the best fit line for the natural logarithm of the intake rates plotted against their corresponding z-scores (Roseberry and Burmaster, 1992). Least squares techniques were used to estimate the best fit straight lines for the transformed data. Summary statistics for the best-fit lognormal distribution are presented in Table 3-11. In this table, the simulated balanced population represents an adjustment to account for the different age distribution of the United States population in 1988 from the age distribution in 1978 when Ershow and Cantor collected their data. Table 3-12 summarizes the quantiles and means of tapwater intake as estimated from the best-fit distributions. The mean total tapwater intake rates for the two adult populations (age 20 to 65 years, and 65+ years) were estimated to be 1.27 and 1.34 L/day.

These intake rates were based on the data originally presented by Ershow and Cantor (1989). Consequently, the same advantages and disadvantages associated with the Ershow and Cantor (1989) apply to this data set.

3.3. RELEVANT GENERAL POPULATION STUDIES ON DRINKING WATER INTAKE

Cantor et al. - National Cancer Institute Study - The National Cancer Institute (NCI), in a population-based, case control study investigating the possible relationship between bladder cancer and drinking water, interviewed approximately 8,000 adult white individuals, 21 to 84 years of age (2,805 cases and 5,258 controls) in their homes, using a standardized questionnaire (Cantor et al., 1987). The cases and controls resided in one of five metropolitan areas (Atlanta, Detroit, New Orleans, San Francisco, and Seattle) and five States (Connecticut, Iowa, New Jersey, New Mexico, and Utah). The individuals interviewed were asked to recall the level of intake of tapwater and other beverages in a typical week during the winter prior to the interview. Total beverage intake was divided into the following two components: 1) beverages derived from tapwater; and 2) beverages from other sources. Tapwater used in cooking foods and in ice cubes was apparently not considered. Participants also supplied information on the primary source of the water consumed (i.e., private well, community supply, bottled water, etc.). The control population was randomly selected from the general population and frequency matched to the bladder cancer case population in terms of age, sex, and geographic location of residence. The case population consisted of Whites only, had no people under the age of 21 years and 57 percent were over the age of 65 years. The fluid intake rates for the bladder cancer cases were not used because their participation in the study was based on selection factors that could bias the intake estimates for the general population. Based on responses from 5,258 White

Table 3-11. Summary Statistics for Best-Fit Lognormal Distributions for Water Intake Rates[a]

Group	ln Total Fluid Intake Rate μ	σ	R^2
0 < age < 1	6.979	0.291	0.996
1 ≤ age < 11	7.182	0.340	0.953
11 ≤ age < 20	7.490	0.347	0.966
20 ≤ age < 65	7.563	0.400	0.977
65 ≤ age	7.583	0.360	0.988
All ages	7.487	0.405	0.984
Simulated balanced population	7.492	0.407	1.000
Group	**ln Total Tapwater Intake μ**	**σ**	**R^2**
0 < age < 1	5.587	0.615	0.970
1 ≤ age < 11	6.429	0.498	0.984
11 ≤ age < 20	6.667	0.535	0.986
20 ≤ age < 65	7.023	0.489	0.956
65 ≤ age	7.088	0.476	0.978
All ages	6.870	0.530	0.978
Simulated balanced population	6.864	0.575	0.995

[a] These values were used in the following equations to estimate the quantiles and averages for total tapwater intake shown in Tables 3-12.

97.5 percentile intake rate = exp [μ + (1.96 $\cdot$ σ)]

75 percentile intake rate = exp [μ + (0.6745 $\cdot$ σ)]

50 percentile intake rate = exp [μ]

25 percentile intake rate = exp [μ - (0.6745 $\cdot$ σ)]

2.5 percentile intake rate = exp [μ - (1.96 $\cdot$ σ)]

Mean intake rate - exp [μ + 0.5 $\cdot$ σ^2)]

Source: Roseberry and Burmaster, 1992.

Table 3-12. Estimated Quantiles and Means for Total Tapwater Intake Rates (mL/day)[a]

Age Group (years)	Percentile 2.5	25	50	75	97.5	Arithmetic Average
0 < age < 1	80	176	267	404	891	323
1 ≤ age < 11	233	443	620	867	1,644	701
11 ≤ age < 20	275	548	786	1,128	2,243	907
20 ≤ age < 65	430	807	1,122	1,561	2,926	1,265
65 ≤ age	471	869	1,198	1,651	3,044	1,341
All ages	341	674	963	1,377	2,721	1,108
Simulated Balanced Population	310	649	957	1,411	2,954	1,129

[a] Total tapwater is defined as "all water from the household tap consumed directly as a beverage or used to prepare foods and beverages."

Source: Roseberry and Burmaster, 1992.

controls (3,892 males; 1,366 females), average tapwater intake rates for a "typical" week were compiled by sex, age group, and geographic region. These rates are listed in Table 3-13. The average total fluid intake rate was 2.01 L/day for men of which 70 percent (1.4 L/day) was derived from tapwater, and 1.72 L/day for women of which 79 percent (1.35 L/day) was derived from tapwater. Frequency distribution data for the 5,081 controls, for which the authors had information on both tapwater consumption and cigarette smoking habits, are presented in Table 3-14. These data follow a lognormal distribution having an average value of 1.30 L/day and an upper 90th percentile value of approximately 2.40 L/day. These values were determined by graphically interpolating the data of Table 3-14 after plotting it on log probability graph paper. These values represent the usual level of intake for this population of adults in the winter.

Table 3-13. Average Total Tapwater Intake Rate by Sex, Age, and Geographic Area

Group/Subgroup	Number of Respondents	Average Total Tapwater Intake,[a,b] L/day
Total group	5,258	1.39
Sex		
Males	3,892	1.40
Females	1,366	1.35
Age, years		
21-44	291	1.30
45-64	1,991	1.48
65-84	2,976	1.33
Geographic area		
Atlanta	207	1.39
Connecticut	844	1.37
Detroit	429	1.33
Iowa	743	1.61
New Jersey	1,542	1.27
New Mexico	165	1.49
New Orleans	112	1.61
San Francisco	621	1.36
Seattle	316	1.44
Utah	279	1.35

[a] Standard deviations not reported in Cantor et al. (1987).

[b] Total tapwater defined as all water and beverages derived from tapwater.

Source: Cantor et al., 1987.

Table 3-14. Frequency Distribution of Total Tapwater Intake Rates[a]

Consumption Rate (L/day)	Frequency[b] (%)	Cumulative Frequency[b] (%)
≤0.80	20.6	20.6
0.81-1.12	21.3	41.9
1.13-1.44	20.5	62.4
1.45-1.95	19.5	81.9
≥1.96	18.1	100.0

[a] Represents consumption of tapwater and beverages derived from tapwater in a "typical" winter week.
[b] Extracted from Table 3 in Cantor et al. (1987).

Source: Cantor, et al., 1987.

A limitation associated with this data set is that the population surveyed was older than the general population and consisted exclusively of Whites. Also, the intake data are based on recall of behavior from the winter previous to the interview. Extrapolation to other seasons and intake durations is difficult.

The authors presented data on person-years of residence with various types of water supply sources (municipal versus private, chlorinated versus nonchlorinated, and surface versus well water). Unfortunately, these data can not be used to draw conclusions about the National average apportionment of surface versus groundwater since a large fraction (24 percent) of municipal water intake in this survey could not be specifically attributed to either ground or surface water.

National Academy of Sciences-Drinking Water and Health - NAS (1977) calculated the average per capita water (liquid) consumption per day to be 1.63 L. This figure was based on a survey of the following literature sources: Evans (1941); Bourne and Kidder (1953); Walker et al. (1957); Wolf (1958); Guyton (1968); McNall and Schlegel (1968); Randall (1973); NAS (1974); and Pike and Brown (1975). Although the calculated average intake rate was 1.63 L per day, NAS (1977) adopted a larger rate (2 L per day) to represent the intake of the majority of water consumers. This value is relatively consistent with the total tapwater intakes rate estimated from the key studies presented previously. However, the use of the term "liquid" was not clearly defined in this study, and it is not known whether the populations surveyed are representative of the adult U.S. population. Consequently, the results of this study are of limited use in recommending total tapwater intake rates and this study is not considered a key study.

Pennington - Total Diet Study - Based on data from the U.S. Food and Drug Administration's (FDA's) Total Diet Study, Pennington (1983) reported average intake rates for various foods and beverages for five age groups of the population. The Total Diet Study is conducted annually to monitor the nutrient and contaminant content of the U.S. food supply and to evaluate trends in consumption. Representative diets were developed based on 24-hour recall and 2-day diary data from the 1977-1978 U.S. Department of Agriculture (USDA) Nationwide Food Consumption Survey (NFCS) and 24-hour recall data from the Second National Health and Nutrition Examination Survey (NHANES II). The number of participants in NFCS and NHANES II was approximately 30,000 and 20,000, respectively. The diets were developed to "approximate 90 percent or more of the weight of the foods usually consumed" (Pennington, 1983). The source of water (bottled water as distinguished from tapwater) was not stated in the Pennington study. For the purposes of this report, the consumption rates for the food categories defined by Pennington were used to calculate total fluid and total water intake rates for five age groups. Total water includes water, tea, coffee, soft drinks, and soups and frozen juices that are reconstituted with water. Reconstituted soups were assumed to be composed of 50 percent water, and juices were assumed to contain 75 percent water. Total fluids include total water in addition to milk, ready-to-use infant formula, milk-based soups, carbonated soft drinks, alcoholic beverages, and canned fruit juices. These intake rates are presented in Table 3-15. Based on the average intake rates for total water for

Table 3-15. Intake Rates of Total Fluids and Total Tapwater by Age Group

	Average Daily Consumption Rate (L/day)	
Age Group	Total Fluids[a]	Total Tapwater[b]
6-11 months	0.80	0.20
2 years	0.99	0.50
14-16 years	1.47	0.72
25-30 years	1.76	1.04
60-65 years	1.63	1.26

[a] Includes milk, "ready-to-use" formula, milk-based soup, carbonated soda, alcoholic beverages, canned juices, water, coffee, tea, reconstituted juices, and reconstituted soups. Does not include reconstituted infant formula.
[b] Includes water, coffee, tea, reconstituted juices, and reconstituted soups.

Source: Derived from Pennington, 1983.

the two adult age groups, 1.04 and 1.26 L/day, the average adult intake rate is about 1.15 L/day. These rates should be more representative of the amount of source-specific water consumed than are total fluid intake rates. Because this study was designed to measure food intake, and it used both USDA 1978 data and NHANES II data, there was not necessarily a systematic attempt to define tapwater intake per se, as distinguished from bottled water. For this reason, it is not considered a key tapwater study in this document.

USDA - Food and Nutrient Intakes by Individuals in the United States, 1 Day, 1989-91. - USDA (1995) collected data on the quantity of "plain drinking water" and various other beverages consumed by individuals in 1 day during 1989 through 1991. The data were collected as part of USDA's Continuing Survey of Food Intakes by Individuals (CSFII). The data used to estimate mean per capita intake rates combined one-day dietary recall data from 3 survey years: 1989, 1990, and 1991 during which 15,128 individuals supplied one-day intake data. Individuals from all income levels in the 48 conterminous states and Washington D.C. were included in the sample. A complex three-stage sampling design was employed and the overall response rate of for the study was 58 percent. To minimize the biasing effects of the low response rate and adjust for the seasonality a series of weighting factors was incorporated into the data analysis. The intake rates based on this study are presented in Table 3-16. Table 3-16 includes data for: a) "plain drinking water", which might be assumed to mean tapwater directly consumed rather than bottled water; b) coffee and tea, which might be assumed to be constituted from tapwater; and 3) fruit

Table 3-16 Mean Per Capita Drinking Water Intake Based on USDA, CSFII Data From 1989-91 (mL/day)

Sex and Age (years)	Plain Drinking Water	Coffee	Tea	Fruit Drinks and Ades[a]	Total
Males and Females:					
Under 1	194	0	< 0.5	17	211.5
1-2	333	< 0.5	9	85	427.5
3-5	409	2	26	100	537
5 & Under	359	1	17	86	463
Males:					
6-11	537	2	44	114	697
12-19	725	12	95	104	936
20-29	842	168	136	101	1,247
30-39	793	407	136	50	1,386
40-49	745	534	149	53	1,481
50-59	755	551	168	51	1,525
60-69	946	506	115	34	1,601
70-79	824	430	115	45	1,414
80 and over	747	326	165	57	1,295
20 and over	809	408	139	60	1,416
Females:					
6-11	476	1	40	86	603
12-19	604	21	87	87	799
20-29	739	154	120	61	1,074
30-39	732	317	136	59	1,244
40-49	781	412	174	36	1,403
50-59	819	438	137	37	1,431
60-69	829	429	124	36	1,418
70-79	772	324	161	34	1,291
80 and over	856	275	149	28	1,308
20 and over	774	327	141	46	1,288
All individuals	711	260	114	65	1,150

[a] Includes regular and low calorie fruit drinks, punches, and ades, including those made from powdered mix and frozen concentrate. Excludes fruit juices and carbonated drinks.

Source: USDA, 1995.

drinks and ades, which might be assumed to be reconstituted from tapwater rather than canned products; and 4) the total of the three sources. With these assumptions, the mean per capita total intake of water is estimated to be 1,416 mL/day for adult males (i.e., 20 years of age and older), 1,288 mL/day for adult females (i.e., 20 years of age and older) and 1,150 mL/day for all ages and both sexes combined. Although these assumptions appear reasonable, a close reading of the definitions used by USDA (1995) reveals that the word "tapwater" does not occur, and this uncertainty prevents the use of this study as a key study of tapwater intake.

The advantages of using these data are that; 1) the survey had a large sample size; 2) the authors attempted to represent the general United States population by oversampling low-income groups and by weighting the data to compensate for low response rates; and 3) it reflects more recent intake data than the key studies. The disadvantages are that: 1) the response rate was low; 2) the word "tapwater" was not defined and the assumptions that must be used in order to compare the data with the other tapwater studies might not be valid; 3) the data collection period reflects only a one-day intake period, and may not reflect long-term drinking water intake patterns; and 4) data on the percentiles of the distribution of intakes were not given.

Gillies and Paulin - New Zealand Study - Gillies and Paulin (1983) conducted a study to evaluate variability of mineral intake from drinking water. A study population of 109 adults (75 females; 34 males) ranging in age from 16 to 80 years (mean age = 44 years) in New Zealand was asked to collect duplicate samples of water consumed directly from the tap or used in beverage preparation during a 24-hour period. Participants were asked to collect the samples on a day when all of the water consumed would be from their own home. Individuals were selected based on their willingness to participate and their ability to comprehend the collection procedures. The mean total tapwater intake rate for this population was 1.25 ($\pm$0.39) L/day, and the 90th percentile rate was 1.90 L/day. The median total tapwater intake rate (1.26 L/day) was very similar to the mean intake rate (Gillies and Paulin, 1983). The reported range was 0.26 to 2.80 L/day.

The advantage of these data are that they were generated using duplicate sampling techniques. Because this approach is more objective than recall methods, it may result in more accurate response. However, these data are based on a short-term survey that may not be representative of long-term behavior, the population surveyed is small and the procedures for selecting the survey population were not designed to be representative of the New Zealand population, and the results may not be applicable to the United States. For these reasons the study is not regarded as a key study in this document.

Hopkins and Ellis - Drinking Water Consumption in Great Britain - A study conducted in Great Britain over a 6-week period during September and October 1978, estimated the drinking water consumption rates of 3,564 individuals from 1,320 households in England, Scotland, and Wales (Hopkins and Ellis, 1980). The participants were selected randomly and were asked to complete a questionnaire and a diary indicating the type and quantity of beverages consumed over a 1-week period. Total liquid intake included total tapwater taken at home and away from home; purchased alcoholic beverages; and non-tapwater-based drinks. Total tapwater included water content of tea, coffee, and other hot water drinks; homemade alcoholic beverages; and tapwater consumed directly as a beverage. The assumed tapwater contents for these beverages are presented in Table 3-17. Based on

Table 3-17. Assumed Tapwater Content of Beverages

Beverage	% Tapwater
Cold Water	100
Home-made Beer/Cider/Lager	100
Home-made Wine	100
Other Hot Water Drinks	100
Ground/Instant Coffee:[a]	
Black	100
White	80
Half Milk	50
All Milk	0
Tea	80
Hot Milk	0
Cocoa/Other Hot Milk Drinks	0
Water-based Fruit Drink	75
Fizzy Drinks	0
Fruit Juice 1[b]	0
Fruit Juice 2[b]	75
Milk	0
Mineral Water[c]	0
Bought cider/beer/lager	0
Bought Wine	0

[a] Black - coffee with all water, milk not added; White - coffee with 80% water, 20% milk;
Half Milk - coffee with 50% water, 50% milk; All Milk - coffee with all milk, water not added;

[b] Fruit juice: individuals were asked in the questionnaire if they consumed ready-made fruit juice (type 1 above), or the variety that is diluted (type 2);

[c] Information on volume of mineral water consumed was obtained only as "number of bottles per week." A bottle was estimated at 500 mL, and the volume was split so that 2/7 was assumed to be consumed on weekends, and 5/7 during the week.

Source: Hopkins and Ellis, 1980.

responses from 3,564 participants, the mean intake rates and frequency distribution data for various beverage categories were estimated by Hopkins and Ellis (1980). These data are listed in Table 3-18. The mean per capita total liquid intake rate for all individuals surveyed was 1.59 L/day, and the mean per capita total tapwater intake rate was 0.95 L/day, with a 90th percentile value of about 1.3 L/day (which is the value of the percentile for the home tapwater alone in Table 3-18). Liquid intake rates were also estimated for males and females in various age groups. Table 3-19 summarizes the total liquid and total tapwater intake rates for 1,758 males and 1,800 females grouped into six age categories (Hopkins and Ellis, 1980). The mean and 90th percentile intake values for adults over age 18 years are, respectively, 1.07 L/day and 1.87 L/day, as determined by pooling data for males and females for the three adult age ranges in Table 3-19. This calculation assumes, as does Table 3-18 and 3-19, that the underlying distribution is normal and not lognormal.

The advantage of using these data is that the responses were not generated on a recall basis, but by recording daily intake in diaries. The latter approach may result in more accurate responses being generated. Also, the use of total liquid and total tapwater was well defined in this study. However, the relatively short-term nature of the survey make extrapolation to long-term consumption patterns difficult. Also, these data were based on the population of Great Britain and not the United States. Drinking patterns may differ among these populations as a result of varying weather conditions and socio-economic factors. For these reasons this study is not considered a key study in this document.

U.S. EPA - Office of Radiation Programs - Using data collected by USDA in the 1977-78 NFCS, U.S. EPA (1984) determined daily food and beverage intake levels by age to be used in assessing radionuclide intake through food consumption. Tapwater, water-based drinks, and soups were identified subcategories of the total beverage category. Daily intake rates for tapwater, water-based drinks, soup, and total beverage are presented in Table 3-20. As seen in Table 3-20, mean tapwater intake for different adult age groups (age 20 years and older) ranged from 0.62 to 0.76 L/day, water-based drinks intake ranged from 0.34 to 0.69 L/day, soup intake ranged from 0.03 to 0.06 L/day, and mean total beverage intake levels ranged from 1.48 to 1.73 L/day. Total tapwater intake rates were estimated by combining the average daily intakes of tapwater, water-based drinks, and soups for each age group. For adults (ages 20 years and older), mean total tapwater intake rates range from 1.04 to 1.47 L/day, and for children (ages <1 to 19 years), mean intake rates range from 0.19 to 0.90 L/day. These intake rates do not include reconstituted infant formula. The total tapwater intake rates, derived by combining data on tapwater, water-based drinks, and soup should be more representative of source-specific drinking water intake than the total beverage intake rates reported in this study. These intake rates are based on the same USDA NFCS data used in Ershow and Cantor (1989). Therefore, the data limitations discussed previously also apply to this study.

International Commission on Radiological Protection - Reference Man - Data on fluid intake levels have also been summarized by the International Commission on Radiological Protection (ICRP) in the Report of the Task Group on Reference Man (ICRP, 1981). These intake levels for adults and children are summarized in Table 3-21. The amount of drinking water (tapwater and water-based drinks) consumed by adults ranged from about 0.37 L/day to about 2.18 L/day under "normal" conditions. The levels for children ranged from 0.54 to 0.79 L/day. Because the populations, survey design, and intake categories are not clearly defined, this study has limited usefulness in developing recommended intake rates for use in exposure assessment. It is reported here as a relevant study because the findings, although poorly defined, are consistent with the results of other studies.

National Human Activity Pattern Survey (NHAPS) - The U.S. EPA collected information on the number of glasses of drinking water and juice reconstituted with tapwater consumed by the general population as part of the National Human Activity Pattern Survey (Tsang and Klepeis, 1996). NHAPS was conducted between October 1992 and September 1994. Over 9,000 individuals in the 48 contiguous United States provided data on the duration and frequency of selected activities and the time spent in selected microenvironments via 24-hour diaries. Over 4,000 NHAPS respondents also provided information of the number of 8-ounce glasses of water and the number of 8-ounce glasses of juice reconstituted with water than they drank during the 24-hour survey period (Tables 3-22 and 3-23). The median number of glasses of tapwater consumed was 1-2 and the median number of glasses of juice with tapwater consumed was 1-2.

Table 3-18. Intake of Total Liquid, Total Tapwater, and Various Beverages (L/day)

Beverage	All Individuals					Consumers Only[a]			
	Mean Intake	Approx. Std. Error of Mean	Approx. 95% Confidence Interval for Mean	10 and 90 Percentiles	1 and 99 Percentiles	Percentage of Total Number of Individuals	Mean Intake	Approx. Std. Error of Mean	Approx. 95% Confidence Interval for Mean
Total Liquid	1.589	0.0203	1.547-1.629	0.77-2.57	0.34-4.50	100.0	1.589	0.0203	1.547-1.629
Total Liquid Home	1.104	0.0143	1.075-1.133	0.49-1.79	0.23-3.10	100.0	1.104	0.0143	1.075-1.133
Total Liquid Away	0.484	0.0152	0.454-0.514	0.00-1.15	0.00-2.89	89.9	0.539	0.0163	0.506-0.572
Total Tapwater	0.955	0.0129	0.929-0.981	0.39-1.57	0.10-2.60	99.8	0.958	0.0129	0.932-0.984
Total Tapwater Home	0.754	0.0116	0.731-0.777	0.26-1.31	0.02-2.30	99.4	0.759	0.0116	0.736-0.782
Total Tapwater Away	0.201	0.0056	0.190-0.212	0.00-0.49	0.00-0.96	79.6	0.253	0.0063	0.240-0.266
Tea	0.584	0.0122	0.560-0.608	0.01-1.19	0.00-2.03	90.9	0.643	0.0125	0.618-0.668
Coffee	0.190	0.0059	0.178-0.202	0.00-0.56	0.00-1.27	63.0	0.302	0.0105	0.281-0.323
Other Hot Water Drinks	0.011	0.0015	0.008-0.014	0.00-0.00	0.00-0.25	9.2	0.120	0.0133	0.093-0.147
Cold Water	0.103	0.0049	0.093-0.113	0.00-0.31	0.00-0.85	51.0	0.203	0.0083	0.186-0.220
Fruit Drinks	0.057	0.0027	0.052-0.062	0.00-0.19	0.00-0.49	46.2	0.123	0.0049	0.113-0.133
Non Tapwater	0.427	0.0058	0.415-0.439	0.20-0.70	0.06-1.27	99.8	0.428	0.0058	0.416-0.440
Home-brew	0.010	0.0017	0.007-0.013	0.00-0.00	0.00-0.20	7.0	0.138	0.0209	0.096-0.180
Bought Alcoholic Beverages	0.206	0.0123	0.181-0.231	0.00-0.68	0.00-2.33	43.5	0.474	0.0250	0.424-0.524

[a] Consumers only is defined as only those individuals who reported consuming the beverage during the survey period.
Source: Hopkin and Ellis, 1980.

Table 3-19. Summary of Total Liquid and Total Tapwater Intake for Males and Females (L/day)

Beverage	Age Group (years)	Number		Mean Intake		Approx. Std. Error of Mean		Approx 95% Confidence Interval for Mean		10 and 90 Percentiles	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Total Liquid Intake	1-4	88	75	0.853	0.888	0.0557	0.0660	0.742-0.964	0.756-1.020	0.38-1.51	0.39-1.48
	5-11	249	201	0.986	0.902	0.0296	0.0306	0.917-1.045	0.841-0.963	0.54-1.48	0.51-1.39
	12-17	180	169	1.401	1.198	0.0619	0.0429	1.277-1.525	1.112-1.284	0.75-2.27	0.65-1.74
	18-30	333	350	2.184	1.547	0.0691	0.0392	2.046-2.322	1.469-1.625	1.12-3.49	0.93-2.30
	31-54	512	551	2.112	1.601	0.0526	0.0215	2.007-2.217	1.558-1.694	1.15-3.27	0.95-2.36
	55+	396	454	1.830	1.482	0.0498	0.0356	1.730-1.930	1.411-1.553	1.03-2.77	0.84-2.17
Total Tapwater Intake	1-4	88	75	0.477	0.464	0.0403	0.0453	0.396-0.558	0.373-0.555	0.17-0.85	0.15-0.89
	5-11	249	201	0.550	0.533	0.0223	0.0239	0.505-0.595	0.485-0.581	0.22-0.90	0.22-0.93
	12-17	180	169	0.805	0.725	0.0372	0.0328	0.731-0.8790	0.659-0.791	0.29-1.35	0.31-1.16
	18-30	333	350	1.006	0.991	0.0363	0.0304	0.933-1.079	0.930-1.052	0.45-1.62	0.50-1.55
	31-54	512	551	1.201	1.091	0.0309	0.0240	1.139-1.263	1.043-1.139	0.64-1.88	0.62-1.68
	55+	396	454	1.133	1.027	0.0347	0.0273	1.064-1.202	0.972-1.082	0.62-1.72	0.54-1.57

Source: Hopkin and Ellis, 1980.

Table 3-20. Mean and Standard Error for the Daily Intake of Beverages and Tapwater by Age

Age (years)	Tapwater Intake (mL)	Water-Based Drinks (mL)[a]	Soups (mL)	Total Beverage Intake[b] (mL)
All ages	662.5 ± 9.9	457.1 ± 6.7	45.9 ± 1.2	1434.0 ± 13.7
Under 1	170.7 ± 64.5	8.3 ± 43.7	10.1 ± 7.9	307.0 ± 89.2
1 to 4	434.6 ± 31.4	97.9 ± 21.5	43.8 ± 3.9	743.0 ± 43.5
5 to 9	521.0 ± 26.4	116.5 ± 18.0	36.6 ± 3.2	861.0 ± 36.5
10 to 14	620.2 ± 24.7	140.0 ± 16.9	35.4 ± 3.0	1025.0 ± 34.2
15 to 19	664.7 ± 26.0	201.5 ± 17.7	34.8 ± 3.2	1241.0 ± 35.9
20 to 24	656.4 ± 33.9	343.1 ± 23.1	38.9 ± 4.2	1484.0 ± 46.9
25 to 29	619.8 ± 34.6	441.6 ± 23.6	41.3 ± 4.2	1531.0 ± 48.0
30 to 39	636.5 ± 27.2	601.0 ± 18.6	40.6 ± 3.3	1642.0 ± 37.7
40 to 59	735.3 ± 21.1	686.5 ± 14.4	51.6 ± 2.6	1732.0 ± 29.3
60 and over	762.5 ± 23.7	561.1 ± 16.2	59.4 ± 2.9	1547.0 ± 32.8

[a] Includes water-based drinks such as coffee, etc. Reconstituted infant formula does not appear to be included in this group.
[b] Includes tapwater and water-based drinks such as coffee, tea, soups, and other drinks such as soft drinks, fruitades, and alcoholic drinks.

Source: U.S. EPA, 1984.

Table 3-21. Measured Fluid Intakes (mL/day)

Subject	Total Fluids	Milk	Tapwater	Water-Based Drinks[a]
Adults ("normal" conditions)[b]	1000-2400	120-450	45-730	320-1450
Adults (high environmental temperature to 32°C)	2840-3410 3256 ± SD = 900			
Adults (moderately active)	3700			
Children (5-14 yr)	1000-1200	330-500	ca. 200	ca. 380
	1310-1670	540-650	540-790	

[a] Includes tea, coffee, soft drinks, beer, cider, wine, etc.
[b] "Normal" conditions refer to typical environmental temperature and activity levels.
Source: ICRP, 1981.

Table 3-22. Number of Glasses of Tapwater Consumed in 24-Hour Period

	Number of Respondents							
	All	None	1-2	3-5	6-9	10-19	20+	DK
Overall	4,663	1,334	1,225	1,253	500	151	31	138
Gender								
Male	2,163	604	582	569	216	87	25	65
Female	2,498	728	643	684	284	64	6	73
Ref	2	2	•	•	•	•	•	•
Age								
1-4	263	114	96	40	7	1	0	5
5-11	348	90	127	86	15	7	2	20
12-17	326	86	109	88	22	7	•	11
18-64	2,972	908	751	769	334	115	26	54
> 64	670	117	127	243	112	20	2	42
Race								
White	3,774	1,048	1,024	1,026	416	123	25	92
Black	463	147	113	129	38	9	1	21
Asian	77	25	18	23	6	1	•	4
Some Others	96	36	18	22	6	7	2	5
Hispanic	193	63	42	40	28	10	2	7
Ref	60	15	10	13	6	1	1	9
Hispanic								
No	4,244	1,202	1,134	1,162	451	129	26	116
Yes	347	116	80	73	41	18	4	13
DK	26	5	6	7	4	3	•	1
Ref	46	11	5	11	4	1	1	8
Employment								
Fulltime	2,017	637	525	497	218	72	18	40
Part-time	379	90	94	120	50	13	7	5
Not Employed	1,309	313	275	413	188	49	3	54
Ref	32	6	4	11	1	2	1	4
Education								
< High School	399	89	95	118	51	14	2	28
High School Grad	1,253	364	315	330	132	52	13	37
< College	895	258	197	275	118	31	5	9
College Grad	650	195	157	181	82	19	4	6
Post Grad	445	127	109	113	62	16	3	12
Census Region								
Northeast	1,048	351	262	266	95	32	7	28
Midwest	1,036	243	285	308	127	26	9	33
South	1,601	450	437	408	165	62	11	57
West	978	290	241	271	113	31	4	20
Day of Week								
Weekday	3,156	864	840	862	334	96	27	106
Weekend	1,507	470	385	391	166	55	4	32
Season								
Winter	1,264	398	321	336	128	45	5	26
Spring	1,181	337	282	339	127	33	10	40
Summer	1,275	352	323	344	155	41	9	40
Fall	943	247	299	234	90	32	7	32
Asthma								
No	4,287	1,232	1,137	1,155	459	134	29	115
Yes	341	96	83	91	40	16	1	13
DK	35	6	5	7	1	1	1	10
Angina								
No	4,500	1,308	1,195	1,206	470	143	29	123
Yes	125	18	25	40	27	6	1	6
DK	38	8	5	7	3	2	1	9
Bronchitis/Emphyszema								
No	4,424	1,280	1,161	1,189	474	142	29	124
Yes	203	48	55	58	24	9	1	5
DK	36	6	9	6	2	•	1	9

NOTE: "•" = Missing Data
"DK" = Don't know
N = sample size
Ref = refused
Source: Tsang and Kleipeis, 1996

Table 3-23. Number of Glasses of Juice Reconstituted with Tapwater Consumed in 24-Hour Period

	Number of Respondents							
	All	None	1-2	3-5	6-9	10-19	20+	DK
Overall	4,663	1,877	1,418	933	241	73	21	66
Gender								
Male	2,163	897	590	451	124	35	17	33
Female	2,498	980	826	482	117	38	4	33
Ref	2	•	2	•	•	•	•	•
Age								
1-4	263	126	71	48	11	4	1	2
5-11	348	123	140	58	12	2	1	11
12-17	326	112	118	63	18	7	1	4
18-64	2,972	1,277	817	614	155	46	16	30
> 64	670	206	252	133	43	12	2	14
Race								
White	3,774	1,479	1,168	774	216	57	16	44
Black	463	200	142	83	15	9	1	7
Asian	77	33	27	15	1	•	•	0
Some Others	96	46	19	24	2	1	3	1
Hispanic	193	95	51	30	5	5	1	5
Ref	60	24	11	7	2	1	•	9
Hispanic								
No	4,244	1,681	1,318	863	226	64	17	49
Yes	347	165	87	61	14	7	4	7
DK	26	11	6	5	•	1	•	3
Ref	46	20	7	4	1	1	•	7
Employment								
Fulltime	2,017	871	559	412	103	32	9	20
Part-time	379	156	102	88	19	7	2	5
Not Employed	1,309	479	426	265	75	20	7	21
Ref	32	15	4	4	2	1	•	3
Education								
< High School	399	146	131	82	25	7	2	4
High School Grad	1,253	520	355	254	68	21	7	17
< College	895	367	253	192	47	18	5	11
College Grad	650	274	201	125	31	7	1	5
Post Grad	445	182	130	92	26	5	3	4
Census Region								
Northeast	1,048	440	297	220	51	13	4	15
Midwest	1,036	396	337	200	63	17	4	14
South	1,601	593	516	332	84	26	10	28
West	978	448	268	181	43	17	3	9
Day of Week								
Weekday	3,156	1,261	969	616	162	51	11	46
Weekend	1,507	616	449	307	79	22	10	20
Season								
Winter	1,264	529	382	245	66	23	4	10
Spring	1,181	473	382	215	54	19	8	17
Summer	1,275	490	389	263	68	18	6	28
Fall	943	385	265	210	53	13	3	11
Asthma								
No	4,287	1,734	1,313	853	216	69	20	55
Yes	341	130	102	74	25	3	1	5
DK	35	13	3	6	•	1	•	6
Angina								
No	4,500	1,834	1,362	900	231	67	20	59
Yes	125	31	53	25	7	5	1	1
DK	38	12	3	8	3	1	•	6
Bronchitis/Emphyszema								
No	4,424	1,782	1,361	882	230	65	21	57
Yes	203	84	53	44	10	6	•	3
DK	36	11	4	7	1	2	•	6

NOTE: "•" = Missing Data
"DK" = Don't know
N = sample size
Ref = refused
Source: Tsang and Klepeis, 1996

For both individuals who drank tapwater and individuals who drank juices reconstituted with tapwater, the number of glasses ranged from 1 to 20. The highest percentage of the population (37.1 percent) who drank tapwater consumed 3-5 glasses and the highest percentage of the population (51.5 percent) who consumed juice reconstituted with tapwater drank 1-2 glasses. Based on the assumption that each glass contained 8 ounces of water (226.4 mL), the total volume of tapwater and juice with tapwater consumed would range from 0.23 L/day (1 glass) to 4.5 L/day (20 glasses) for respondents who drank tapwater. Using the same assumption, the volume of tapwater consumed for the population who consumed 3-5 glasses would be 0.68 L/day to 1.13 L/day and the volume of juice with tapwater consumed for the population who consumed 1-2 glasses would be 0.23 L/day to 0.46 L/day. Assuming that the average individual consumes 3-5 glasses of tapwater plus 1-2 glasses of juice with tapwater, the range of total tapwater intake for this individual would range from 0.9 L/day to 1.64 L/day. These values are consistent with the average intake rates observed in other studies.

The advantages of NHAPS is that the data were collected for a large number of individuals and that the data are representative of the U.S. population. However, evaluation of drinking water intake rates was not the primary purpose of the study and the data do not reflect the total volume of tapwater consumed. However, using the assumptions described above, the estimated drinking water intake rates from this study are within the same ranges observed for other drinking water studies.

AIHC Exposure Factors Handbook - The Exposure Factors Sourcebook (AIHC, 1994) presented drinking water intake rate recommendations for adults. Although AIHC (1994) provided little information on the studies used to derive mean and upper percentile recommendations, the references indicate that several of the studies used were the same as ones categorized as relevant studies in this Handbook. The mean adult drinking water recommendations in AIHC (1994) and this Handbook are in agreement. However, the upper percentile value recommended by AIHC (1994) (2.0 L/day) is slightly lower than that recommended by this Handbook (2.4 L/day). Based on data provided by Ershow and Cantor (1989), 2.0 L/day corresponds to only approximately the 84th percentile of the drinking water intake rate distribution. Thus, a slightly higher value is appropriate for representing the upper percentile (i.e., 90 to 95th percentile) of the distribution. AIHC (1994) also presents simulated distributions of drinking water intake based on Roseberry and Burmaster (1992). These distributions are also described in detail in Section 3.2 of this Handbook. AIHC (1994) has been classified as a relevant rather than a key study because it is not the primary source for the data used to make recommendations for this document.

3.4. PREGNANT AND LACTATING WOMEN

Ershow et al., 1991 - Intake of Tapwater and Total Water by Pregnant and Lactating Women - Ershow et al. (1991) used data from the 1977-78 USDA NFCS to estimate total fluid and total tapwater intake among pregnant and lactating women (ages 15 to 49 years). Data for 188 pregnant women, 77 lactating women, and 6,201 non-pregnant, non-lactating control women were evaluated. The participants were interviewed based on 24 hour recall, and then asked to record a food diary for the next 2 days. "Tapwater" included tapwater consumed directly as a beverage and tapwater used to prepare food and tapwater-based beverages. "Total water" was defined as all water from tapwater and non-tapwater sources, including water contained in food. Estimated total fluid and total tapwater intake rates for the three groups are presented in Tables 3-24 and 3-25, respectively. Lactating women had the highest mean total fluid intake rate (2.24 L/day) compared with both pregnant women (2.08 L/day) and control women (1.94 L/day). Lactating women also had a higher mean total tapwater intake rate (1.31 L/day) than pregnant women (1.19 L/day) and control women (1.16 L/day). The tapwater distributions are neither normal nor lognormal, but lactating women had a higher mean tapwater intake than controls and pregnant women. Ershow et al. (1991) also reported that rural women (n = 1,885) consumed more total water (1.99 L/day) and tapwater (1.24 L/day) than urban/suburban women (n = 4,581, 1.93 and 1.13 L/day, respectively). Totalwater and tapwater intake rates were lowest in the northeastern region of the United States (1.82 and 1.03 L/day) andhighest in the western region of the United States (2.06 L/day and 1.21 L/day). Mean intake per unit body weight was highest among lactating women for both total fluid and total tapwater intake. Total tapwater intake accounted for over 50 percent of mean total fluid in all three groups of women (Table 3-25). Drinking water accounted for the largest single proportion of the total fluid intake for control (30 percent), pregnant (34 percent), and lactating women (30 percent) (Table 3-26). All other beverages combined accounted for approximately 46 percent, 43 percent, and 45 percent of the total water intake for control, pregnant, and lactating

Table 3-24. Total Fluid Intake of Women 15-49 Years Old

Reproductive Status[a]	Mean	Standard Division	Percentile Distribution 5	10	25	50	75	90	95
mL/day									
Control	1940	686	995	1172	1467	1835	2305	2831	3186
Pregnant	2076	743	1085	1236	1553	1928	2444	3028	3475
Lactating	2242	658	1185	1434	1833	2164	2658	3169	3353
mL/kg/day									
Control	32.3	12.3	15.8	18.5	23.8	30.5	38.7	48.4	55.4
Pregnant	32.1	11.8	16.4	17.8	22.8	30.5	40.4	48.9	53.5
Lactating	37.0	11.6	19.6	21.8	28.4	35.1	45.0	53.7	59.2

[a] Number of observations: nonpregnant, nonlactating controls (n = 6,201); pregnant (n = 188); lactating (n = 77).
Source: Ershow et al., 1991.

Table 3-25. Total Tapwater Intake of Women 15-49 Years Old

Reproductive Status[a]	Mean	Standard Deviation	Percentile Distribution						
			5	10	25	50	75	90	95
mL/day									
Control	1157	635	310	453	709	1065	1503	1983	2310
Pregnant	1189	699	274	419	713	1063	1501	2191	2424
Lactating	1310	591	430	612	855	1330	1693	1945	2191
mL/kg/day									
Control	19.1	10.8	5.2	7.5	11.7	17.3	24.4	33.1	39.1
Pregnant	18.3	10.4	4.9	5.9	10.7	16.4	23.8	34.5	39.6
Lactating	21.4	9.8	7.4	9.8	14.8	20.5	26.8	35.1	37.4
Fraction of daily fluid intake that is tapwater (%)									
Control	57.2	18.0	24.6	32.2	45.9	59.0	70.7	79.0	83.2
Pregnant	54.1	18.2	21.2	27.9	42.9	54.8	67.6	76.6	83.2
Lactating	57.0	15.8	27.4	38.0	49.5	58.1	65.9	76.4	80.5

[a] Number of observations: nonpregnant, nonlactating controls (n = 6,201); pregnant (n = 188); lactating (n = 77).
Source: Ershow et al., 1991.

Table 3-26. Total Fluid (mL/Day) Derived from Various Dietary Sources by Women Aged 15-49 Years[a]

	Control Women			Pregnant Women			Lactating Women		
		Percentile			Percentile			Percentile	
Sources	Mean[b]	50	95	Mean[b]	50	95	Mean[b]	50	95
Drinking Water	583	480	1440	695	640	1760	677	560	1600
Milk and Milk Drinks	162	107	523	308	273	749	306	285	820
Other Dairy Products	23	8	93	24	9	93	36	27	113
Meats, Poultry, Fish, Eggs	126	114	263	121	104	252	133	117	256
Legumes, Nuts, and Seeds	13	0	77	18	0	88	15	0	72
Grains and Grain Products	90	65	257	98	69	246	119	82	387
Citrus and Noncitrus Fruit Juices	57	0	234	69	0	280	64	0	219
Fruits, Potatoes, Vegetables, Tomatoes	198	171	459	212	185	486	245	197	582
Fats, Oils, Dressings, Sugars, Sweets	9	3	41	9	3	40	10	6	50
Tea	148	0	630	132	0	617	253	77	848
Coffee and Coffee Substitutes	291	159	1045	197	0	955	205	80	955
Carbonated Soft Drinks[c]	174	110	590	130	73	464	117	57	440
Noncarbonated Soft Drinks[c]	38	0	222	48	0	257	38	0	222
Beer	17	0	110	7	0	0	17	0	147
Wine Spirits, Liqueurs, Mixed Drinks	10	0	66	5	0	25	6	0	59
All Sources	1940	NA	NA	2076	NA	NA	2242	NA	NA

[a] Number of observations: nonpregnant, nonlactating controls (n = 6,201); pregnant (n = 188); lactating (n = 77).
[b] Individual means may not add to all-sources total due to rounding.
[c] Includes regular, low-calorie, and noncalorie soft drinks.
NA: Not appropriate to sum the columns for the 50th and 95th percentiles of intake.
Source: Ershow et al., 1991.

women, respectively. Food accounted for the remaining portion of total water intake.

The same advantages and limitations associated with the Ershow and Cantor (1989) data also apply to these data sets (Section 3.2). A further advantage of this study is that it provides information on estimates of total water and tapwater intake rates for pregnant and lactating women. This topic has rarely been addressed in the literature.

3.5. HIGH ACTIVITY LEVELS/ HOT CLIMATES

McNall and Schlegel, 1968 - Practical Thermal Environmental Limits for Young Adult Males Working in Hot, Humid Environments - McNall and Schlegel (1968) conducted a study that evaluated the physiological tolerance of adult males working under varying degrees of physical activity. Subjects were required to pedal pedal-driven propeller fans for 8-hour work cycles under varying environmental conditions. The activity pattern for each individual was: cycled at 15 minute pedalling and 15 miute rest for each 8-hour period. Two groups of eight subjects each were used. Work rates were divided into three categories as follows: high activity level [0.15 horsepower (hp) per person], medium activity level (0.1 hp per person), and low activity level (0.05 hp per person). Evidence of physical stress (i.e., increased body temperature, blood pressure, etc.) was recorded, and individuals were eliminated from further testing if certain stress criteria were met. The amount of water consumed by the test subjects during the work cycles was also recorded. Water was provided to the individuals on request. The water intake rates obtained at the three different activity levels and the various environmental temperatures are presented in Table 3-27. The data presented are for test subjects with continuous data only (i.e., those test subjects who were not eliminated at any stage of the study as a result of stress conditions). Water intake was the highest at all activity levels when environmental temperatures were increased. The highest intake rate was observed at the low activity level at 100°F (0.65 L/hour) however, there were no data for higher activity levels at 100°F. It should be noted that this study estimated intake on an hourly basis during various levels of physical activity. These hourly intake rates cannot be converted to daily intake rates by multiplying by 24 hours/day because they are only representative of intake during the specified activity levels and the intake rates for the rest of the day are not known. Therefore, comparison of intake rate values from this study cannot be made with values from the previously described studies on drinking water intake.

Table 3-27. Water Intake at Various Activity Levels (L/hr)[a]

Room Temperature[b] (°F)	Activity Level					
	High (0.15 hp/man)[c]		Medium (0.10 hp/man)[c]		Low (0.05 hp/man)[c]	
	No.[d]	Intake	No.	Intake	No.	Intake
100	--	--	--	--	15	0.653 (0.75)
95	18	0.540 (0.31)	12	0.345 (0.59)	6	0.50 (0.31)
90	7	0.286 (0.26)	7	0.385 (0.26)	16	0.23 (0.20)
85	7	0.218 (0.36)	16	0.213 (0.20)	--	--
80	16	0.222 (0.14)	--	--	--	--

[a] Data expressed as mean intake with standard deviation in parentheses.
[b] Humidity = 80 percent; air velocity = 60 ft/min.
[c] The symbol "hp" refers to horsepower.
[d] Number of subjects with continuous data.
Source: McNall and Schlegel, 1968.

United States Army - Water Consumption Planning Factors Study - The U.S. Army has developed water consumption planning factors to enable them to transport an adequate amount of water to soldiers in the field under various conditions (U.S. Army, 1983). Both climate and activity levels were used to determine the appropriate water consumption needs. Consumption factors have been established for the following uses: 1) drinking, 2) heat treatment, 3) personal hygiene, 4) centralized hygiene, 5) food preparation, 6) laundry, 7) medical treatment, 8) vehicle and aircraft maintenance, 9) graves registration, and 10) construction. Only personal drinking water consumption factors are described here.

Drinking water consumption planning factors are based on the estimated amount of water needed to replace fluids lost by urination, perspiration, and respiration. It assumes that water lost to urinary output averages one quart/day (0.9 L/day) and perspiration losses range from almost nothing in a controlled environment to 1.5 quarts/day (1.4 L/day) in a very hot climate where individuals are performing strenuous work. Water losses to respiration are typically very low except in extreme cold where water losses can range from 1 to 3 quarts/day (0.9 to 2.8 L/day). This occurs when the humidity of inhaled air is near zero, but expired air is 98 percent saturated at body temperature (U.S. Army, 1983). Drinking water is defined by the U.S. Army (1983) as "all fluids consumed by individuals to satisfy body needs for internal water." This includes soups, hot and cold drinks, and tapwater. Planning factors have been established for hot, temperate, and cold climates based on the following mixture of activities among the work force: 15 percent of the force performing light work, 65 percent of the force performing medium work, and 20 percent of the force performing heavy work. Hot climates are defined as tropical and arid areas where the temperature is greater than 80°F. Temperate climates are defined as areas where the mean daily temperature ranges from 32°F to 80°F. Cold regions are areas where the mean daily temperature is less than 32°F. Drinking water consumption factors for these three climates are presented in Table 3-28. These factors are based on research on individuals and small unit training exercises. The estimates are assumed to be conservative because they are rounded up to account for the subjective nature of the activity mix and minor water losses that are not considered (U.S. Army, 1983). The advantage of using these data is that they provide a conservative estimate of drinking water intake among individuals performing at various levels of physical activity in hot, temperate, and cold climates. However, the planning factors described here are based on assumptions about water loss from urination, perspiration, and respiration, and are not based on survey data or actual measurements.

Table 3-28. Planning Factors for Individual Tapwater Consumption

Environmental Condition	Recommended Planning Factor (gal/day)[a]	Recommended Planning Factor (L/day)[a,b]
Hot	3.0[c]	11.4
Temperate	1.5[d]	5.7
Cold	2.0[e]	7.6

[a] Based on a mix of activities among the work force as follows: 15% light work; 65% medium work; 20% heavy work. These factors apply to the conventional battlefield where no nuclear, biological, or chemical weapons are used.
[b] Converted from gal/day to L/day.
[c] This assumes 1 quart/12-hour rest period/man for perspiration losses and 1 quart/day/man for urination plus 6 quarts/12-hours light work/man, 9 quarts/12-hours moderate work/man, and 12 quarts/12-hours heavy work/man.
[d] This assumes 1 quart/12-hour rest period/man for perspiration losses and 1 quart/day/man for urination plus 1 quart/12-hours light work/man, 3 quarts/12-hours moderate work/man, and 6 quarts/12-hours heavy work/man.
[e] This assumes 1 quart/12-hour rest period/man for perspiration losses, 1 quart/day/man for urination, and 2 quarts/day/man for respiration losses plus 1 quart/12-hours light work/man, 3 quarts/12-hours moderate work/man, and 6 quarts/6-hours heavy work/man.

3.6. RECOMMENDATIONS

The key studies described in this section were used in selecting recommended drinking water (tapwater) consumption rates for adults and children. The studies on other subpopulations were not classified as key versus relevant. Although different survey designs and populations were utilized by key and relevant studies described in this report, the mean and upper-percentile estimates reported in these studies are reasonably similar. The general design of both key and relevant studies and their limitations are summarized in Table 3-29. It should be noted that studies that surveyed large representative samples of the population provide more reliable estimates of intake rates for the general population. Most of the surveys described here are based on short-term recall which may be biased toward excess intake rates. However, Cantor et al. (1987) noted that retrospective dietary assessments generally produce moderate correlations with "reference data from the past."

Adults - The total tapwater consumption rates for adults (older than 18 or 20 years) that have been reported in the key surveys can be summarized as follows:

Mean (L/day)	90th Percentile (L/day)	Number in Survey	Reference
1.38	2.41	639	Canadian Minstry of Health and Welfare, 1981
1.41	2.28	11,731	Ershow and Cantor, 1989

For comparison, the relevant studies had the following values for daily tapwater intake:

Mean (L/day)	90th Percentile	Reference
1.30[a]	2.40	Cantor et al., 1987
1.63 (calculated)	--	NAS, 1977
1.25	1.90	Gillies and Paulin, 1983
1.04 (25 to 30 yrs)	--	Pennington, 1983
1.26 (60 to 65 yrs)	--	Pennington, 1983
1.04-1.47 (ages 20+)	--	U.S. EPA, 1984
1.37 (20 to 64 yrs)	2.27	Ershow and Cantor, 1989
1.46 (65+ yrs)	2.29	Ershow and Cantor, 1989
1.15	--	USDA, 1995
1.07	1.87	Hopkins and Ellis, 1980

[a] Age of the Cantor et al. (1987) population was higher than the U.S. average.

Note that both Ershow and Cantor (1989) and Pennington (1983) found that adults above 60 years of age had larger intakes than younger adults. This is difficult to reconcile with the Cantor, et al. (1987) study because the latter, older population had a smaller average intake.

Table 3-29. Drinking Water Intake Surveys

Study	Number of Individuals	Type of Water Consumed	Time Period/ Survey Type	Population Surveyed	Comments
KEY					
Canadian Ministry of National Health and Welfare, 1981	970	Total tapwater consumption	Weekday and weekend day in both summer and winter; estimation based on sizes and types of containers used	All ages; Canada	Seasonal data; includes many tapwater-containing items not commonly surveyed; possible bias because identification of vessel size used as survey techniques; short-term study
Ershow and Cantor, 1989	Based on data from NFCS; approximately 30,000 individuals	Total tapwater; total fluid consumption	3-day recall, diaries	All ages; large sample representative of U.S. population	Short-term recall data; seasonally balanced data
Rosenberry and Burmaster, 1992	Based on data from Ershow and Cantor, 1987	Total tapwater; total fluid consumption	3-day recall, diaries	All ages; large sample representative of US population	Short-term recall data; seasonally balanced; suitable for Monte Carlo simulations
RELEVANT					
Cantor et al., 1987	5,258	Total tapwater; total fluid consumption	1 week/usual intake in winter based on recall	Adults only; weighted toward older adults; U.S. population	Based on recall of behavior from previous winter; short-term data; population not representative of general U.S. population
Gillies and Paulin, 1983	109	Total tapwater consumption	24 hours; duplicate water samples collected	Adults only; New Zealand	Based on short-term data
Hopkin and Ellis, 1980	3,564	Total tapwater, total liquid consumption	1 week period, diaries	All ages; Great Britain	Short-term diary data
ICRP, 1981	Based on data from several sources	Water and water-based drinks; milk; total fluids	NA[a]	NA[a]	Survey design and intake categories not clearly defined
NAS 1977	Calculated average based on several sources	Average per capita "liquid" consumption	NA[a]	NA[a]	Total tapwater not reported; population and survey design not reported

Table 3-29. Drinking Water Intake Surveys (continued)

Study	Number of Individuals	Type of Water Consumed	Time Period/ Survey Type	Population Surveyed	Comments
Pennington, 1983	Based on NFCS and NHANES II; approximately 30,000 and 20,000 participants, respectively	Total tapwater; total fluid consumption	NFCS:24-hour recall on 2-day dairy; NHANES II:24-hour recall	NFCS:1 month to 97 years; NHANES II:6 months to 74 years; representative samples of US population	Based on short-term recall data
USDA, 1995	Based on 89-91 CSF11; approximately 15,000 individuals	Plain drinking water, coffee, tea, fruit drinks and ades	1-day recall	All ages, large sample representative of U.S. population	Short-term recall data; seasonally adjusted
USEPA, 1984	Based on NFCS; approximately 30,000 individuals	Tapwater; water based foods and beverages; soups; beverage consumption	3-day recall, diaries	All ages; large sample representative of US population	Short-term recall data; seasonally balanced
USEPA, 1995	Over 4,000 participants of NHAPS	Number of glasses of drinking water and juice with tapwater	24-hour diaries	All ages, large representative sample of US population	Does not provide data on the volume of tapwater consumed
McNall and Schlegel, 1968	Based on 2 groups of 8 subjects each	Tapwater	8-hour work cycle	Males between 17-25 years of age; small sample; high activity levels/hot climates	Based on short-term data
U.S. Army, 1983	NA	All fluids consumed to satisfy body needs for internal water; includes soups, hot and cold drinks and tapwater	NA	High activity levels/hot climates	Study designed to provide water consumption planning factors for various activities and field conditions; based on estimated amount of water required to account for losses from urination, perspiration, and respiration

[a] Not applicable.

Because of these results, combined with the fact that the Cantor, et al. (1987) study was not intended to be representative of the U. S. population, it is not included here in the determination of the recommended value. The USDA (1995) data are not included because tapwater was not defined in the survey and because the response rate was low, although the results (showing lower intakes than the studies based on older data) may be accurately reflecting an expected lower use of tapwater (compared to 1978) because of increasing use of bottled water and soft drinks in recent years.

A value of 1.41 L/day, which is the population-weighted mean of the two national studies (Ershow and Cantor, 1989 and Canadian Ministry of Health and Welfare, 1981) is the recommended average tapwater intake rate.

The average of the 90th percentile values from the same two studies (2.35 L/day) is recommended as the appropriate upper limit. (The commonly-used 2.0 L/day intake rate corresponds to the 84th percentile of the intake rate distribution among the adults in the Ershow and Cantor (1989) study). In keeping with the desire to incorporate body weight into exposure assessments without introducing extraneous errors, the values from the Ershow and Cantor (1989) study (Tables 3-7 and 3-8) expressed as mL/kg-day are recommended in preference to the liters/day units. For adults, the mean and 90th percentile values are 21 mL/kg-day and 34.2 mL/kg/day, respectively.

In the absence of actual data on chronic intake, the values in the previous paragraph are recommended as chronic values, although the chronic 90th upper percentile may very well be larger than 2.35 L/day. If a mathematical description of the intake distribution is needed, the parameters of lognormal fit to the Ershow and Cantor (1989) data (Tables 3-11 and 3-12) generated by Roseberry and Burmaster (1992) may be used. The simulated balanced population distribution of intakes generated by Roseberry and Burmaster is not recommended for use in the post-1997 time frame, since it corrects the 1978 data only for the differences in the age structure of the U. S. population between 1978 and 1988.

These recommended values are different than the 2 liters/day commonly assumed in EPA risk assessments. Assessors are encouraged to use values which most accurately reflect the exposed population. When using values other than 2 liters/day, however, the assessors should consider if the dose estimate will be used to estimate risk by combining with a dose-response relationship which was derived assuming a tap water intake of 2 liters/day. If such an inconsistency exists, the ssessor should adjust the dose-response relationship as described in Appendix 1 of Chapter 1. IRIS does not use a tap water intake assumption in the derivation of RfCs and RfDs, but does make the 2 liter/day assumption in the derivation of cancer slope factors and unit risks.

Children - The tapwater intake rates for children reported in the key studies are summarized below.

Age	Mean (L/day)	90th Percentile (L/day)	Reference
< 1	0.30	0.65	Ershow and Cantor, 1989
< 3	0.61	1.50	Canadian Ministry of National Health and Welfare, 1981
3-5	0.87	1.50	Canadian Ministry of National Health and Welfare, 1981
1-10	0.74	1.29	Ershow and Cantor, 1989
6-17	1.14	2.21	Canadian Ministry of National Health and Welfare, 1981
11-19	0.97	1.70	Ershow and Cantor, 1989

The intake rates, as expressed as liters per day, generally increase with age, and the data are consistent across ages for the two key studies except for the Canadian Ministry of Health and Welfare (1981) data for ages 6 to 17 years; it is recommended that any of the liters/day values that match the age range of interest except the Canada data for ages 6 to 17 be used. The mL/kg-day intake values show a consistent downward trend with increasing ages; using the Ershow and Cantor (1989) data in preference to the Canadian Ministry of National Health and Welfare (1981) data is recommended where the age ranges overlap.

The intakes for children as reported in the relevant studies are as follows:

Age	Mean (L/day)	Reference
6-11 months	0.20	Pennington, 1983
< 1 yr	0.19	U.S. EPA, 1984
< 1 yr	0.32	Roseberry and Burmaster, 1992
2	0.50	Pennington, 1983
1-4	0.58	U.S. EPA, 1984
5-9	0.67	U.S. EPA, 1984
1-10	0.70	Roseberry and Burmaster, 1992
10-14	0.80	U.S. EPA, 1984
14-16	0.72	Pennington, 1983
15-19	0.90	U.S. EPA, 1984
11-19	0.91	Roseberry and Burmaster, 1992

Disregarding the Roseberry and Burmaster study, which is a recalculation of the Ershow and Cantor (1989) study, the non-key studies generally have lower mean intake values than the Ershow and Cantor study. The reason is not known, but the results are not persuasive enough to discount the recommendations based on the latter study. Intake rates for specific percentiles of the distribution may be selected using the lognormal distribution data generated by Roseberry and Burmaster (1992) (Tables 3-11 and 3-12).

Pregnant and Lactating Women -The data on tapwater intakes for control, pregnant, and lactating women are presented in Table 3-25. Although lactating women have higher tapwater intakes than pregnant or control (non-pregnant and non-lactating) women, they are not higher than the general population of males and females combined. If this Handbook had attempted to derive separate intake values for males and females, then these data might justify further separation of lactating from non-lactating females. However, within the scope of the current document, general population intake rates are recommended for pregnant and lactating women.

High Activity/Hot Climates - Data intake rates for individuals performing strenuous activities under various environmental conditions are limited. However, the data presented by McNall and Schlegel (1968) and U.S. Army (1983) provide bounding intake values for these individuals. According to McNall and Schlegel (1968), hourly intake can range from 0.21 to 0.65 L/hour depending on the temperature and activity level. Intake among physically active individuals can range from 6 L/day in temperate climates to 11 L/day in hot climates (U.S. Army, 1983). A summary of the recommended values is presented in Table 3-30.

Table 3-30. Summary of Recommended Drinking Water Intake Rates

Age Group/ Population	Mean	90th Percentile	Multiple Percentiles	Fitted Distributions
< 1 year	0.30 L/day 44 mL/kg-day	0.65 L/day 102 mL/kg-day	See Tables 3-6, 3-7, and 3-8	See Table 3-11
< 3 years	0.61 L/day	1.5 L/day	See Table3-3	
3-5 years	0.87 L/day	1.5 L/day	See Table3-3	
1-10 years	0.74 L/day 35 mL/kg-day	1.3 L/day 64 mL/kg-day	See Tables 3-6, 3-7, and 3-8	See Table 3-11
11-19 years	0.97 L/day 18 mL/kg-day	1.7 L/day 32 mL/kg-day	See Tables 3-6, 3-7, and 3-8	See Table 3-11
Adults	1.4 L/day 21 mL/kg-day	2.4 L/day 34 mL/kg-day	See Tables 3-6, 3-7, and 3-8	See Table 3-11
Pregnant and Lactating Women	1.4 L/day 21 mL/kg-day	2.4 L/day 34 mL/kg-day	See Tables 3-6, 3-7, and 3-8	
Adults in High Activity/Hot Climate Conditions	0.21 to 0.65 L/hour, depending on ambient temperature and activity level; see Table 3-25.			
Active Adults	6 L/day (temperate climate) to 11 L/day (hot climate); see Table 3-26.			

A characterization of the overall confidence in the accuracy and appropriateness of these recommendations is presented in Table 3-31. Although the study of Ershow and Cantor (1989) is of high quality and consistent with the other surveys, the low currency of the information (1978 data collection), in the presence of anecdotal information (not presented here) that the consumption of bottled water and beverages has increased since 1980 was the main reason for lowering the confidence score of the overall recommendations from high to medium.

Table 3-31. Confidence in Tapwater Intake Recommendations

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	Ershow and Cantor: Thorough expert panel review. Canada: Review procedures not stated; government report. Other reports: Published in scientific journals	High
• Accessibility	The two monographs are available from the sponsoring agencies; the others are library-accessible.	High
• Reproducibility	Methods are well-described.	High
• Focus on factor of interest	The studies are directly relevant to tap water.	High
• Data pertinent to U.S.	See “representativeness” below	NA
• Primary data	The two monographs used recent primary data (less than one week) on recall of intake.	High
• Currency	Data were all collected in the 1978 era. Tap water use may have changed since then.	Low
• Adequacy of data collection period	These are one- to three-day intake data. However, long term variability may be small. Their use as a chronic intake measure can be assumed.	Medium
• Validity of approach	Competently executed study.	High
• Study size	Largest monograph had data for 11,000 individuals.	High
• Representativeness of the population	The Ershow and Cantor and Canada surveys were validated as demographically representative.	High
• Characterization of variability	The full distributions were given in the main studies	High
• Lack of bias in study design (high rating is desirable)	None apparent.	High
• Measurement error	No physical measurements were taken. The method relied on recent recall of standardized volumes of drinking water containers, and was not validated.	Medium
Other Elements		
• Number of studies	Two key studies for the adult and child recommendations. There were six other studies for adults, one study for pregnant and lactating women, and two studies for high activity/hot climates.	High for adult and children. Low for the other recommended subpopulation values.
• Agreement between researchers	Good	High
Overall Rating	The excellent data are not current.	Medium

3.7. REFERENCES FOR CHAPTER 3

Bourne, G.H.; Kidder, G.W., eds. (1953) Biochemistry and physiology of nutrition. Vol. 1. New York, NY: Academic Press.

Canadian Ministry of National Health and Welfare (1981) Tapwater consumption in Canada. Document number 82-EHD-80. Public Affairs Directorate, Department of National Health and Welfare, Ottawa, Canada.

Cantor, K.P.; Hoover, R.; Hartge, P.; Mason, T.J.; Silverman, D.T.; et al. (1987) Bladder cancer, drinking water source, and tapwater consumption: A case-control study. J. Natl. Cancer Inst. 79(6):1269-1279.

Ershow, A.G.; Brown, L.M.; Cantor, K.P. (1991) Intake of tapwater and total water by pregnant and lactating women. American Journal of Public Health. 81:328-334.

Ershow, A.G.; Cantor, K.P. (1989) Total water and tapwater intake in the United States: population-based estimates of quantities and sources. Life Sciences Research Office, Federation of American Societies for Experimental Biology.

Evans, C.L., ed. (1941) Starling's principles of human physiology, 8th ed. Philadelphia, PA: Lea and Febiger.

Gillies, M.E.; Paulin, H.V. (1983) Variability of mineral intakes from drinking water: A possible explanation for the controversy over the relationship of water quality to cardiovascular disease. Int. J. Epid. 12(1):45-50.

Guyton, A.C. (1968) Textbook of medical physiology, 3rd ed. Philadelphia, PA: W.B. Saunders Co.

Hopkins, S.M.; Ellis, J.C. (1980) Drinking water consumption in Great Britain: a survey of drinking habits with special reference to tap-water-based beverages. Technical Report 137, Water Research Centre, Wiltshire Great Britain.

ICRP. (1981) International Commission on Radiological Protection. Report of the task group on reference man. New York: Pergammon Press.

McNall, P.E.; Schlegel, J.C. (1968) Practical thermal environmental limits for young adult males working in hot, humid environments. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Transactions 74:225-235.

National Academy of Sciences (NAS). (1974) Recommended dietary allowances, 8th ed. Washington, DC: National Academy of Sciences-National Research Council.

National Academy of Sciences (NAS). (1977) Drinking water and health. Vol. 1. Washington, DC: National Academy of Sciences-National Research Council.

Pennington, J.A.T. (1983) Revision of the total diet study food list and diets. J. Am. Diet. Assoc. 82:166-173.

Pike, R.L.; Brown, M. (1975) Minerals and water in nutrition--an integrated approach, 2nd ed. New York, NY: John Wiley.

Randall, H.T. (1973) Water, electrolytes and acid base balance. In: Goodhart RS, Shils ME, eds. Modern nutrition in health and disease. Philadelphia, PA: Lea and Febiger.

Roseberry, A.M.; Burmaster, D.E. (1992) Lognormal distribution for water intake by children and adults. Risk Analysis 12:99-104.

Tsang, A.M.; Klepeis, N.E. (1996) Results tables from a detailed analysis of the National Human Activity Pattern Survey (NHAPS) responses. Draft Report prepared for the U.S. Environmental Protection Agency by Lockheed Martin, Contract No. 68-W6-001, Delivery Order No. 13.

U.S. Army. (1983) Water Consumption Planning Factors Study. Directorate of Combat Developments, United States Army Quartermaster School, Fort Lee, Virginia.

USDA. (1995) Food and nutrient intakes by individuals in the United States, 1 day, 1989-91. United States Department of Agriculture, Agricultural Research Service. NFS Report No. 91-2.

U.S. EPA. (1980) U.S. Environmental Protection Agency. Water quality criteria documents; availability. Federal Register, (November 28) 45(231):79318-79379.

U.S. EPA. (1984) An estimation of the daily average food intake by age and sex for use in assessing the radionuclide intake of individuals in the general population. EPA-520/1-84-021.

Walker, B.S.; Boyd, W.C.; Asimov, I. (1957) Biochemistry and human metabolish, 2nd ed. Baltimore, MD: Williams & Wilkins Co.

Wolf, A.V. (1958) Body water. Sci. Am. 99:125.

TABLE OF CONTENTS

4. SOIL INGESTION AND PICA

4.1 BACKGROUND

The ingestion of soil is a potential source of human exposure to toxicants. The potential for exposure to contaminants via this source is greater for children because they are more likely to ingest more soil than adults as a result of behavioral patterns present during childhood. Inadvertent soil ingestion among children may occur through the mouthing of objects or hands. Mouthing behavior is considered to be a normal phase of childhood development. Adults may also ingest soil or dust particles that adhere to food, cigarettes, or their hands. Deliberate soil ingestion is defined as pica and is considered to be relatively uncommon. Because normal, inadvertent soil ingestion is more prevalent and data for individuals with pica behavior are limited, this section focuses primarily on normal soil ingestion that occurs as a result of mouthing or unintentional hand-to-mouth activity.

Several studies have been conducted to estimate the amount of soil ingested by children. Most of the early studies attempted to estimate the amount of soil ingested by measuring the amount of dirt present on children's hands and making generalizations based on behavior. More recently, soil intake studies have been conducted using a methodology that measures trace elements in feces and soil that are believed to be poorly absorbed in the gut. These measurements are used to estimate the amount of soil ingested over a specified time period. The available studies on soil intake are summarized in the following sections. Studies on soil intake among children have been classified as either key studies or relevant studies based on their applicability to exposure assessment needs. Recommended intake rates are based on the results of key studies, but relevant studies are also presented to provide the reader with added perspective on the current state-of-knowledge pertaining to soil intake. Information on soil ingestion among adults is presented based on available data from a limited number of studies. Relevant information on the prevalence of pica and intake among individuals exhibiting pica behavior is also presented.

4.2. KEY STUDIES ON SOIL INTAKE AMONG CHILDREN

Stanek and Calabrese (1995a) - Daily Estimates of Soil Ingestion in Children - Stanek and Calabrese (1995a) presented a methodology which links the physical passage of food and fecal samples to construct daily soil ingestion estimates from daily food and fecal trace-element concentrations. Soil ingestion data for children obtained from the Amherst study (Calabrese et al., 1989) were reanalyzed by Stanek and Calabrese (1995a). In the Amherst study, soil ingestion measurements were made over a period of 2 weeks for a non-random sample of sixty-four children (ages of 1-4 years old) living adjacent to an academic area in western Massachusetts. During each week, duplicate food samples were collected for 3 consecutive days and fecal samples were collected for 4 consecutive days for each subject. The total amount of each of eight trace elements present in the food and fecal samples were measured. The eight trace elements are aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium. The authors expressed the amount of trace element in food input or fecal output as a "soil equivalent," which was defined as the amount of the element in average daily food intake (or average daily fecal output) divided by the concentration of the element in soil. A lag period of 28 hours between food intake and fecal output was assumed for all respondents. Day 1 for the food sample corresponded to the 24 hour period from midnight on Sunday to midnight on Monday of a study week; day 1 of the fecal sample corresponded to the 24 hour period from midnight on Monday to noon on Tuesday (Stanek and Calabrese, 1995a). Based on these definitions, the food soil equivalent was subtracted from the fecal soil equivalent to obtain an estimate of soil ingestion for a trace element. A daily "overall" ingestion estimate was constructed for each child as the median of trace element values remaining after tracers falling outside of a defined range around the overall median were excluded. Additionally, estimates of the distribution of soil ingestion projected over a period of 365 days were derived by fitting log-normal distributions to the "overall" daily soil ingestion estimates.

Table 4-1 presents the estimates of mean daily soil ingestion intake per child (mg/day) for the 64 study participants. (The authors also presented estimates of the median values of daily intake for each child. For most risk assessment purposes the child mean values, which are proportional to the cumulative soil intake by the child, are needed instead of the median values.) The approach adopted in this paper led to changes in ingestion estimates from those presented in Calabrese et al. (1989). Specifically, among elements that may be more useful for estimation of ingestion, the mean estimates decreased for Al (153 mg/d to 122 mg/d) and Si (154 mg/d to 139 mg/d), but increased for Ti (218 mg/d to 271 mg/d) and Y (85 mg/d to 165 mg/d). The "overall" mean estimate from this reanalysis was 179 mg/d. Table 4-1 presents the empirical distribution of the the "overall" mean daily

Table 4-1. Distribution of Average (Mean) Daily Soil Ingestion Estimates per Child for 64 Children[a] (mg/day)

Type of Estimate Number of Samples	Overall (64)	A1 (64)	Ba (33)	Mn (19)	Si (63)	Ti (56)	V (52)	Y (61)	Zr (62)
Mean	179	122	655	1,053	139	271	112	165	23
25th Percentile	10	10	28	35	5	8	8	0	0
50th Percentile	45	19	65	121	32	31	47	15	15
75th Percentile	88	73	260	319	94	93	177	47	41
90th Percentile	186	131	470	478	206	154	340	105	87
95th Percentile	208	254	518	17,374	224	279	398	144	117
Maximum	7,703	4,692	17,991	17,374	4,975	12,055	845	8,976	208

[a] For each child, estimates of soil ingestion were formed on days 4-8 and the mean of these estimates was then evaluated for each child. The values in the column "overall" correspond to percentiles of the distribution of these means over the 64 children. When specific trace elements were not excluded via the relative standard deviation criteria, estimates of soil ingestion based on the specific trace element were formed for 108 days for each subject. The mean soil ingestion estimate was again evaluated. The distribution of these means for specific trace elements is shown.

Source: Stanek and Calabrese, 1995a.

soil ingestion estimates for the 8-day study period (not based on lognormal modeling). The estimated intake based on the "overall" estimates is 45 mg/day or less for 50 percent of the children and 208 mg/day or less for 95 percent of the children. The upper percentile values for most of the individual trace elements are somewhat higher. Next, estimates of the respondents soil intake averaged over a period of 365 days were presented based upon the lognormal models fit to the daily ingestion estimates (Table 4-2). The estimated median value of the 64 respondents' daily soil ingestion averaged over a year is 75 mg/day, while the 95th percentile is 1,751 mg/day.

Table 4-2. Estimated Distribution of Individual Mean Daily Soil Ingestion Based on Data for 64 Subjects Projected Over 365 Days[a]

Range	1 - 2,268 mg/d[b]
50th Percentile (median)	75 mg/d
90th Percentile	1,190 mg/d
95th Percentile	1,751 mg/d

[a] Based on fitting a log-normal distribution to model daily soil ingestion values.

[b] Subject with pica excluded.

Source: Stanek and Calabrese, 1995a.

A strength of this study is that it attempts to make full use of the collected data through estimation of daily ingestion rates for children. The data are then screened to remove less consistent tracer estimates and the remaining values are aggregated. Individual daily estimates of ingestion will be subject to larger errors than are weekly average values, particularly since the assumption of a constant lag time between food intake and fecal output may be not be correct for many subject days. The aggregation approach used to arrive at the "overall" ingestion estimates rests on the assumption that the mean ingestion estimates across acceptable tracers provides the most reliable ingestion estimates. The validity of this assumption depends on the particular set of tracers used in the study, and is not fully assessed.

In developing the 365 day soil ingestion estimates, data that were obtained over a short period of time (as is the case with all available soil ingestion studies) were extrapolated over a year. The 2-week study period may not reflect variability in tracer element ingestion over a year. While Stanek and Calabrese (1995a) attempt to address this through lognormal modeling of the long term intake, new uncertainties are introduced through the parametric modeling of the limited subject day data. Also, the sample population size of the original study was small and site limited, and, therefore, is not representative of the U.S. population. Study mean estimates of soil ingestion, such as the study mean estimates presented in Table 4-1, are substantially more reliable than any available distributional estimates.

Binder et al. (1986) - Estimating Soil Ingestion: Use of Tracer Elements in Estimating the Amount of Soil Ingested by Young Children - Binder et al. (1986) studied the ingestion of soil among children 1 to 3 years of age who wore diapers using a tracer technique modified from a method previously used to measure soil ingestion among grazing animals. The children were studied during the summer of 1984 as part of a larger study of residents living near a lead smelter in East Helena, Montana. Soiled diapers were collected over a 3-day period from 65 children (42 males and 23 females), and composited samples of soil were obtained from the children's yards. Both excreta and soil samples were analyzed for aluminum, silicon, and titanium. These elements were found in soil, but were thought to be poorly absorbed in the gut and to have been present in the diet only in limited quantities. This made them useful tracers for estimating soil intake. Excreta measurements were obtained for 59 of the children. Soil ingestion by each child was estimated based on each of the three tracer elements using a standard assumed fecal dry weight of 15 g/day, and the following equation:

$$T_{i,e} = \frac{f_{i,e} \ x \ F_i}{S_{i,e}} \qquad \text{(Eqn. 4-1)}$$

where:

$T_{i,e}$ = estimated soil ingestion for child i based on element e (g/day);

$f_{i,e}$ = concentration of element e in fecal sample of child i (mg/g);

F_i = fecal dry weight (g/day); and

$S_{i,e}$ = concentration of element e in child i's yard soil (mg/g).

The analysis conducted by Binder et al. (1986) assumed that: (1) the tracer elements were neither lost nor introduced during sample processing; (2) the soil ingested by children originates primarily from their own yards; and (3) that absorption of the tracer elements by children occurred in only small amounts. The study did not distinguish between ingestion of soil and housedust nor did it account for the presence of the tracer elements in ingested foods or medicines.

The arithmetic mean quantity of soil ingested by the children in the Binder et al. (1986) study was estimated to be 181 mg/day (range 25 to 1,324) based on the aluminum tracer; 184 mg/day (range 31 to 799) based on the silicon tracer; and 1,834 mg/day (range 4 to 17,076) based on the titanium tracer (Table 4-3). The overall mean soil ingestion estimate based on the minimum of the three individual tracer estimates for each child was 108 mg/day (range 4 to 708). The 95th percentile values for aluminum, silicon, and titanium were 584 mg/day, 578 mg/day, and 9,590 mg/day, respectively. The 95th percentile value based on the minimum of the three individual tracer estimates for each child was 386 mg/day.

The authors were not able to explain the difference between the results for titanium and for the other two elements, but speculated that unrecognized sources of titanium in the diet or in the laboratory processing of stool samples may have accounted for the increased levels. The frequency distribution graph of soil ingestion estimates based on titanium shows that a group of 21 children had particularly high titanium values (i.e., > 1,000 mg/day). The remainder of the children showed titanium ingestion estimates at lower levels, with a distribution more comparable to that of the other elements.

The advantages of this study are that a relatively large number of children were studied and tracer elements were used to estimate soil ingestion. However, the children studied may not be representative of the U.S. population and the study did not account for tracers ingested via foods or medicines. Also, the use of an assumed fecal weight instead of actual fecal weights may have biased the results of this study. Finally, because of the short-term nature of the survey, soil intake estimates may not be entirely representative of long-term behavior, especially at the upper-end of the distribution of intake.

Clausing et al. (1987) - A Method for Estimating Soil Ingestion by Children - Clausing et al. (1987) conducted a soil ingestion study with Dutch children using a tracer element methodology similar to that of Binder et al. (1986). Aluminum, titanium, and acid-insoluble residue (AIR) contents were determined for fecal samples from children, aged 2 to 4, attending a nursery school, and for samples of playground dirt at that school. Twenty-seven daily fecal samples were obtained over a 5-day period for the 18 children examined. Using the average soil concentrations present at the school, and assuming a standard fecal dry weight of 10 g/day, Clausing et al. (1987) estimated soil ingestion for each tracer. Clausing et al. (1987) also collected eight daily fecal samples from six hospitalized, bedridden children. These children served as a control group, representing children who had very limited access to soil.

Table 4-3. Estimated Daily Soil Ingestion Based on Aluminum, Silicon, and Titanium Concentrations

Estimation Method	Mean (mg/day)	Median (mg/day)	Standard Deviation (mg/day)	Range (mg/day)	95th Percentile (mg/day)	Geometric Mean (mg/day)
Aluminum	181	121	203	25-1,324	584	128
Silicon	184	136	175	31-799	5,78	130
Titanium	1,834	618	3,091	4-17,076	9,590	401
Minimum	108	88	121	4-708	386	65

Source: Binder et al., 1986.

The average quantity of soil ingested by the school children in this study was as follows: 230 mg/day (range 23 to 979 mg/day) for aluminum; 129 mg/day (range 48 to 362 mg/day) for AIR; and 1,430 mg/day (range 64 to 11,620 mg/day) for titanium (Table 4-4). As in the Binder et al. (1986) study, a fraction of the children (6/19) showed titanium values well above 1,000 mg/day, with most of the remaining children showing substantially lower values. Based on the Limiting Tracer Method (LTM), mean soil intake was estimated to be 105 mg/day with a population standard deviation of 67 mg/day (range 23 to 362 mg/day). Use of the LTM assumed that "the maximum amount of soil ingested corresponded with the lowest estimate from the three tracers" (Clausing et al., 1987). Geometric mean soil intake was estimated to be 90 mg/day. This assumes that the maximum amount of soil ingested cannot be higher than the lowest estimate for the individual tracers.

Mean soil intake for the hospitalized children was estimated to be 56 mg/day based on aluminum (Table 4-5). For titanium, three of the children had estimates well in excess of 1,000 mg/day, with the remaining three children in the range of 28 to 58 mg/day. Using the LTM method, the mean soil ingestion rate was estimated to be 49 mg/day with a population standard deviation of 22 mg/day (range 26 to 84 mg/day). The geometric mean soil intake rate was 45 mg/day. The data on hospitalized children suggest a major nonsoil source of titanium for some children, and may suggest a background nonsoil source of aluminum. However, conditions specific to hospitalization (e.g., medications) was not considered. AIR measurements were not reported for the hospitalized children. Assuming that the tracer-based soil ingestion rates observed in hospitalized children actually represent background tracer intake from dietary and other nonsoil sources, mean soil ingestion by nursery school children was estimated to be 56 mg/day, based on the LTM (i.e., 105 mg/day for nursery school children minus 49 mg/day for hospitalized children) (Clausing et al. 1987).

The advantages of this study are that Clausing et al. (1987) evaluated soil ingestion among two populations of children that had differences in access to soil, and corrected soil intake rates based on background estimates derived from the hospitalized group. However, a smaller number of children were used in this study than in the Binder et al. (1986) study and these children may not be representative of the U.S. population. Tracer elements in foods or medicines were not evaluated. Also, intake rates derived from this study may not be representative of soil intake over the long-term because of the short-term nature of the study.

Van Wïjnen et al. (1990) - Estimated Soil Ingestion by Children - In a study by Van Wïjnen et al. (1990), soil ingestion among Dutch children ranging in age from 1 to 5 years was evaluated using a tracer element methodology similar to that used by Clausing et al. (1987). Van Wïjnen et al. (1990) measured three tracers (i.e., titanium, aluminum, and AIR) in soil and feces and estimated soil ingestion based on the LTM. An average daily feces weight of 15 g dry weight was assumed. A total of 292 children attending daycare centers were sampled during the first of two sampling periods and 187 children were sampled in the second sampling period; 162 of these children were sampled during both periods (i.e., at the beginning and near the end of the summer of 1986). A total of 78 children were sampled at campgrounds, and 15 hospitalized children were sampled. The mean values for these groups were: 162 mg/day for children in daycare centers, 213 mg/day for campers and 93 mg/day for hospitalized children. Van Wïjnen et al. (1990) also

Table 4-4. Calculated Soil Ingestion by Nursery School Children

Child	Sample Number	Soil Ingestion as Calculated from Ti (mg/day)	Soil Ingestion as Calculated from Al (mg/day)	Soil Ingestion as Calculated from AIR (mg/day)	Limiting Tracer (mg/day)
1	L3	103	300	107	103
	L14	154	211	172	154
	L25	130	23	-	23
2	L5	131	-	71	71
	L13	184	103	82	82
	L27	142	81	84	81
3	L2	124	42	84	42
	L17	670	566	174	174
4	L4	246	62	145	62
	L11	2,990	65	139	65
5	L8	293	-	108	108
	L21	313	-	152	152
6	L12	1,110	693	362	362
	L16	176	-	145	145
7	L18	11,620	-	120	120
	L22	11,320	77	-	77
8	L1	3,060	82	96	82
9	L6	624	979	111	111
10	L7	600	200	124	124
11	L9	133	-	95	95
12	L10	354	195	106	106
13	L15	2,400	-	48	48
14	L19	124	71	93	71
15	L20	269	212	274	212
16	L23	1,130	51	84	51
17	L24	64	566	-	64
18	L26	184	56	-	56
Arithmetic Mean		1,431	232	129	105

Source: Adapted from Clausing et al. 1987.

Table 4-5.Calculated Soil Ingestion by Hospitalized, Bedridden Children

Child	Sample	Soil Ingestion as Calculated from Ti (mg/day)	Soil Ingestion as Calculated from Al (mg/day)	Limiting Tracer (mg/day)
1	G5	3,290	57	57
	G6	4,790	71	71
2	G1	28	26	26
3	G2	6,570	94	84
	G8	2,480	57	57
4	G3	28	77	28
5	G4	1,100	30	30
6	G7	58	38	38
Arithmetic Mean		2,293	56	49

Source: Adapted from Clausing et al. 1987.

reported geometric mean LTM values because soil intake rates were found to be skewed and the log transformed data were approximately normally distributed. Geometric mean LTM values were estimated to be 111 mg/day for children in daycare centers, 174 mg/day for children vacationing at campgrounds (Table 4-6) and 74 mg/day for hospitalized children (70-120 mg/day based on the 95 percent confidence limits of the mean). AIR was the limiting tracer in about 80 percent of the samples. Among children attending daycare centers, soil intake was also found to be higher when the weather was good (i.e., <2 days/week precipitation) than when the weather was bad (i.e., >4 days/week precipitation (Table 4-7). Van Wïjnen et al. (1990) suggest that the mean LTM value for hospitalized infants represents background intake of tracers and should be used to correct the soil intake rates based on LTM values for other sampling groups. Using mean values, corrected soil intake rates were 69 mg/day (162 mg/day minus 93 mg/day) for daycare children and 120 mg/day (213 mg/day minus 93 mg/day) for campers. Corrected geometric mean soil intake was estimated to range from 0 to 90 mg/day with a 90th percentile value of 190 mg/day for the various age categories within the daycare group and 30 to 200 mg/day with a 90th percentile value of 300 mg/day for the various age categories within the camping group.

The advantage of this study is that soil intake was estimated for three different populations of children; one expected to have high intake, one expected to have "typical" intake, and one expected to have low or background-level intake. Van Wïjnen et al. (1990) used the background tracer measurements to correct soil intake rates for the other two populations. Tracer concentrations in food and medicine were not evaluated. Also, the population of children studied was relatively large, but may not be representative of the U.S. population. This study was conducted over a relatively short time period. Thus, estimated intake rates may not reflect long-term patterns, especially at the high-end of the distribution. Another limitation of this study is that values were not reported element-by-element which would be the preferred way of reporting.

Table 4-6. Geometric Mean (GM) and Standard Deviation (GSD) LTM Values for Children at Daycare Centers and Campgrounds

Age (yrs)	Sex	Daycare Centers			Campgrounds		
		n	GM LTM (mg/day)	GSD LTM (mg/day)	n	GM LTM (mg/day)	GSD LTM (mg/day)
< 1	Girls	3	81	1.09	-	-	-
	Boys	1	75	-	-	-	-
1- < 2	Girls	20	124	1.87	3	207	1.99
	Boys	17	114	1.47	5	312	2.58
2- < 3	Girls	34	118	1.74	4	367	2.44
	Boys	17	96	1.53	8	232	2.15
3-4	Girls	26	111	1.57	6	164	1.27
	Boys	29	110	1.32	8	148	1.42
4- < 5	Girls	1	180	-	19	164	1.48
	Boys	4	99	1.62	18	136	1.30
All girls		86	117	1.70	36	179	1.67
All boys		72	104	1.46	42	169	1.79
Total		162[a]	111	1.60	78[b]	174	1.73

[a] Age and/or sex not registered for eight children.
[b] Age not registered for seven children.
Source: Adapted from Van Wijnen et al., 1990.

Table 4-7. Estimated Geometric Mean LTM Values of Children Attending Day-Care Centers According to Age, Weather Category, and Sampling Period

Weather Category	Age (years)	First Sampling Period		Second Sampling Period	
		n	Estimated Geometric Mean LTM Value (mg/day)	n	Estimated Geometric Mean LTM Value (mg/day)
Bad	< 1	3	94	3	67
(> 4 days/week precipitation)	1- < 2	18	103	33	80
	2- < 3	33	109	48	91
	4- < 5	5	124	6	109
Reasonable	< 1			1	61
(2-3 days/week precipitation)	1- < 2			10	96
	2- < 3			13	99
	3- < 4			19	94
	4- < 5			1	61
Good	< 1	4	102		
(< 2 days/week precipitation)	1- < 2	42	229		
	2- < 3	65	166		
	3- < 4	67	138		
	4- < 5	10	132		

Source: Van Wijnen et al., 1990.

Davis et al. (1990) - Quantitative Estimates of Soil Ingestion in Normal Children Between the ages of 2 and 7 years: Population-Based Estimates Using Aluminum, Silicon, and Titanium as Soil Tracer Elements - Davis et al. (1990) also used a mass-balance/tracer technique to estimate soil ingestion among children. In this study, 104 children between the ages of 2 and 7 years were randomly selected from a three-city area in southeastern Washington State. The study was conducted over a seven day period, primarily during the summer. Daily soil ingestion was evaluated by collecting and analyzing soil and house dust samples, feces, urine, and duplicate food samples for aluminum, silicon, and titanium. In addition, information on dietary habits and demographics was collected in an attempt to identify behavioral and demographic characteristics that influence soil intake rates among children. The amount of soil ingested on a daily basis was estimated using the following equation:

$$S_{i,e} = \frac{(DW_f + DW_p) \times (E_f + 2E_u) - (DW_{fd} \times E_{fd})}{E_{soil}} \qquad \text{(Eqn. 4-2)}$$

where:

$S_{i,e}$ = soil ingested for child i based on tracer e (g);
DW_f = feces dry weight (g);
DW_p = feces dry weight on toilet paper (g);
E_f = tracer amount in feces (μg/g);
E_u = tracer amount in urine (μg/g);
DW_{fd} = food dry weight (g);
E_{fd} = tracer amount in food (μg/g); and
E_{soil} = tracer concentration in soil (μg/g).

The soil intake rates were corrected by adding the amount of tracer in vitamins and medications to the amount of tracer in food, and adjusting the food quantities, feces dry weights, and tracer concentrations in urine to account for missing samples.

Soil ingestion rates were highly variable, especially those based on titanium. Mean daily soil ingestion estimates were 38.9 mg/day for aluminum, 82.4 mg/day for silicon and 245.5 mg/day for titanium (Table 4-8). Median values were 25 mg/day for aluminum, 50 mg/day for silicon, and 81 mg/day for titanium. Davis et al. (1990) also evaluated the extent to which differences in tracer concentrations in house dust and yard soil impacted estimated soil ingestion rates. The value used in the denominator of the mass balance equation was recalculated to represent a weighted average of the tracer concentration in yard soil and house dust based on the proportion of time the child spent indoors and outdoors. The adjusted mean soil/dust intake rates were 64.5 mg/day for aluminum, 160.0 mg/day for silicon, and 268.4 mg/day for titanium. Adjusted median soil/dust intake rates were: 51.8 mg/day for aluminum, 112.4 mg/day for silicon, and 116.6 mg/day for titanium. Davis et al. (1990) also observed that the following demographic characteristics were associated with high soil intake rates: male sex, non-white racial group, low income, operator/laborer as the principal occupation of the parent, and city of residence. However, none of these factors were predictive of soil intake rates when tested using multiple linear regression.

The advantages of the Davis et al. (1990) study are that soil intake rates were corrected based on the tracer content of foods and medicines and that a relatively large number of children were sampled. Also, demographic and behavioral information was collected for the survey group. However, although a relatively large sample population was surveyed, these children were all from a single area of the U.S. and may not be representative of the U.S. population as a whole. The study was conducted over a one-week period during the summer and may not be representative of long-term (i.e., annual) patterns of intake.

Calabrese et al. (1989) - How Much Soil do Young Children Ingest: An Epidemiologic Study - Calabrese et al. (1989) studied soil ingestion among children using the basic tracer design developed by Binder et al. (1986). However, in contrast to the Binder et al. (1987) study, eight tracer elements (i.e., aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium) were analyzed instead of only three (i.e., aluminum, silicon, and titanium). A total of 64 children between the ages of 1 and 4 years old were included in the study. These children were all selected from the greater Amherst, Massachusetts area and were predominantly from two-parent households where the parents were highly educated. The Calabrese et al. (1989) study was conducted over eight days during a two week period and included the use of a mass-balance methodology in which duplicate samples of food, medicines, vitamins, and others

Table 4-8. Average Daily Soil Ingestion Values Based on Aluminum, Silicon, and Titanium as Tracer Elements[a]

Element	Mean (mg/d)	Median (mg/d)	Standard Error of the Mean (mg/d)	Range (mg/d)[b]
Aluminum	38.9	25.3	14.4	279.0 to 904.5
Silicon	82.4	59.4	12.2	-404.0 to 534.6
Titanium	245.5	81.3	119.7	-5,820.8 to 6,182.2
Minimum	38.9	25.3	12.2	-5,820.8
Maximum	245.5	81.3	119.7	6,182.2

[a] Excludes three children who did not provide any samples (N = 101).
[b] Negative values occurred as a result of correction for nonsoil sources of the tracer elements.
Source: Adapted from Davis et al., 1990.

were collected and analyzed on a daily basis, in addition to soil and dust samples collected from the child's home and play area. Fecal and urine samples were also collected and analyzed for tracer elements. Toothpaste, low in tracer content, was provided to all participants.

In order to validate the mass-balance methodology used to estimate soil ingestion rates among children and to determine which tracer elements provided the most reliable data on soil ingestion, known amounts of soil (i.e., 300 mg over three days and 1,500 mg over three days) containing eight tracers were administered to six adult volunteers (i.e., three males and three females). Soil samples and feces samples from these adults and duplicate food samples were analyzed for tracer elements to calculate recovery rates of tracer elements in soil. Based on the adult validation study, Calabrese et al. (1989) confirmed that the tracer methodology could adequately detect tracer elements in feces at levels expected to correspond with soil intake rates in children. Calabrese et al. (1989) also found that aluminum, silicon, and yttrium were the most reliable of the eight tracer elements analyzed. The standard deviation of recovery of these three tracers was the lowest and the percentage of recovery was closest to 100 percent (Calabrese, et al., 1989). The recovery of these three tracers ranged from 120 to 153 percent when 300 mg of soil had been ingested over a three-day period and from 88 to 94 percent when 1,500 mg soil had been ingested over a three-day period (Table 4-9).

Using the three most reliable tracer elements, the mean soil intake rate for children, adjusted to account for the amount of tracer found in food and medicines, was estimated to be 153 mg/day based on aluminum, 154 mg/day based on silicon, and 85 mg/day based on yttrium (Table 4-10). Median intake rates were somewhat lower (29 mg/day for aluminum, 40 mg/day for silicon, and 9 mg/day for yttrium). Upper-percentile (i.e., 95th) values were 223 mg/day for aluminum, 276 mg/day for silicon, and 106 mg/day for yttrium. Similar results were observed when soil and dust ingestion was combined (Table 4-10). Intake of soil and dust was estimated using a weighted average of tracer concentration in dust composite samples and in soil composite samples based on the timechildren spent at home and away from home, and indoors and outdoors. Calabrese et al. (1989) suggested that the use of titanium as a tracer in earlier studies that lacked food ingestion data may have significantly overestimated soil intake because of the high levels of titanium in food. Using the median values of aluminum and silicon, Calabrese et al. (1989) estimated the quantity

Table 4-9. Mean and Standard Deviation Percentage Recovery of Eight Tracer Elements

	300 mg Soil Ingested		1500 mg Soil Ingested	
Tracer Element	Mean	SD	Mean	SD
Al	152.8	107.5	93.5	15.5
Ba	2304.3	4533.0	149.8	69.5
Mn	1177.2	1341.0	248.3	183.6
Si	139.3	149.6	91.8	16.6
Ti	251.5	316.0	286.3	380.0
V	345.0	247.0	147.6	66.8
Y	120.5	42.4	87.5	12.6
Zr	80.6	43.7	54.6	33.4

Source: Adapted from Calabrese et al., 1989.

Table 4-10. Soil and Dust Ingestion Estimates for Children Aged 1-4 Years

Tracer Element	N	Intake (mg/day)[a]				
		Mean	Median	SD	95th Percentile	Maximum
Aluminum						
soil	64	153	29	852	223	6,837
dust	64	317	31	1,272	506	8,462
soil/dust combined	64	154	30	629	478	4,929
Silicon						
soil	64	154	40	693	276	5,549
dust	64	964	49	6,848	692	54,870
soil/dust combined	64	483	49	3,105	653	24,900
Yttrium						
soil	62	85	9	890	106	6,736
dust	64	62	15	687	169	5,096
soil/dust combined	62	65	11	717	159	5,269
Titanium						
soil	64	218	55	1,150	1,432	6,707
dust	64	163	28	659	1,266	3,354
soil/dust combined	64	170	30	691	1,059	3,597

[a] Corrected for Tracer Concentrations in Foods

Source: Adapted from Calabrese et al., 1989.

of soil ingested daily to be 29 mg/day and 40 mg/day, respectively. It should be noted that soil ingestion for one child in the study ranged from approximately 10 to 14 grams/day during the second week of observation. Average soil ingestion for this child was 5 to 7 mg/day, based on the entire study period.

The advantages of this study are that intake rates were corrected for tracer concentrations in foods and medicines and that the methodology was validated using adults. Also, intake was observed over a longer time period in this study than in earlier studies and the number of tracers used was larger than for other studies. A relatively large population was studied, but they may not be entirely representative of the U.S. population because they were selected from a single location.

Stanek and Calabrese (1995b) - Soil Ingestion Estimates for Use in Site Evaluations Based on the Best Tracer Method - Stanek and Calabrese (1995b) recalculated ingestion rates that were estimated in three previous mass-balance studies (Calabrese et al., 1989 and Davis et al., 1990 for children's soil ingestion, and Calabrese et al., 1990 for adult soil ingestion) using the Best Tracer Method (BTM). This method allows for the selection of the most recoverable tracer for a particular subject or group of subjects. The selection process involves ordering trace elements for each subject based on food/soil (F/S) ratios. These ratios are estimated by dividing the total amount of the tracer in food by the tracer concentration in soil. The F/S ratio is small when the tracer concentration in food is almost zero when compared to the tracer concentration in soil. A small F/S ratio is desirable because it lessens the impact of transit time error (the error that occurs when fecal output does not reflect food ingestion, due to fluctuation in gastrointestinal transit time) in the soil ingestion calculation. Because the recoverability of tracers can vary within any group of individuals, the BTM uses a ranking scheme of F/S ratios to determine the best tracers for use in the ingestion rate calculation. To reduce biases that may occur as a result of sources of fecal tracers other than food or soil, the median of soil ingestion estimates based on the four lowest F/S ratios was used to represent soil ingestion among individuals.

For adults, Stanek and Calabrese (1995b) used data for 8 tracers from the Calabrese et al. (1990) study to estimate soil ingestion by the BTM. The lowest F/S ratios were Zr and Al and the element with the highest F/S ratio was Mn. For soil ingestion estimates based on the median of the lowest four F/S ratios, the tracers contributing most often to the soil ingestion estimates were Al, Si, Ti, Y, V, and Zr. Using the median of the soil ingestion rates based on the best four tracer elements, the average adult soil ingestion rate was estimated to be 64 mg/day with a median of 87 mg/day. The 90th percentile soil ingestion estimate was 142 mg/day. These estimates are based on

18 subject weeks for the six adult volunteers described in Calabrese et al. (1990).

For children, Stanek and Calabrese (1995b) used data on 8 tracers from Calabrese et al., 1989 and data on 3 tracers from Davis et al. (1990) to estimate soil ingestion rates. The median of the soil ingestion estimates from the lowest four F/S ratios from the Calabrese et al. (1989) study most often included Al, Si, Ti, Y, and Zr. Based on the median of soil ingestion estimates from the best four tracers, the mean soil ingestion rate was 132 mg/day and the median was 33 mg/day. The 95th percentile value was 154 mg/day. These estimates are based on data for 128 subject weeks for the 64 children in the Calabrese et al. (1989) study. For the 101 children in the Davis et al. (1990) study, the mean soil ingestion rate was 69 mg/day and the median soil ingestion rate was 44 mg/day. The 95th percentile estimate was 246 mg/day. These data are based on the three tracers (i.e., Al, Si, and Ti) from the Davis et al. (1990) study. When the Calabrese et al. (1989) and Davis et al. (1990) studies were combined, soil ingestion was estimated to be 113 mg/day (mean); 37 mg/day (median); and 217 mg/day (95th percentile), using the BTM.

This study provides a reevaluation of previous studies. Its advantages are that it combines data from 2 studies for children, one from California and one from Massachusetts, which increases the number of observations. It also corrects for biases associated with the differences in tracer metabolism. The limitations associated with the data used in this study are the same as the limitations described in the summaries of the Calabrese et al. (1989), Davis et al. (1990) and Calabrese et al. (1990) studies.

4.3. RELEVANT STUDIES ON SOIL INTAKE AMONG CHILDREN

Thompson and Burmaster (1991) - Parametric Distributions for Soil Ingestion by Children - Thompson and Burmaster (1991) developed parameterized distributions of soil ingestion rates for children based on a reanalysis of the data collected by Binder et al. (1986). In the original Binder et al. (1986) study, an assumed fecal weight of 15 g/day was used. Thompson and Burmaster reestimated the soil ingestion rates from the Binder et al. (1986) study using the actual stool weights of the study participants instead of the assumed stool weights. Because the actual stool weights averaged only 7.5 g/day, the soil ingestion estimates presented by Thompson and Burmaster (1991) are approximately one-half of those reported by Binder et al. (1986). Table 4-11 presents the distribution of estimated soil ingestion rates calculated by Thompson and Burmaster (1991) based on the three tracers elements (i.e., aluminum, silicon, and titanium), and on the arithmetic average of soil ingestion based on aluminum and silicon. The mean soil intake rates were 97 mg/day for aluminum, 85 mg/day for silicon, and 1,004 mg/day for titanium. The 90th percentile estimates were 197 mg/day for aluminum, 166 mg/day for silicon, and 2,105 mg/day for titanium. Based on the arithmetic average of aluminum and silicon for each child, mean soil intake was estimated to be 91 mg/day and 90th percentile intake was estimated to be 143 mg/day.

Thompson and Burmaster (1991) tested the hypothesis that soil ingestion rates based on the adjusted Binder et al. (1986) data for aluminum, silicon and the average of these two tracers were lognormally distributed. The distribution of soil intake based on titanium was not tested for lognormality because titanium may be present in food in high concentrations and the Binder et al. (1986) study did not correct for food sources of titanium (Thompson and Burmaster, 1991). Although visual inspection of the distributions for aluminum, silicon, and the average of these tracers all indicated that they may be lognormally distributed, statistical tests indicated that only silicon and the average of the silicon and aluminum tracers were lognormally distributed. Soil intake rates based on aluminum were not lognormally distributed. Table 4-11 also presents the lognormal distribution parameters and underlying normal distribution parameters (i.e., the natural logarithms of the data) for aluminum, silicon, and the average of these two tracers. According to the authors, "the parameters estimated from the underlying normal distribution are much more reliable and robust" (Thompson and Burmaster, 1991).

The advantages of this study are that it provides percentile data and defines the shape of soil intake distributions. However, the number of data points used to fit the distribution was limited. In addition, the study did not generate "new" data. Instead, it provided a reanalysis of previously-reported data using actual fecal weights. No corrections were made for tracer intake from food or medicine and the results may not be representative of long-term intake rates because the data were derived from a short-term study.

Lepow et al. (1974) - Role of Airborne Lead in Increased Body Burden of Lead in Hartford Children - Lepow et al. (1974) estimated ingestion of airborne lead fallout among urban children by: (1) analyzing surface dirt and dust samples from locations where children

Table 4-11. Estimated Soil Ingestion Rate Summary Statistics and Parameters for Distributions Using Binder et al. (1986) Data with Actual Fecal Weights

Trace Element Basis	Soil Intake (mg/day)			
	A1	Si	Ti	MEAN[a]
Mean	97	85	1,004	91
Min	11	10	1	13
10th	21	19	3	22
20th	33	23	22	34
30th	39	36	47	43
40th	43	52	172	49
Med	45	60	293	59
60th	55	65	475	69
70th	73	79	724	92
80th	104	106	1,071	100
90th	197	166	2,105	143
Max	1,201	642	14,061	921
	Lognormal Distribution Parameters			
Median	45	60	--	59
Standard Deviation	169	95	--	126
Arithmetic Mean	97	85	--	91
	Underlying Normal Distribution Parameters			
Mean	4.06	4.07	--	4.13
Standard Deviation	0.88	0.85	--	0.80

[a] MEAN = arithmetic average of soil ingestion based on aluminum and silicon.
Source: Thompson and Burmaster, 1991.

played; (2) measuring hand dirt by applying preweighed adhesive labels to the hands and weighing the amount of dirt that was removed; and (3) observing "mouthing" behavior over 3 to 6 hours of normal play. Twenty-two children from an urban area of Connecticut were included in the study. Lepow et al. (1974) found that the mean weight of soil/dust on the hands was 11 mg. Assuming that a child would put fingers or other "dirty" objects into his mouth about 10 times a day ingesting 11 mg of dirt each time, Lepow et al. (1974) estimated that the daily soil ingestion rate would be about 100 mg/day. According to Lepow et al. (1974), the amount of hand dirt measured with this technique is probably an underestimate because dirt trapped in skin folds and creases was probably not removed by the adhesive label. Consequently, mean soil ingestion rates may be somewhat higher than the values estimated in this study.

Duggan and Williams (1977) - Lead in Dust in City Streets - Duggan and Williams (1977) assessed the risks associated with lead in street dust by analyzing street dust from areas in and around London for lead, and estimating the amount of hand dirt that a child might ingest. Duggan and Williams (1977) estimated the amount of dust that would be retained on the forefinger and thumb by removing a small amount of dust from a weighed amount, rubbing the forefinger and thumb together, and reweighing to determine the amount retained on the finger and thumb. The results of "a number of tests with several different people" indicated that the mean amount of dust retained on the finger and thumb was approximately 4 mg with a range of 2 to 7 mg (Duggan and Williams, 1977). Assuming that a child would suck his/her finger or thumb 10 times a day and that all of the dirt is removed each time and replaced with new dirt prior to subsequent mouthing behavior, Duggan and Williams (1977) estimated that 20 mg of dust would be ingested per day.

Day et al. (1975) - Lead in Urban Street Dust - Day et al. (1975) evaluated the contribution of incidental ingestion of lead-contaminated street dust and soil to children's total daily intake of lead by measuring the amount of lead in street dust and soil and estimating the amount of dirt ingested by children. The amount of soil that might be ingested was estimated by measuring the amount of dirt that was transferred to a "sticky sweet" during 30 minutes of play and assuming that a child might eat from 2 to 20 such sweets per day. Based on "a small number of direct measurements," Day et al. (1975) found that 5 to 50 mg of dirt from a child's hands may be transferred to a "sticky sweet" during 30 minutes of "normal playground activity. Assuming that all of the dirt is ingested with the 2 to 20 "sticky sweets," Day et al. (1975) estimated that intake of soil among children could range from 10 to 1000 mg/day.

Hawley et al. (1985) - Assessment of Health Risk from Exposure to Contaminated Soil - Using existing literature, Hawley (1985) developed scenarios for estimating exposure of young children, older children, and adults to contaminated soil. Annual soil ingestion rates were estimated based on assumed intake rates of soil and housedust for indoor and outdoor activities and assumptions about the duration and frequency of the activities. These soil ingestion rates were based on the assumption that the contaminated area is in a region having a winter season. Housedust was assumed to be comprised of 80 percent soil.

Outdoor exposure to contaminated soil among young children (i.e., 2.5 years old) was assumed to occur 5 days per week during only 6 months of the year (i.e., mid-April through mid-October). Children were assumed to ingest 250 mg soil/day while playing outdoors based on data presented in Lepow et al. (1974; 1975) and Roels et al. (1980). Indoor exposures among this population were based on the assumption that young children ingest 100 mg of housedust per day while spending all of their time indoors during the winter months, and 50 mg of housedust per day during the warmer months when only a portion of their time is spent indoors. Based on these assumptions, Hawley (1985) estimated that the annual average soil intake rate for young children is 150 mg/day (Table 4-12). Older children (i.e., 6 year olds) were assumed to ingest 50 mg of soil per day from an area equal to the area of the fingers on one hand while playing outdoors. This assumption was based on data from Lepow et al. (1975). Outdoor activities were assumed to occur each day over 5 months of the year (i.e., during May through October). These children were also assumed to ingest 3 mg/day of housedust from the indoor surfaces of the hands during indoor activities occurring over the entire year. Using these data, Hawley (1985) estimated the annual average soil intake rate for older children to be 23.4 mg/day (Table 4-12).

Sedman and Mahmood (1994) - Soil Ingestion by Children and Adults Reconsidered Using the Results of Recent Tracer Studies - Sedman and Mahmood (1994) used the results of two recent childrens' (Calabrese et al. 1989; Davis et al. 1990) tracer studies to determine estimates of average daily soil ingestion in young children and for over a lifetime. In the two studies, the intake and excretion of a variety of tracers were monitored, and concentrations of tracers in soil adjacent to the childrens' dwellings were determined (Sedman and Mahmood, 1994). From a mass balance approach, estimates of soil ingestion in these children were determined by dividing the excess tracer intake (i.e., quantity of tracer recovered in the feces in excess of the measured intake) by the average concentration of tracer in soil samples from each child's dwelling. Sedman and Mahmood (1994) adjusted the mean estimates of soil ingestion in children for each

Table 4-12. Estimates of Soil Ingestion for Children

Scenarios	Media	Exposure (mg/day)	Days/Year Activity	Fraction Soil Content	Annual Average Soil Intake (mg/day)
Young Child (2.5 Years Old)					
Outdoor Activities (Summer)	Soil	250	130	1	90
Indoor Activities (Summer)	Dust	50	182	0.8	20
Indoor Activities (Winter	Dust	100	182	0.8	40
TOTAL SOIL INTAKE					150
Older Child (6 Years Old)					
Outdoor Activities (Summer)	Soil	50	152	1	21
Indoor Activities (Year-Round)	Dust	3	365	0.8	2.4
TOTAL SOIL INTAKE					23.4

Source: Hawley, 1985.

tracer (Y) from both studies to reflect that of a 2-year old child using the following equation:

$$Y_i = xe^{(-0.112 * yr)}$$

where:

Y_i = adjusted mean soil ingestion (mg/day)

x = a constant

yr = average age (2 years)

In addition to the study in young children, a study (Calabrese et al., 1989) in adults was conducted to evaluate the tracer methodology. In the adult studies, percent recoveries of tracers were determined in six adults who ingested known quantities of tracers in 1.5 or 0.3 grams of soil. The distribution of tracer recoveries from adults was evaluated using data analysis techniques involving visualization and exploratory data analysis (Sedman and Mahmood, 1994). From the results obtained in these studies, the distribution of tracer recoveries from adults were determined. In addition, an analysis of variance (ANOVA) and Tukey's multiple comparison method-ologies were employed to identify differences in the recoveries of the various tracers (Sedman and Mahmood, 1994).

From the adult studies, the ANOVA of the natural logarithm of the recoveries of tracers from 0.3 or 1.5 g of ingested soil showed a significant difference ($\propto = 0.05$) among the estimates of recovery of the tracers regardless of whether the recoveries were combined or analyzed separately (Sedman and Mahmood, 1994). Sedman and Mahmood (1994) also reported that barium, manganese, and zirconium yielded significantly different estimates of soil ingestion than the other tracers (aluminum, silicon, yttrium, titanium, and vanadium). Table 4-13 presents the Tukey's multiple comparison of mean log tracer recovery in adults ingesting known quantities of soil.

The average ages of children in the two recent studies were 2.4 years in Calabrese, et al. (1989) and 4.7 years in Davis et al. (1990). The mean of the adjusted levels of soil ingestion for a two year old child was 220 mg/kg for the Calabrese et al. (1989) study and 170 mg/kg for the Davis et al. (1990) study (Sedman and Mahmood, 1994). From the adjusted soil ingestion estimates, based on a normal distribution of means, the mean estimate for a 2-year old child was 195 mg/day and the overall mean of soil ingestion and the standard error of the mean was 53 mg/day (Sedman and Mahmood, 1994). Based on uncertainties associated with the method employed, Sedman and Mahmood (1994) recommended a conservative estimate of soil ingestion in young children of 250 mg/day. Based on the 250 mg/day ingestion rate in a 2-year old child, an average daily soil ingestion over a lifetime was estimated to be 70 mg/day. The lifetime

Table 4-13. Tukey's Multiple Comparison of Mean Log Tracer Recovery in Adults Ingesting Known Quantities of Soil

Tracer	Reported Mean (mg/day)	Age Adjusted Mean (mg/day)
	Calabrese et al., 1989 Study	
Aluminum	153	160
Silicon	154	161
Titanium	218	228
Vanadium	459	480
Yttrium	85	89
	Davis et al., 1990 Study	
Aluminum	39	53
Silicon	81	111
Titanium	246	333

[a] Age adjusted mean estimates of soil ingestion in young children. Mean estimates of soil ingestion for each tracer in each study were adjusted using the following equation:

$Y = Xe^{(-0.112*yr)}$, where Y = adjusted mean soil ingestion (mg/day), x = a constant, and yr = age in years.

Source: Sedman and Mahmood, 1994.

estimates were derived using the equation presented above that describes changes in soil ingestion with age (Sedman and Mahmood, 1994).

Calabrese and Stanek (1995) - Resolving Intertracer Inconsistencies in Soil Ingestion Estimation - Calabrese and Stanek (1995) explored sources and magnitude of positive and negative errors in soil ingestion estimates for children on a subject-week and trace element basis. Calabrese and Stanek (1995) identified possible sources of negative and positive errors to be the following: negative bias may result from tracers being ingested in food but not being captured either in the fecal sample due to slow lag time or not having a fecal sample available on the final study day; ingestion of high levels of tracers before the study starts and low ingestion during study period may result in over estimation of soil ingestion (positive bias); positive bias may occur if a subject ingests element tracers from a non-food or non-soil source during the study period; sample measurement errors which result in diminished detection of fecal tracers but not soil tracer levels may result in negative bias. The authors developed an approach which attempted to reduce the magnitude of error in the individual trace element ingestion estimates. Results from a previous study conducted by Calabrese et al. (1989) were used to quantify these errors based on the following criteria: (1) a lag period of 28 hours was assumed for the passage of tracers ingested in food to the feces (this value was applied to all subject-day estimates); (2) daily soil ingestion rate was estimated for each tracer for each 24-hr day a fecal sample was obtained; (3) the median tracer-based soil ingestion rate for each subject-day was determined. Also, upper and lower bound estimates were determined based on criteria formed using an assumption of the magnitude of the relative standard deviation (RSD) presented in another study conducted by Stanek and Calabrese (1995a). Daily soil ingestion rates for tracers that fell beyond the upper and lower ranges were excluded from subsequent calculations, and the median soil ingestion rates of the remaining tracer elements were considered the best estimate for that particular day. The magnitude of positive or negative error for a specific tracer per day was derived by determining the difference between the value for the tracer and the median value; (4) negative errors due to missing fecal samples at the end of the study period were also determined (Calabrese and Stanek, 1995).

Table 4-14 presents the estimated magnitude of positive and negative error for six tracer elements in the children's study (i.e., conducted by Calabrese et al., 1989). The original mean soil ingestion rates ranged from a low of 21 mg/day based on zirconium to a high of 459 mg/day based on titanium (Table 4-14). The adjusted mean soil ingestion rate after correcting for negative and positive errors ranged from 97 mg/day based on yttrium to 208 mg/day based on titanium (Table 4-14). Calabrese and Stanek (1995) concluded that correcting for errors at the individual level for each tracer element provides more reliable estimates of soil ingestion.

This report is valuable in providing additional understanding of the nature of potential errors in trace element specific estimates of soil ingestion. However, the operational definition used for estimating the error in a

Table 4-14. Positive/Negative Error (bias) in Soil Ingestion Estimates in the Calabrese et al. (1989) Mass-balance Study (5): Effect on Mean Soil Ingestion Estimate (mg/day)[a]

	Negative Error						
	Lack of Fecal Sample on Final Study Day	Other Causes[b]	Total Negative Error	Total Positive Error	Net Error	Original Mean	Adjusted Mean
Aluminum	14	11	25	43	+18	153	136
Silicon	15	6	21	41	+20	154	133
Titanium	82	187	269	282	+13	218	208
Vanadium	66	55	121	432	+311	459	148
Yttrium	8	26	34	22	-12	85	97
Zirconium	6	91	97	5	-92	21	113

[a] How to read table: for example, aluminum as a soil tracer displayed both negative and positive error. The cumulative total negative error is estimated to bias the mean estimate by 25 mg/day downward. However, aluminum has positive error biasing the original mean upward by 43 mg/day. The net bias in the original mean was 18 mg/day positive bias. Thus, the original 156 mg/day mean for aluminum should be corrected downward to 136 mg/day.

[b] Values indicate impact on mean of 128-subject-weeks in milligrams of soil ingested per day.

Source: Calabrese and Stanek, 1995.

trace element estimate was the observed difference of that tracer from a median tracer value. Specific identification of sources of error, or direct evidence that individual tracers were indeed in error was not developed. Corrections to individual tracer means were then made according to how different values for that tracer were from the median values. This approach is based on the hypothesis that the median tracer value is the most accurate estimate of soil ingestion, and the validity of this assumption depends on the specific set of tracers used in the study and need not be correct. The approach used for the estimation of daily tracer intake is the same as in Stanek and Calabrese (1995a), and some limitations of that approach are mentioned in the review of that study.

Sheppard (1995) - Parameter Values to Model the Soil Ingestion Pathway - Sheppard (1995) summarized the available literature on soil ingestion to estimate the amount of soil ingestion in humans for the purposes of risk assessment. Sheppard (1995) categorized the available soil ingestion studies into two general approaches: (1) those that measured the soil intake rate with the use of tracers in the soil, and (2) those that estimated soil ingestion based on activity (e.g., hand-to-mouth) and exposure duration. Sheppard (1995) provided estimates of soil intake based on previously published tracer studies. The data from these studies were assumed to be lognormally distributed due to the broad range, the concept that soil ingestion is never zero, and the possibility of very high values. In order to account for skewness in the data, geometric means rather than arithmetic means, were calculated by age, excluding pica and geophagy values. The geometric mean for soil ingestion rate for children under six was estimated to be 100 mg/day. For children over six and adults, the geometric mean intake rate was estimated to be 20 mg/day. Sheppard (1995) also provided soil ingestion estimates for indoor and outdoor activities based on data from Hawley (1985) and assumptions regarding duration of exposure (Table 4-15).

Sheppard's (1995) estimates, based on activity and exposure duration, are quite similar to the mean values from intake rate estimates described in previous sections. The advantages of this study are that the model can be used to calculate the ingestion rate from non-food sources with variability in exposure ingestion rates and exposure durations. The limitation of this study is that it does not introduce new data; previous data are re-evaluated. In addition, because the model is based on previous data, the same advantages and limitations of those studies apply.

AIHC Exposure Factors Sourcebook (1994) - The Exposure Factors Sourcebook (AIHC, 1994) uses data from the Calabrese et al. (1990) study to derive soil ingestion rates using zirconium as the tracer. More recent papers indicate that zirconium is not a good tracer. Therefore, the values recommended in the AIHC Sourcebook are not appropriate. Furthermore, because individuals were only studied for a short period of time, deriving a distribution of usual intake is not possible and is inappropriate.

Table 4-15. Soil Ingestion Rates for Assessment Purposes

Receptor Age	Setting	Soil Load on Hands (mg/cm^2)	Soil Exposure Ingestion Rate (mg/hr)	Suggested Exposure Durations (hr/yr)	Average Daily Soil Ingestion (mg/day)
Pica Child		---	1,000	200	500
2.5 yrs	Outdoor	0.5	20	1,000	50
	Indoor	0.4	3	Remaining[a]	60
6 yrs	Outdoor	0.5	10	700	20
	Indoor	0.04	0.15	5,000	2
Adult	Gardening	1.0	20	300	20
	Indoor	0.04	0.03	5,000	0.4

[a] Hawley (1985) assumed the child spent all the time at home, so that the indoor time was 8,760 hours/year minus the outdoor time.
Source: Sheppard, 1995

4.4. SOIL INTAKE AMONG ADULTS

Information on soil ingestion among adults is very limited. Hawley (1985) estimated soil ingestion among adults based on assumptions regarding activity patterns and corresponding ingestion amounts. Hawley (1985) assumed that adults ingest outdoor soil at a rate of 480 mg/day while engaged in yardwork or other physical activity. These outdoor exposures were assumed to occur 2 days/week during 5 months of the year (i.e., May through October). The ingestion estimate was based on the assumption that a 50 μm/thick layer of soil is ingested from the inside surfaces of the thumb and fingers of one hand. Ingestion of indoor housedust was assumed to occur from typical living space activities such as eating and smoking, and work in attics or other uncleaned areas of the house. Hawley (1985) assumed that adults ingest an average of 0.56 mg housedust/day during typical living space activities and 110 mg housedust/day while working in attics. Attic work was assumed to occur 12 days/year. Hawley (1985) also assumed that soil comprises 80 percent of household dust. Based on these assumptions about soil intake and the frequency of indoor and outdoor activities, Hawley (1985) estimated the annual average soil intake rate for adults to be 60.5 mg/day (Table 4-16).

Table 4-16. Estimates of Soil Ingestion for Adults

Scenarios	Media	Exposure (mg/day)	Days/Year Activity	Fraction Soil Content	Annual Average Soil Intake (mg/day)
Adult					
Work in attic (year-round)	Dust	110	12	0.8	3
Living Space (year-round)	Dust	0.56	365	0.8	0.5
Outdoor Work (summer)	Soil	480	43	1	57
TOTAL SOIL INTAKE					60.5

Source: Hawley, 1985.

The soil intake value estimated by Hawley (1985) is consistent with adult soil intake rates suggested by other researchers. Calabrese et al. (1987) suggested that soil intake among adults ranges from 1 to 100 mg/day. According to Calabrese et al. (1987), these values "are conjectural and based on fractional estimates" of earlier Center for Disease Control (CDC) estimates. In an evaluation of the scientific literature concerning soil ingestion rates for children and adults (Krablin, 1989), Arco Coal Company suggested that 10 mg/day may be an appropriate value for adult soil ingestion. This value is based on "extrapolation from urine arsenic epidemiological studies and information on mouthing behavior and time activity patterns" (Krablin, 1989).

Calabrese et al. - Preliminary Adult Soil Ingestion Estimates: Results of a Pilot Study- Calabrese et al. (1990) studied six adults to evaluate the extent to which they ingest soil. This adult study was originally part of the children soil ingestion study conducted by Calabrese and was used to validate part of the analytical methodology used in the children study. The participants were six healthy adults, three males and three females, 25-41 years old. Each volunteer ingested one empty gelatin capsule at breakfast and one at dinner Monday, Tuesday, and Wednesday during the first week of the study. During the second week, they ingested 50 mg of sterilized soil within a gelatin capsule at breakfast and at dinner (a total of 100 mg of sterilized soil per day) for 3 days. For the third week, the participants ingested 250 mg of sterilized soil in a gelatin capsule at breakfast and at dinner (a total of 500 mg of soil per day) during the three days. Duplicate meal samples (food and beverage) were collected from the six adults. The sample included all foods ingested from breakfast Monday, through the evening meal Wednesday during each of the 3 weeks. In addition, all medications and vitamins ingested by the adults were collected. Total excretory output were collected from Monday noon through Friday midnight over 3 consecutive weeks. Table 4-17 provides the mean and median values of soil ingestion for each element by week. Data obtained from the first week, when empty gelatin capsules were ingested, may be used to derive an estimate of soil intake by adults. The mean intake rates for the eight tracers are: Al, 110

Table 4-17. Adult Daily Soil Ingestion Estimates by Week and Tracer Element After Subtracting Food and Capsule Ingestion, Based on Median Amherst Soil Concentrations: Means and Medians Over Subjects (mg)[a]

Week	Al	Ba	Mn	Si	Ti	V	Y	Zr
Means								
1	110	-232	330	30	71	1,288	63	134
2	98	12,265	1,306	14	25	43	21	58
3	28	201	790	-23	896	532	67	-74
Medians								
1	60	-71	388	31	102	1,192	44	124
2	85	597	1,368	15	112	150	35	65
3	66	386	831	-27	156	047	60	-144

[a] Data were converted to milligrams
Source: Calabrese et al., 1990

mg; Ba, -232 mg; Mn, 330 mg; Si, 30 mg; Ti, 71 mg; V, 1,288 mg; Y, 63 mg; and Zr, 134 mg.

The advantage of this study is that it provides quantitative estimates of soil ingestion for adults. The study also corrected for tracer concentrations in foods and medicines. However, a limitation of this study is that a limited number of subjects were studied. In addition, the subjects were only studied for one week before soil capsules were ingested.

4.5. PREVALENCE OF PICA

The scientific literature define pica as "the repeated eating of non-nutritive substances" (Feldman, 1986). For the purposes of this handbook, pica is defined as an deliberately high soil ingestion rate. Numerous articles have been published that report on the incidence of pica among various populations. However, most of these papers describe pica for substances other than soil including sand, clay, paint, plaster, hair, string, cloth, glass, matches, paper, feces, and various other items. These papers indicate that the pica occurs in approximately half of all children between the ages of 1 and 3 years (Sayetta, 1986). The incidence of deliberate ingestion behavior in children has been shown to differ for different subpopulations. The incidence rate appears to be higher for black children than for white children. Approximately 30 percent of black children aged 1 to 6 years are reported to have deliberate ingestion behavior, compared with 10 to 18 percent of white children in the same age group (Danford, 1982). There does not appear to be any sex differences in the incidence rates for males or females (Kaplan and Sadock, 1985). Lourie et al. (1963) states that the incidence of pica is higher among children in lower socioeconomic groups (i.e., 50 to 60 percent) than in higher income families (i.e., about 30 percent). Deliberate soil ingestion behavior appears to be more common in rural areas (Vermeer and Frate, 1979). A higher rate of pica has also been reported for pregnant women and individuals with poor nutritional status (Danford, 1982). In general, deliberate ingestion behavior is more frequent and more severe in mentally retarded children than in children in the general population (Behrman and Vaughan 1983, Danford 1982, Forfar and Arneil 1984, Illingworth 1983, Sayetta 1986).

It should be noted that the pica statistics cited above apply to the incidence of general pica and not soil pica. Information on the incidence of soil pica is limited, but it appears that soil pica is less common. A study by Vermeer and Frate (1979) showed that the incidence of geophagia (i.e., earth-eating) was about 16 percent among children from a rural black community in Mississippi. However, geophagia was described as a cultural practice among the community surveyed and may not be representative of the general population. Average daily consumption of soil was estimated to be 50 g/day. Bruhn and Pangborn (1971) reported the incidence of pica for "dirt" to be 19 percent in children, 14 percent in pregnant women, and 3 percent in nonpregnant women. However, "dirt" was not clearly defined. The Bruhn and Pangborn (1971) study was conducted among 91 non-black, low income families of migrant agricultural workers in California. Based on the data from the five key tracer studies (Binder et al., 1986; Clausing et al., 1987; Van Wijnen et al., 1990; Davis et al., 1990; and Calabrese et al., 1989) only one child out of the more than 600 children involved in all of these studies ingested an amount of soil significantly greater than the range for other children. Although these studies did not include all populations and were representative of short-term ingestions only, it can be assumed that the incidence rate of deliberate soil ingestion behavior in the general population is low.

4.6. DELIBERATE SOIL INGESTION AMONG CHILDREN

Information on the amount of soil ingested by children with abnormal soil ingestion behavior is limited. However, some evidence suggests that a rate on the order of 10 g/day may not be unreasonable.

Calabrese et al. (1994) - Evidence of Soil Pica Behavior and Quantification of Soil Ingestion - Calabrese et al. (1991) estimated that upper range soil ingestion values may range from approximately 5-7 grams/day. This estimate was based on observations of one pica child among the 64 children who participated in the study. In the study, a 3.5-year old female exhibited extremely high soil ingestion behavior during one of the two weeks of observation. Intake ranged from 74 mg/day to 2.2 g/day during the first week of observation and 10.1 to 13.6 g/day during the second week of observation (Table 4-18). These results are based on mass-balance analyses for seven (i.e., aluminum, barium, manganese, silicon, titanium, vanadium, and yttrium) of the eight tracer elements used. Intake rates based on zirconium was significantly lower but Calabrese et al. (1991) indicated that this may have "resulted from a limitation in the analytical protocol."

Table 4-18. Daily Soil Ingestion Estimation in a Soil-Pica Child by Tracer and by Week (mg/day)

Tracer	Week 1 Estimated Soil Ingestion	Week 2 Estimated Soil Ingestion
Al	74	13,600
Ba	458	12,088
Mn	2,221	12,341
Si	142	10,955
Ti	1,543	11,870
V	1,269	10,071
Y	147	13,325
Zr	86	2,695

Source: Calabrese et al., 1991

Calabrese and Stanek (1992) - Distinguishing Outdoor Soil Ingestion from Indoor Dust Ingestion in a Soil Pica Child - Calabrese and Stanek (1992) quantitatively distinguished the amount of outdoor soil ingestion from indoor dust ingestion in a soil pica child. This study was based on a previous mass-balance study (conducted in 1991) in which a 3-1/2 year old child ingested 10-13 grams of soil per day over the second week of a 2-week soil ingestion study. Also, the previous study utilized a soil tracer methodology with eight different tracers (Al, Ba, Mn, Si, Ti, V, Y, Zr). The reader is referred to Calabrese et al. (1989) for a detailed description and results of the soil ingestion study. Calabrese and Stanek (1992) distinguished indoor dust from outdoor soil in ingested soil based on a methodology which compared differential element ratios.

Table 4-19 presents tracer ratios of soil, dust, and residual fecal samples in the soil pica child. Calabrese and Stanek (1992) reported that there was a maximum total of 28 pairs of tracer ratios based on eight tracers. However, only 19 pairs of tracer ratios were available for quantitative evaluation as shown in Table 4-19. Of these 19 pairs, 9 fecal tracer ratios fell within the boundaries for soil and dust (Table 4-19). For these 9 tracer soils, an interpolation was performed to estimate the relative contribution of soil and dust to the residual fecal tracer ratio. The other 10 fecal tracer ratios that fell outside the soil and dust boundaries were concluded to be 100 percent of the fecal tracer ratios from soil origin (Calabrese and Stanek, 1992). Also, the 9 residual fecal samples within the boundaries revealed that a high percentage (71-99 percent) of the residual fecal tracers were estimated to be of soil origin. Therefore, Calabrese and Stanek (1992) concluded that the predominant proportion of the fecal tracers was from outdoor soil and not from indoor dust origin.

In conducting a risk assessment for TCDD, U.S. EPA (1984) used 5 g/day to represent the soil intake rate for pica children. The Centers for Disease Control (CDC) also investigated the potential for exposure to TCDD through the soil ingestion route. CDC used a value of 10 g/day to represent the amount of soil that a child with deliberate soil ingestion behavior might ingest (Kimbrough et al., 1984). These values are consistent with those observed by Calabrese et al. (1991).

4.7. RECOMMENDATIONS

The key studies described in this section were used to recommend values for soil intake among children. The key and relevant studies used different survey designs and study populations. These studies are summarized in Table 4-20. For example, some of the studies considered food and nonfood sources of trace elements, while other did not. In other studies, soil ingestion estimates were adjusted to account for the contribution of house dust to this estimate. Despite these differences, the mean and upper-percentile estimates reported for these studies are relatively consistent. The confidence rating for soil intake recommendations is presented in Table 4-21.

It is important, however, to understand the various uncertainties associated with these values. First,

Table 4-19. Ratios of Soil, Dust, and Residual Fecal Samples in the Soil Pica Child

Tracer Ratio Pairs		Soil	Fecal	Dust	Estimated % of Residual Fecal Tracers of Soil Origin as Predicted by Specific Tracer Ratios
1.	Mn/Ti	208.368	215.241	260.126	87
2.	Ba/Ti	187.448	206.191	115.837	100
3.	Si/Ti	148.117	136.662	7.490	92
4.	V/Ti	14.603	10.261	17.887	100
5.	Ai/Ti	18.410	21.087	13.326	100
6.	Y/Ti	8.577	9.621	5.669	100
7.	Mn/Y	24.293	22.373	45.882	100
8.	Ba/Y	21.854	21.432	20.432	71
9.	Si/Y	17.268	14.205	1.321	81
10.	V/Y	1.702	1.067	3.155	100
11.	Al/Y	2.146	2.192	2.351	88
12.	Mn/Al	11.318	10.207	19.520	100
13.	Ba/Al	10.182	9.778	8.692	73
14.	Si/Al	8.045	6.481	0.562	81
15.	V/Al	0.793	0.487	1.342	100
16.	Si/V	10.143	13.318	0.419	100
17.	Mn/Si	1.407	1.575	34.732	99
18.	Ba/Si	1.266	1.509	15.466	83
19.	Mn/Ba	1.112	1.044	2.246	100

Source: Calabrese and Stanek, 1992.

individuals were not studied for sufficient periods of time to get a good estimate of the usual intake. Therefore, the values presented in this section may not be representative of long term exposures. Second, the experimental error in measuring soil ingestion values for individual children is also a source of uncertainty. For example, incomplete sample collection of both input (i.e., food and nonfood sources) and output (i.e., urine and feces) is a limitation for some of the studies conducted. In addition, an individual's soil ingestion value may be artificially high or low depending on the extent to which a mismatch between input and output occurs due to individual variation in the gastrointestinal transit time. Third, the degree to which the tracer elements used in these studies are absorbed in the human body is uncertain. Accuracy of the soil ingestion estimates depends on how good this assumption is. Fourth, there is uncertainty with regard to the homogeneity of soil samples and the accuracy of parent's knowledge about their child's playing areas. Fifth, all the soil ingestion studies presented in this section with the exception of Calabrese et al. (1989) were conducted during the summer when soil contact is more likely.

Although the recommendations presented below are derived from studies which were mostly conducted in the summer, exposure during the winter months when the ground is frozen or snow covered should not be considered as zero. Exposure during these months, although lower than in the summer months, would not be zero because some portion of the house dust comes from outdoor soil.

Soil Ingestion Among Children - Estimates of the amount of soil ingested by children are summarized below. The mean values ranged from 39 mg/day to 271 mg/day with an average of 146 mg/day for soil ingestion and 191 mg/day for soil and dust ingestion. Results obtained using titanium as a tracer in the Binder et al. (1986) and Clausing et al. (1987) studies were not considered in the derivation of this recommendation because these studies did not take into consideration other sources of the element in the diet which for titanium seems to be significant. Therefore, these values may overestimate the soil intake. One can note that this group of mean values is consistent with the 200 mg/day value that EPA programs have used as a conservative mean estimate. Taking into consideration that the highest values were seen with titanium, which may exhibit greater variability than the other tracers, and the fact that the Calabrese et al. (1989) study included a pica child, 100 mg/day appears to represent, based on judgment, the best estimate of the mean for children under 6 years of age. However, since the children were studied for short periods

Table 4-20. Soil Intake Studies

Study	Study Type	Number of Observations	Age	Population Studied	Comments
KEY STUDIES:					
Binder et al., 1986	Tracer study using aluminum, silicon, and titanium	59 children	1-3 years	Children living near lead smelter in Montana	Did not account for tracer in food and medicine; used assumed fecal weight of 15 g/day; short-term study conducted over 3 days
Calabrese et al., 1989	Tracer - mass balance study using aluminum, barium, manganese, silicon, titanium, vanadium, ytrium, and zirconium	64 Children	1-4 years	Children from greater Amherst area of Massachusetts; highly-educated parents	Corrected for tracer in food and medicine; study conducted over two-week period; used adults to validate methods; one pica child in study group.
Clausing et al., 1987	Tracer study using aluminum, acid insoluble residue, and titanium	18 nursery school children; 6 hospitalized children	2-4 years	Dutch children	Did not account for tracer in food and medicines; used tracer-based intake rates for hospitalized children as background values; short-term study conducted over 5 days
Davis et al., 1990	Tracer - mass balance study using aluminum silicon and titanium	104 children	2-7 years	Children from 3-city area in Washington State	Corrected for tracer in food and medicine; short-term study conducted over seven-day period; collected information on demographic characteristics affecting soil intake.
Stanek and Calabrese, 1995a	Adjusted soil intake estimates	64 children	1-4 years	Same children as in Calabrese et al., 1989	Based on data from Calabrese et al., 1989
Stanek and Calabrese, 1995b	Recalculated intake rates based on three previous mass-balance studies using the Best Tracer Method	164 children 6 adults	1-7 years 25-41 years	Children from three mass-balance studies	Based on studies of Calabrese et al., 1989; Davis et al., 1990; and Calabrese et al., 1990.
Van Wïjnen et al., 1990	Tracer study using aluminum, acid insoluble residue, and titanium	292 daycare children; 78 campers; 15 hospitalized children	1-5 years	Dutch children	Did not account for tracer in food and medicines; used tracer-based intake for hospitalized children as background values; evaluated population (campers) with greater access to soil; evaluated differences in soil intake due to weather conditions.

Table 4-20. Soil Intake Studies (continued)

Study	Study Type	Number of Observations	Age	Population Studied	Comments
RELEVANT STUDIES:					
Calabrese and Stanek, 1995	Adjusted soil intake estimated based on data from Calabrese et al., 1989	64 children	1-4 years	Same children as in Calabrese et al., 1989	Based on data from Calabrese et al., 1989
Day et al., 1977	Measured dirt on sticky sweets and assumed number of sweets eaten per day	Not specified	Not specified	Not specified	Based on observations and crude measurements
Duggan and Williams, 1977	Measured soil on fingers and observed mouthing behavior	Not specified	Not specified	Areas around London	Based on observations and crude measurements.
Hawley, 1985	Assumed soil intake rates based on nature and duration of activities	Not specified	Young children, older children, adults	Not specified	No data on soil intake collected; estimates based on assumptions regarding data from previous studies.
Lepow et al., 1974	Measured soil on hands and observed mouthing behavior	22 children	2-6 years	Urban children from Connecticut	Based on observations over 3-6 hours of play and crude measurement techniques.
Sedman and Mahmood, 1994	Adjusted data from earlier tracer-mass balance studies to generate mean soil intake rates for a 2-year old child	64 children from Calabrese et al., 1989 study and 104 children from Davis et al., 1990 study	Adjusted to 2-year old child	Same children as in Calabrese et al., 1989 and Davis et al., 1990 study	Based on data from Calabrese et al., 1989 and Davis et al., 1990
Sheppard, 1995	Provides estimates based on the current literature on soil ingestion from tracer methods and recommends values for use in assessments	Not specified	1 year-adults (age not specified)	Various	Presents mean estimates for children and adults; provides ingestion estimates for indoor and outdoor activities based on Hawley, 1985.
Thompson and Burmaster, 1991	Re-evaluation of Binder et al., 1986 data	59 children	1-3 years	Children living near lead smelter in Montana	Re-calculated soil intake rates from Binder et al., 1986 data using actual fecal weights instead of assumed weights.
PICA STUDIES:					
Calabrese et al., 1991	Tracer - mass balance	1 pica child	3.5 years	1 pica child from greater Amherst area of Massachusetts	Child was observed as part of the Calabrese et al., 1989 study.
Calabrese and Stanek, 1992	Reanalysis of data from Calabrese et al., 1991	1 pica child	3.5 years	1 pica child from greater Amherst area of Massachusetts	Distinguished between outdoor soil ingestion and indoor dust ingestion in a soil pica child.

Table 4-21. Confidence in Soil Intake Recommendation

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	All key studies are from peer review literature	High
• Accessibility	Papers are widely available from peer review journals	High
• Reproducibility	Methodology used was presented, but results are difficult to reproduce	Medium
• Focus on factor of interest	The focus of the studies was on estimating soil intake rate by children; studies did not focus on intake rate by adults	High (for children) Low (for adults)
• Data pertinent to U.S.	Two of the key studies focused on Dutch children; other studies used children from specific areas of the U.S.	Medium
• Primary data	Al l the studies were based on primary data	High
• Currency	Studies were conducted after 1980	High
• Adequacy of data collection period	Children were not studied long enough to fully characterize day to day variability.	Medium
• Validity of approach	The basic approach is the only practical way to study soil intake, but refinements are needed in tracer selection and matching input with outputs. The more recent studies corrected the data for sources of the tracers in food. There are, however, some concerns about abosorption of the tracers into the body and lag time between input and output.	Medium
• Study size	The sample sizes used in the key studies were adequate for children. However, only few adults have been studied.	Medium (for children) Low (for adults)
• Representativeness of the population	Study population may not be representative of the U.S. in terms of race, socio-economics, and geographical location; Studies focused on specific areas; two of the studies used Dutch children	Low
• Characterization of variability	Day-to-day variability was not very well characterized	Low
• Lack of bias in study design (high rating is desirable)	The selection of the population studied may introduce some bias in the results (i.e., children near a smelter site, volunteers in nursery school, Dutch children)	Medium
• Measurement error	Errors may result due to problems with absorption of the tracers in the body and mismatching inputs and outputs.	Medium
Other Elements		
• Number of studies	There are 5 key studies	High
• Agreement between researchers	Despite the variability, there is general agreement among researchers on central estimates of daily intake for children	Medium
Overall Rating	Studies were well designed; results were fairly consistent; sample size was adequate for children and very small for adults; accuracy of methodology is uncertain; variability cannot be characterized due to limitations in data collection period. Insufficient data to recommend upper percentile estimates for both children and adults.	Medium (for children - long-term central estimate) Low (for adults) Low (for upper percentile)

of time and the prevalence of pica behavior is not known, excluding the pica child from the calculations may underestimate soil intake rates. It is plausible that many children may exhibit some pica behavior if studied for longer periods of time. Over the period of study, upper percentile values ranged from 106 mg/day to 1,432 mg/day with an average of 383 mg/day for soil ingestion and 587 mg/day for soil and dust ingestion. Rounding to one significant figure, the recommended upper percentile soil ingestion rate for children is 400 mg/day. However, since the period of study was short, these values are not estimates of usual intake. The recommended values for soil ingestion among children and adults are summarized in Table 4-22.

Mean (mg/day)					Upper Percentile (mg/day)				References
Al	Si	AIR[a]	Ti	Y	Al	Si	Ti	Y	
181	184				584	578			Binder et al. 1986
230		129							Clausing et al. 1987
39	82		245.5						Davis et al. 1990
64.5[b]	160[b]		268.4[b]						
153	154		218	85	223	276	1,432	106	Calabrese et al. 1989
154[b]	483[b]		170[b]	65[b]	478[b]	653[b]	1,059[b]	159[b]	
122	139	--	271	165	254	224	279	144	Stanek and Calabrese, 1995a
133[d]					217[d]				Stanek and Calabrese, 1995b
69-120[c]									Van Wïjnen et al. 1990
Average =	146 mg/day soil 191 mg/day soil and dust combined				383 mg/day soil 587 mg/day soil and dust combined				

[a] AIR = Acid Insoluble Residue
[b] Soil and dust combined
[c] LTM; corrected value
[d] BTM

Table 4-22. Summary of Recommended Values for Soil Ingestion

Population	Mean	Upper Percentile
Children	100 mg/day[a]	400 mg/day[b]
Adults	50 mg/day	-- mg/day (outdoor activities)
Pica child	10 g/day[c]	---

[a] 200 mg/day may be used as a conservative estimate of the mean (see text).
[b] Study period was short; therefore, these values are not estimates of usual intake.
[c] To be used in acute exposure assessments. Based on only one pica child (Calabrese et al., 1989).

Data on soil ingestion rates for children who deliberately ingest soil are also limited. However, an ingestion rate of 10 g/day may not be an unreasonable assumption for use in acute exposure assessments, based on the available information. It should be noted, however, that this value is based on only one pica child observed in the Calabrese et al. (1989) study.

Soil Ingestion Among Adults - Only three studies have attempted to estimate adult soil ingestion. Hawley (1985) suggested a value of 480 mg/day for adults engaged in outdoor activities and a range of 0.56 to 110 mg/day of house dust during indoor activities. These estimates were derived from assumptions about soil/dust levels on hands and mouthing behavior; no supporting measurements wre made. Making further assumptions about frequencies of indoor and outdoor activities Hawley derived an annual average of 60.5 mg/day. Given the lack of supporting measurements, these estimates must be considered conjectural, Krablin (1989) used arsenic levels in urine (n = 26) combined with information on mouthing behavior and activity patterns to suggest an estimate for adult soil ingestion of 10 mg/day. The study protocols are not well described and has not been formally published. Finally, Calabrese (1990) conducted a tracer study on 6 adults and found a range of 30 to 100 mg/day. This study is probably the most reliable of the three, but still has two significant uncertainties: (1) representativeness of the general population is unknown due to the small study size (n = 6); and (2) representativeness of long-term behavior is unknown since the study was conducted over only 2 weeks. In the past, many EPA risk assessments hve assumed an adult soil ingestion rate of 50 mg/day for industrial settings and 100 mg/day for residential and agricultural scenarios. These values are within the range of estimates from the studies discussed sbove. Thus, 50 mg/day still represents a reasonable central estimate of adult soil ingestion and is recommended here. This recommendation is clearly highly uncertain; however, and as indicated in Table 4-21, is given a low confidence rating. Considering the uncertainties in the central estimate, any speculation about an upper percentile would be inappropriate. Table 4-22 summarizes soil ingestion recommendations for adults.

4.8. REFERENCES FOR CHAPTER 4

American Industrial Health Council (AIHC). (1994) Exposure factors sourcebook. AIHC, Washington, DC.

Binder, S.; Sokal, D.; Maughan, D. (1986) Estimating soil ingestion: the use of tracer elements in estimating the amount of soil ingested by young children. Arch. Environ. Health. 41(6):341-345.

Behrman, L.E.; Vaughan, V.C., III. (1983) Textbook of Pediatrics. Philadelphia, PA: W.B. Saunders Company.

Bruhn, C.M.; Pangborn, R.M. (1971) Reported incidence of pica among migrant families. J. of the Am. Diet. Assoc. 58:417-420.

Calabrese, E.J.; Kostecki, P.T.; Gilbert, C.E. (1987) How much soil do children eat? An emerging consideration for environmental health risk assessment. In press (Comments in Toxicology).

Calabrese, E.J.; Pastides, H.; Barnes, R.; Edwards, C.; Kostecki, P.T.; et al. (1989) How much soil do young children ingest: an epidemiologic study. In: Petroleum Contaminated Soils, Lewis Publishers, Chelsea, MI. pp. 363-397.

Calabrese, E.J.; Stanek, E.J.; Gilbert, C.E.; Barnes, R.M. (1990) Preliminary adult soil ingestion estimates; results of a pilot study. Regul. Toxicol. Pharmacol. 12:88-95.

Calabrese, E.J.; Stanek, E.J.; Gilbert, C.E. (1991) Evidence of soil-pica behavior and quantification of soil ingested. Hum. Exp. Toxicol. 10:245-249.

Calabrese, E.J.; Stanek, E.J. (1992) Distinguishing outdoor soil ingestion from indoor dust ingestion in a soil pica child. Regul. Toxicol. Pharmacol. 15:83-85.

Calabrese, E.J.; Stanek, E.J. (1995) Resolving intertracer inconsistencies in soil ingestion estimation. Environ. Health Perspect. 103(5):454-456.

Clausing, P.; Brunekreef, B.; Van Wijnen, J.H. (1987) A method for estimating soil ingestion by children. Int. Arch. Occup. Environ. Health (W. Germany) 59(1):73-82.

Danford, D.C. (1982) Pica and nutrition. Annual Review of Nutrition. 2:303-322.

Davis, S.; Waller, P.; Buschbon, R.; Ballou, J.; White, P. (1990) Quantitative estimates of soil ingestion in normal children between the ages of 2 and 7 years: population based estimates using aluminum, silicon, and titanium as soil tracer elements. Arch. Environ. Hlth. 45:112-122.

Day, J.P.; Hart, M.; Robinson, M.S. (1975) Lead in urban street dust. Nature 253:343-345.

Duggan, M.J.; Williams, S. (1977) Lead in dust in city streets. Sci. Total Environ. 7:91-97.

Feldman, M.D. (1986) Pica: current perspectives. Psychosomatics (USA) 27(7):519-523.

Forfar, J.O.; Arneil, G.C., eds. (1984) Textbook of Paediatrics. 3rd ed. London: Churchill Livingstone.

Hawley, J.K. (1985) Assessment of health risk from exposure to contaminated soil. Risk Anal. 5:289-302.

Illingworth, R.S. (1983) The normal child. New York: Churchill Livingstone.

Kaplan, H.I.; Sadock, B.J. (1985) Comprehensive textbook of psychiatry/IV. Baltimore, MD: Williams and Wilkins.

Kimbrough, R.; Falk, H.; Stemr, P.; Fries, G. (1984) Health implications of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) contamination of residential soil. J. Toxicol. Environ. Health 14:47-93.

Krablin, R. (1989) [Letter to Jonathan Z. Cannon concerning soil ingestion rates[. Denver, CO: Arco Coal Co.; October 13, 1989.

Lepow, M.L.; Bruckman, L.; Robino, R.A.; Markowitz, S.; Gillette, M.; et al. (1974) Role of airborne lead in increased body burden of lead in Hartford children. Environ. Health Perspect. 6:99-101.

Lepow, M.L.; Buckman, L.; Gillette, M.; Markowitz, S.; Robino, R.; et al. (1975) Investigations into sources of lead in the environment of urban children. Environ. Res. 10:415-426.

Lourie, R.S.; Layman, E.M.; Millican, F.K. (1963) Why children eat things that are not food. Children 10:143-146.

Roels, H.; Buchet, J.P.; Lauwerys, R.R. (1980) Exposure to lead by the oral and pulminary route of children living in the vicinity of a primary lead smelter. Environ. Res. 22:81-94.

Sayetta, R.B. (1986) Pica: An overview. American Family Physician 33(5):181-185.

Sedman, R.; Mahmood, R.S. (1994) Soil ingestion by children and adults reconsidered using the results of recent tracer studies. Air and Waste, 44:141-144.

Sheppard, S.C. (1995) Parameter values to model the soil ingestion pathway. Environmental Monitoring and Assessment 34:27-44.

Stanek, E.J.; Calabrese, E.J. (1995a) Daily estimates of soil ingestion in children. Environ. Health Perspect. 103(3):276-285.

Stanek, E.J.; Calabrese, E.J. (1995b) Soil ingestion estimates for use in site evaluations based on the best tracer method. Human and Ecological Risk Assessment. 1:133-156.

Thompson, K.M.; Burmaster, D.E. (1991) Parametric distributions for soil ingestion by children. Risk Analysis. 11:339-342.

U.S. EPA. (1984) Risk analysis of TCDD contaminated soil. Washington, DC: U.S. Environmental Protection Agency, Office of Health and Environmental Assessment. EPA 600/8-84-031.

Van Wijnen, J.H.; Clausing, P.; Brunekreff, B. (1990) Estimated soil ingestion by children. Environ. Res. 51:147-162.

Vermeer, D.E.; Frate, D.A. (1979) Geophagia in rural Mississippi: environmental and cultural contexts and nutritional implications. Am. J. Clin. Nutr. 32:2129-2135.

TABLE OF CONTENTS

5. INHALATION ROUTE

This chapter presents data and recommendations for inhalation rates that can be used to assess exposure to contaminants in air. The studies discussed in this chapter have been classified as key or relevant. Key studies are used as the basis for deriving recommendations and the relevant studies are included to provide additional background and perspective. The recommended inhalation rates are summarized in Section 5.2.4 and cover adults, children, and outdoor workers/athletes.

Inclusion of this chapter in the Exposure Factors Handbook is not meant to imply that assessors will always need to select and use inhalation rates when evaluating exposure to air contaminants. In fact, it is unnecessary to calculate inhaled dose when using dose-response factors from Integrated Risk Information System (IRIS). This is due to the fact that the "dose-response" relationships recommended in IRIS for air contaminants are not really based on dose, but rather concentration. Such "dose-response" relationships require only an average air concentration to evaluate health concerns:

- For non-carcinogens, IRIS uses Reference Concentrations (RfC) which are expressed in concentration units. Hazard is evaluated by comparing the inspired air concentration to the RfC.

- For carcinogens, IRIS uses unit risk values which are expressed in inverse concentration units. Risk is evaluated by multiplying the unit risk by the inspired air concentration.

5.1. EXPOSURE EQUATION FOR INHALATION

The general equation for calculating average daily dose (ADD) for inhalation exposure is:

$$ADD = [[C \times IR \times ED] / [BW \times AT]] \qquad \text{(Eqn. 5-1)}$$

where:

ADD	=	average daily dose (mg/kg-day);
C	=	contaminant concentration in inhaled air ($\mu g/m^3$) for gaseous measurements expressed in ppm (1 ppm = 10^6 $\mu g/m^3$);
IR	=	inhalation rate (m^3/day);
ED	=	exposure duration (days);
BW	=	body weight (kg); and
AT	=	averaging time (days), for non-carcinogenic effects AT = ED, for carcinogenic or chronic effects AT = 70 years or 25,550 days (lifetime).

The average daily dose is the dose rate averaged over a pathway-specific period of exposure expressed as a daily dose on a per-unit-body-weight basis. The ADD is used for exposure to chemicals with non-carcinogenic non-chronic effects. For compounds with carcinogenic or chronic effects, the lifetime average daily dose (LADD) is used. The LADD is the dose rate averaged over a lifetime. The contaminant concentration refers to the concentration of the contaminant in inhaled air. Exposure duration refers to the total time an individual is exposed to an air pollutant. Factors affecting inhalation rates (expressed as cubic meters per hour) are age, gender, weight, health status and activity patterns (i.e., frequencies and durations of physical activities) (Layton, 1993).

5.2. INHALATION RATE

5.2.1. Background

The health risk associated with human exposure to airborne toxics is a function of concentration of air pollutants, chemical species, duration of exposure, and inhalation rate. The estimation for inhaled dose for a given air pollutant is dependent on inhalation rate, commonly described as ventilation rate (VR) or breathing rate, which is usually measured as minute volume, the volume in liters of air exhaled per minute (V_E). The volume of air exhaled (V_E) is the product of the number of respiratory cycles in a minute and the volume of air respired during each respiratory cycle, the tidal volume (V_T).

When interested in calculating absorbed dose, assessors must consider the alveolar ventilation rate. This is the amount of air available for exchange with alveoli per unit time. It is equivalent to the tidal volume (V_T) minus the anatomic dead space of the lungs (the space containing air that does not come into contact with the alveoli). Alveolar ventilation is approximately 70 percent of total ventilation; tidal volume is approximately 500 milliliters (ml) and the amount of anatomic dead space in the lungs is approximately 150 ml, approximately 30 percent of the amount of air inhaled (Menzel and Admur, 1986). This adjustment is not needed for those assessments using dose-response factors that are based on administered dose.

Breathing rates are affected by numerous individual characteristics, including age, gender, weight, health status, and levels of activity (running, walking, jogging, etc.). Ventilation rates (VR) are either measured directly using a spirometer and a collection system or indirectly from heart rate (HR) measurements. In many of the studies described in the following sections, HR measurements are usually correlated with VR in simple and multiple regression analysis.

In the Ozone Criteria Document prepared by the U.S. EPA Office of Environmental Criteria and Assessment, the EPA identified the collapsed range of activities and its corresponding VR as follows: light exercise (V_E < 23 L/min or 1.4 m^3/hr); moderate/ medium exercise (V_E = 24-43 L/min or 1.4-2.6 m^3/hr); heavy exercise (V_E = 43-63 L/min or 2.6-3.8 m^3/hr); and very heavy exercise (V_E > 64 L/min or 3.8 m^3/hr), (CARB, 1993). Also, 20 m^3/day has been adopted as a standard inhalation rate for humans (Federal Register, 1980). This value is widely used to determine the inhaled dose for a given air pollutant for adults.

The available studies on inhalation rates are summarized in the following sections. Inhalation rates are reported for outdoor workers/athletes, adults, and children, including infants performing various activities. Inhalation rates may be higher among outdoor workers/athletes because levels of activity outdoors may be higher. Therefore, this subpopulation group may be more susceptible to air pollutants and are considered a "high-risk" subgroup (Shamoo et al., 1991; Linn et al., 1992). The activity levels have been categorized as resting, sedentary, light, moderate, and heavy. In most studies, the sample population kept diaries to record their physical activities, locations, and breathing rates. Ventilation rates were either measured, self-estimated or predicted from equations derived using VR-HR calibration relationships.

5.2.2. Key Inhalation Rate Studies

Layton - Metabolically Consistent Breathing Rates for use in Dose Assessments - Layton (1993) presented a new method for estimating metabolically consistent inhalation rates for use in quantitative dose assessments of airborne radionuclides. Generally, the approach for estimating the breathing rate for a specified time frame was to calculate a time-weighted-average of ventilation rates associated with physical activities of varying durations (Layton, 1993). However, in this study, breathing rates were calculated based on oxygen consumption associated with energy expenditures for short (hours) and long (weeks and months) periods of time, using the following general equation to calculate energy-dependent inhalation rates:

$$V_E = E \times H \times VQ \qquad \text{(Eqn. 5-2)}$$

where:

V_E = ventilation rate (L/min or m^3/hr);
E = energy expenditure rate; [kilojoules/minute (KJ/min) or megajoules/hour (MJ/hr)];
H = volume of oxygen (at standard temperature and pressure, dry air [STPD]) consumed in the production of 1 kilojoule [KJ of energy expended (L/KJ or m^3/MJ); and
VQ = ventilatory equivalent (ratio of minute volume (L/min) to oxygen uptake (L/min)) unitless.

Three alternative approaches were used to estimate daily chronic (long term) inhalation rates for different age/gender cohorts of the U.S. population.

<u>First Approach</u>

Inhalation rates were estimated by multiplying average daily food energy intakes for different age/gender cohorts, volume of oxygen (H), and ventilatory equivalent (VQ) as shown in the equation above (see footnote (a) on Table 5-2). The average food energy intake data (Table 5-1) were obtained from the USDA 1977-78 Nationwide Food Consumption Survey (USDA-NFCS). The food energy intakes were adjusted upwards by a constant factor of 1.2 for all individuals 9 years and older (Layton, 1993). This factor compensated for a consistent bias in USDA-NFCS atrributed to under reporting of the foods consumed or the methods used to ascertain dietary intakes. Layton (1993) used a weighted average oxygen uptake of 0.05 L O_2/KJ which was determined from data reported in the 1977-78 USDA-NFCS and the second National Health and Nutrition Examination Survey (NHANES II). The ventilatory equivalent (VQ) of 27 used was calculated as the geometric mean of VQ data that were obtained from several studies by Layton (1993).

Table 5-2 presents the daily inhalation rate for each age/gender cohort. The highest daily inhalation rates were reported for children between the ages of 6-8 years (10 m^3/day), for males between 15-18 years (17 m^3/day), and females between 9-11 years (13 m^3/day). Estimated average lifetime inhalation rates for males and females are 14 m^3/day and 10 m^3/day, respectively (Table 5-2). Inhalation rates were also calculated for active and inactive periods for the various age/gender cohorts.

The inhalation rate for inactive periods was estimated by multiplying the basal metabolic rate (BMR) times the oxygen uptake (H) times the ventilatory equivalent(VQ). BMR was defined as "the minimum

Table 5-1. Comparisons of Estimated Basal Metabolic Rates (BMR) with Average Food-energy Intakes for Individuals Sampled in the 1977-78 NFCS

Cohort/Age	Body Weight	BMR[a]		Energy Intake (EFD)		Ratio
(y)	kg	MJ d^{-1}[b]	kcal d^{-1}[c]	MJ d^{-1}	kcal d^{-1}	EFD/BMR
Children						
Under 1	7.6	1.74	416	3.32	793	1.90
1 to 2	13	3.08	734	5.07	1209	1.65
3 to 5	18	3.69	881	6.14	1466	1.66
6 to 8	26	4.41	1053	7.43	1774	1.68
Males						
9 to 11	36	5.42	1293	8.55	2040	1.58
12 to 14	50	6.45	1540	9.54	2276	1.48
15 to 18	66	7.64	1823	10.8	2568	1.41
19 to 22	74	7.56	1804	10.0	2395	1.33
23 to 34	79	7.87	1879	10.1	2418	1.29
35 to 50	82	7.59	1811	9.51	2270	1.25
51 to 64	80	7.49	1788	9.04	2158	1.21
65 to 74	76	6.18	1476	8.02	1913	1.30
75 +	71	5.94	1417	7.82	1866	1.32
Females						
9 to 11	36	4.91	1173	7.75	1849	1.58
12 to 14	49	5.64	1347	7.72	1842	1.37
15 to 18	56	6.03	1440	7.32	1748	1.21
19 to 22	59	5.69	1359	6.71	1601	1.18
23 to 34	62	5.88	1403	6.72	1603	1.14
35 to 50	66	5.78	1380	6.34	1514	1.10
51 to 64	67	5.82	1388	6.40	1528	1.10
65 to 74	66	5.26	1256	5.99	1430	1.14
75 +	62	5.11	1220	5.94	1417	1.16

[a] Calculated from the appropriate age and gender-based BMR equations given in Appendix Table 5A-1.
[b] MJ d^{-1} - mega joules/day
[c] kcal d^{-1} - kilo calories/day
Source: Layton, 1993.

Table 5-2. Daily Inhalation Rates Calculated from Food-Energy Intakes

Cohort/Age	L[d]	Daily[a] Inhalation Rate (m^3/day)	Sleep (h)	MET[b] Value A[e]	MET[b] Value F[f]	Inhalation Rates Inactive[c] (m^3/day)	Inhalation Rates Active[c] (m^3/day)
Children							
< 1	1	4.5	11	1.9	2.7	2.35	6.35
1 - 2	2	6.8	11	1.6	2.2	4.16	9.15
3 - 5	3	8.3	10	1.7	2.2	4.98	10.96
6 - 8	3	10	10	1.7	2.2	5.95	13.09
Males							
9 - 11	3	14	9	1.9	2.5	7.32	18.3
12 - 14	3	15	9	1.8	2.2	8.71	19.16
15 - 18	4	17	8	1.7	2.1	10.31	21.65
19 - 22	4	16	8	1.6	1.9	10.21	19.4
23 - 34	11	16	8	1.5	1.8	10.62	19.12
35 - 50	16	15	8	1.5	1.8	10.25	18.45
51 - 64	14	15	8	1.4	1.7	10.11	17.19
65 - 74	10	13	8	1.6	1.8	8.34	15.01
75+	1	13	8	1.6	1.9	8.02	15.24
Lifetime[g] average		14					
Females							
9 - 11	3	13	9	1.9	2.5	6.63	16.58
12 - 14	3	12	9	1.6	2.0	7.61	15.20
15 - 18	4	12	8	1.5	1.7	8.14	13.84
19 - 22	4	11	8	1.4	1.6	7.68	12.29
23 - 34	11	11	8	1.4	1.6	7.94	12.7
35 - 50	16	10	8	1.3	1.5	7.80	11.7
51 - 64	14	10	8	1.3	1.5	7.86	11.8
65 - 74	10	9.7	8	1.4	1.5	7.10	10.65
75+	1	9.6	8	1.4	1.6	6.90	11.04
Lifetime[g] average		10					

[a] Daily inhalation rate was calculated by multiplying the EFD values (see Table 5-1) by H x VQ for subjects under 9 years of age and by 1.2 x H x VQ for subjects 9 years of age and older (see text for explanation).
Where:
EFD = Food energy intake (MJ/day) or (KCal/sec)
H = Oxygen uptake = 0.05 LO_2/KJ or M^3O_2/MJ
VQ = Ventilation equivalent = 27 = geometric mean of VQs (unitless)

[b] MET = Metabolic equivalent

[c] Inhalation rate for inactive periods was calculated as BMR x H x VQ and for active periods by multiplying inactive inhalation rate by F (See footnote f); BMR values are from Table 5-1.
Where:
BMR = Basal metabolic rate (MJ/day) or (kg/hr)

[d] L is the number of years for each age cohort.

[e] For individuals 9 years of age and older, A was calculated by multiplying the ratio for EFD/BMR (unitless) (Table 5-1) by the factor 1.2 (see text for explanation).

[f] F = (24A - S)/(24 - S) (unitless), ratio of the rate of energy expenditure during active hours to the estimated BMR (unitless)
Where:
S = Number of hours spent sleeping each day (hrs)

[g] Lifetime average was calculated by multiplying individual inhalation rate by corresponding L values summing the products across cohorts and dividing the result by 75, the total of the cohort age spans.

Source: Layton, 1993.

amount of energy required to support basic cellular respiration while at rest and not actively digesting food"(Layton, 1993). The inhalation rate for active periods was calculated by multiplying the inactive inhalation rate by the ratio of the rate of energy expenditure during active hours to the estimated BMR. This ratio is presented as F in Table 5-2. These data for active and inactive inhalation rates are also presented in Table 5-2. For children, inactive and active inhalation rates ranged between 2.35 and 5.95 m^3/day and 6.35 to 13.09 m^3/day, respectively. For adult males (19-64 years old), the average inactive and active inhalation rates were approximately 10 and 19 m^3/day, respectively. Also, the average inactive and active inhalation rates for adult females (19-64 years old) were approximately 8 and 12 m^3/day, respectively.

Second Approach

Inhalation rates were calculated by multiplying the BMR of the population cohorts times A (ratio of total daily energy expenditure to daily BMR) times H (oxygen uptake) times VQ (ventilation equivalent). The BMR data obtained from literature had been statistically analyzed and regression equations were developed to predict BMR from body weights of various age/gender cohorts (Layton, 1993). The statistical data used to develop the regression equations are presented in Appendix Table 5A-1. The data obtained from the second approach are presented in Table 5-3. Inhalation rates for children (6 months - 10 years) ranged from 7.3-9.3 m^3/day and ages 10-18 years was 15 m^3/day, while adult females (18 years and older) ranged from 9.9-11 m^3/day and adult males (18 years and older) ranged from 13-17 m^3/day. These rates are similar to the daily inhalation rates obtained using the first approach. Also, the inactive inhalation rates obtained from the first approach are lower than the inhalation rates obtained using the second approach. This may be attributed to the BMR multiplier employed in the equation of the second approach to calculate inhalation rates.

Third Approach

Inhalation rates were calculated by multiplying estimated energy expenditures associated with different levels of physical activity engaged in over the course of an average day by VQ (ventilation equivalent) and H (oxygen uptake) for each age/gender cohort. The energy expenditure associated with each level of activity was estimated by multiplying BMRs of each activity level by the metabolic equivalent (MET) and by the time spent per day performing each activity for each age/gender population. The time-activity data used in this approach were obtained from a survey conducted by Sallis et al.

Table 5-3. Daily Inhalation Rates Obtained from the Ratios of Total Energy Expenditure to Basal Metabolic Rate (BMR)

Gender/Age (yrs)	Body Weight[a] (kg)	BMR[b] (MJ/day)	VQ	A[c]	H (m^3O_2/MJ)	Inhalation Rate, V_E (m^3/day)[d]
Male						
0.5 - < 3	14	3.4	27	1.6	0.05	7.3
3 - < 10	23	4.3	27	1.6	0.05	9.3
10 - < 18	53	6.7	27	1.7	0.05	15
18 - < 30	76	7.7	27	1.59	0.05	17
30 - < 60	80	7.5	27	1.59	0.05	16
60 +	75	6.1	27	1.59	0.05	13
Female						
0.5 - < 3	11	2.6	27	1.6	0.05	5.6
3 - < 10	23	4.0	27	1.6	0.05	8.6
10 - < 18	50	5.7	27	1.5	0.05	12
18 - < 30	62	5.9	27	1.38	0.05	11
30 - < 60	68	5.8	27	1.38	0.05	11
60 +	67	5.3	27	1.38	0.05	9.9

[a] Body weight was based on the average weights for age/gender cohorts in the U.S. population.
[b] The BMRs (basal metabolic rate) are calculated using the respective body weights and BMR equations (see Appendix Table 5A-1).
[c] The values of the BMR multiplier (EFD/BMR) for those 18 years and older were derived from the Basiotis et al. (1989) study: Male = 1.59, Female = 1.38. For males and females under 10 years old, the mean BMR multiplier used was 1.6. For males and females aged 10 to < 18 years, the mean values for A given in Table 5-2 for 12-14 years and 15-18 years, age brackets for males and females were used: male = 1.7 and female = 1.5.
[d] Inhalation rate = BMR x A x H x VQ; VQ = ventilation equivalent and H = oxygen uptake.
Source: Layton, 1993.

(1985) (Layton, 1993). In that survey, the physical-activity categories and associated MET values used were sleep, MET = 1; light-activity, MET = 1.5; moderate activity, MET = 4; hard activity, MET = 6; and very hard activity, MET = 10. The physical activities were based on recall (Layton, 1993). The survey sample was 2,126 individuals (1,120 women and 1,006 men) ages 20-74 years that were randomly selected from four communities in California. The BMRs were estimated using the metabolic equations presented in Appendix Table 5A-1. The body weights were obtained from a study conducted by Najjar and Rowland (1987) which randomly sampled individuals from the U.S. population (Layton, 1993). Table 5-4 presents the inhalation rates (V_E) in m^3/day and m^3/hr for adult males and females aged 20-74 years at five physical activity levels. The total daily inhalation rates ranged from 13-17 m^3/day for adult males and 11-15 m^3/day for adult females. The rates for adult females were higher when compared with the other two approaches. Layton (1993) reported that the estimated inhalation rates obtained from the third approach were particularly sensitive to the MET value that represented the energy expenditures for light activities. Layton (1993) stated further that in the original time-activity survey (i.e., conducted by Sallis et al., 1985), time spent performing light activities was not presented. Therefore, the time spent at light activities was estimated by subtracting the total time spent at sleep, moderate, heavy, and very heavy activities from 24 hours (Layton, 1993). The range of inhalation rates for adult females were 9.6 to 11 m^3/day, 9.9 to 11 m^3/day, and 11 to 15 m^3/day, for the first, second, and third approach, respectively. The inhalation rates for adult males ranged from 13 to 16 m^3/day for the first approach, and 13 to 17 m^3/day for the second and third approaches.

Inhalation rates were also obtained for short-term exposures for various age/gender cohorts and five energy-expenditure categories (rest, sedentary, light, moderate, and heavy). BMRs were multiplied by the product of MET, H, and VQ. The data obtained for short term exposures are presented in Table 5-5.

Table 5-5. Inhalation Rates for Short-Term Exposures

			Activity Type				
			Rest	Sedentary	Light	Moderate	Heavy
Gender/Age (yrs)	Weight (kg[e])	BMR[a] (kJ/day)	MET (BMR Multiplier)				
			1	1.2	2[b]	4[c]	10[d]
			Inhalation Rate (m^3/hr)[f,g]				
Male							
0.5 - < 3	14	3.40	0.19	0.23	0.38	0.78	1.92
3 - < 10	23	4.30	0.24	0.29	0.49	0.96	2.40
10 - < 18	53	6.70	0.38	0.45	0.78	1.50	3.78
18 - < 30	76	7.70	0.43	0.52	0.84	1.74	4.32
30 - < 60	80	7.50	0.42	0.50	0.84	1.68	4.20
60 +	75	6.10	0.34	0.41	0.66	1.38	3.42
Female							
0.5 - < 3	11	2.60	0.14	0.17	0.29	0.60	1.44
3 - < 10	23	4.00	0.23	0.27	0.45	0.90	2.28
10 - < 18	50	5.70	0.32	0.38	0.66	1.26	3.18
18 - < 30	62	5.90	0.33	0.40	0.66	1.32	3.30
30 - < 60	68	5.80	0.32	0.39	0.66	1.32	3.24
60 +	67	5.30	0.30	0.36	0.59	1.20	3.00

[a] The BMRs for the age/gender cohorts were calculated using the respective body weights and the BMR equations (Appendix Table 5A-1).
[b] Range of 1.5 - 2.5.
[c] Range of 3 - 5.
[d] Range of > 5 - 20.
[e] Body weights were based on average weights for age/gender cohorts of the U.S. population
[f] The inhalation rate was calculated by multiplying BMR (KJ/day) x H (0.05 L/KJ) x MET x VQ (27) x (d/1,440 min)
[g] Original data were presented in L/min. Conversion to m^3/hr was obtained as follows:

$$\frac{60 \text{ min}}{\text{hr}} \times \frac{m^3}{1000 \text{ L}} \times \frac{\text{L}}{\text{min}}$$

Source: Layton, 1993.

Table 5-4. Daily Inhalation Rates Based on Time-Activity Survey

Age (yrs) and Activity	MET	Males: Body Weight[a] (kg)	Males: BMR[b] (KJ/hr)	Males: Duration[c] (hr/day)	Males: E[d] (mJ/day)	Males: V_e[e] (m^3/day)	Males: V_e[f] (m^3/hr)	Females: Body Weight[a] (kg)	Females: BMR[b] (KJ/hr)	Females: Duration[c] (hr/day)	Females: E[d] (mJ/day)	Females: V_e[e] (m^3/day)	Females: V_e[f] (m^3/hr)
20-34													
Sleep	1	76	320	7.2	2.3	3.1	0.4	62	283	7.2	2.0	2.8	0.4
Light	1.5	76	320	14.5	7.0	9.4	0.7	62	283	14.5	6.2	8.3	0.6
Moderate	4	76	320	1.2	1.5	2.1	1.7	62	283	1.2	1.4	1.8	1.5
Hard	6	76	320	0.64	1.2	1.7	2.6	62	283	0.64	1.1	1.5	2.3
Very Hard	10	76	320	0.23	0.74	1.0	4.3	62	283	0.23	0.65	0.88	3.8
Totals				24	17	17				24	11	15	
35-49													
Sleep	1	81	314	7.1	2.2	3.0	0.4	67	242	7.1	1.7	2.3	0.3
Light	1.5	81	314	14.6	6.9	9.3	0.6	67	242	14.6	5.3	7.2	0.5
Moderate	4	81	314	1.4	1.8	2.4	1.7	67	242	1.4	1.4	1.8	1.3
Hard	6	81	314	0.59	1.1	1.5	2.5	67	242	0.59	0.9	1.2	2.0
Very Hard	10	81	314	0.29	0.91	1.2	4.2	67	242	0.29	0.70	0.95	3.2
Totals				24	13	17				24	9.9	13	
50-64													
Sleep	1	80	312	7.3	2.3	3.1	0.4	68	244	7.3	1.8	2.4	0.3
Light	1.5	80	312	14.9	7.0	9.4	0.6	68	244	14.9	5.4	7.4	0.5
Moderate	4	80	312	1.1	1.4	1.9	1.7	68	244	1.1	1.1	1.4	1.3
Hard	6	80	312	0.50	0.94	1.3	2.5	68	244	0.5	0.7	1.0	2.0
Very Hard	10	80	312	0.14	0.44	0.6	4.2	68	244	0.14	0.34	0.46	3.3
Totals				24	12	16				24	9.4	13	
65-74													
Sleep	1	75	256	7.3	1.9	2.5	0.3	67	221	7.3	1.6	2.2	0.3
Light	1.5	75	256	14.9	5.7	7.7	0.5	67	221	14.9	4.9	6.7	0.4
Moderate	4	75	256	1.1	1.1	1.5	1.4	67	221	1.1	1.0	1.3	1.2
Hard	6	75	256	0.5	0.8	1.0	2.1	67	221	0.5	0.7	0.9	1.8
Very Hard	10	75	256	0.14	0.36	0.48	3.5	67	221	0.14	0.31	0.42	3.0
Totals				24	9.8	13				24	8.5	11	

a Body weights were obtained from Najjar and Rowland (1987)
b The basal metabolic rates (BMRs) for the age/gender cohorts were calculated using the respective body weights and the BMR equations (Appendix Table 5A-1)
c Duration of activities were obtained from Sallis et al (1985)
d Energy expenditure rate (E) was calculated by multiplying BMR (KJ/hr) x (MJ/1000 KJ) x duration (hr/day) x MET
e V_E (inhalation rate) was calculated by multiplying E (MJ/day) by H(0.05 m^3 O_2/MJ) by VQ (27)
f V_E (m^3/hr) was calculated by multiplying BMR (KJ/hr) x (MJ/1000 KJ) x MET x H (0.05 m^3 O_2/MJ) x VQ (27)

Source: Layton, 1993.

The major strengths of the Layton (1993) study are that it obtains similar results using three different approaches to estimate inhalation rates in different age groups and that the populations are large, consisting of men, women, and children. Explanations for differences in results due to metabolic measurements, reported diet, or activity patterns are supported by observations reported by other investigators in other studies. Major limitations of this study are that activity pattern levels estimated in this study are somewhat subjective, the explanation that activity pattern differences is responsible for the lower level obtained with the metabolic approach (25 percent) compared to the activity pattern approach is not well supported by the data, and different populations were used in each approach which may introduce error.

Linn et al. - Documentation of Activity Patterns in "High-Risk" Groups Exposed to Ozone in the Los Angeles Area - Linn et al. (1992) conducted a study that estimated the inhalation rates for "high-risk" subpopulation groups exposed to ozone (O_3) in their daily activities in the Los Angeles area. The population surveyed consisted of seven subject panels: *Panel 1*: 20 healthy outdoor workers (15 males, 5 females, ages 19-50 years); *Panel 2*: 17 healthy elementary school students (5 males, 12 females, ages 10-12 years); *Panel 3*: 19 healthy high school students (7 males, 12 females, ages 13-17 years); *Panel 4*: 49 asthmatic adults (clinically mild, moderate, and severe, 15 males, 34 females, ages 18-50 years); *Panel 5*: 24 asthmatic adults from 2 neighborhoods of contrasting O_3 air quality (10 males, 14 females, ages 19-46 years); *Panel 6*: 13 young asthmatics (7 males, 6 females, ages 11-16 years); *Panel 7*: construction workers (7 males, ages 26-34 years).

Initially, a calibration test was conducted, followed by a training session. Finally, a field study was conducted which involved subjects' collecting their own heart rate (HR) and diary data. During the calibration tests, ventilation rates (VR) and HR were measured simultaneously at each exercise level. From the calibration data an equation was developed using linear regression analysis to predict VR from measured HR (Linn et al., 1992).

In the field study, each subject (except construction workers) recorded in diaries their daily activities, change in locations (indoors, outdoors, or in a vehicle), self-estimated breathing rates during each activity/location, and time spent at each activity/location. Healthy subjects recorded their HR once every 60 seconds and asthmatic subjects recorded their diary information once every hour using a Heart watch. Construction workers dictated their diary information to a technician accompanying them on the job. Subjective breathing rates were defined as slow (walking at their normal pace); medium (faster than normal walking); and fast (running or similarly strenuous exercise). Table 5-6 presents the calibration and field protocols for self-monitoring of activities for each subject panel.

Table 5-7 presents the mean VR, the 99th percentile VR, and the mean VR at each subjective activity level (slow, medium, fast). The mean VR and 99th percentile VR were derived from all HR recordings (that appeared to be valid) without considering the diary data. Each of the three activity levels was determined from both the concurrent diary data and HR recordings by direct calculation or regression (Linn et al., 1992). The mean VR for healthy adults according to Table 5-7 was 0.8 m^3/hr. while the mean VR for asthmatic adults was 1.02 m^3/hr (Table 5-7). The preliminary data for construction workers indicated that during a 10-hr work shift, their mean VR (1.5 m^3/hr) exceeded the VRs of other subject panels (Table 5-7). Linn et al. (1992) reported that the diary data showed that most individuals except construction workers spent most of their time (in a typical day) indoors at slow activity level. During slow activity level, asthmatic subjects had higher VRs than healthy subjects (Table 5-7). Also, Linn et al. (1992) reported that in every panel, the predicted VR correlated significantly with the subjective estimates of activity levels.

A limitation of this study is that calibration data may overestimate the predictive power of HR during actual field monitoring, because the wider variety of exercise in everyday activities may result in wider variation of the VR-HR relationship. Another limitation of this study is the small sample size of each subpopulation surveyed. An advantage of this study is that diary data can provide rough estimates of ventilation patterns which are useful in exposure assessments. Another advantage is that inhalation rates were presented for various subpopulations (i.e., healthy outdoor workers, asthmatics, healthy adults, and healthy children).

Linn et al. - Activity patterns in Ozone Exposed Construction Workers - Linn et al. (1993) estimated the inhalation rates of 19 construction workers (who perform heavy outdoor labor) before and during a typical work shift. The workers were employed at a hospital construction site in suburban Los Angeles. The study was conducted between mid-July and early November, 1991.

Table 5-6. Calibration and Field Protocols for Self-Monitoring of Activities Grouped by Subject Panels

Panel	Calibration Protocol	Field Protocol
Panel 1 - Healthy Outdoor Workers - 15 female, 5 male, age 19-50	Laboratory treadmill exercise tests, indoor hallway walking tests at different self-chosen speeds, 2 outdoor tests consisting of 1-hour cycles each of rest, walking, and jogging.	3 days in 1 typical summer week (includes most active workday and most active day off); HR recordings and activity diary during waking hours.
Panel 2 - Healthy Elementary School Students - 5 male, 12 female, age 10-12	Outdoor exercises consisted each of 20 minute rest, slow walking, jogging and fast walking	Saturday, Sunday and Monday (school day) in early autumn; HR recordings and activity diary during waking hours and during sleep.
Panel 3 - Healthy High School Students - 7 male, 12 female, age 13-17	Outdoor exercises consisted each of 20 minute rest, slow walking, jogging and fast walking	Same as panel 2, however, no HR recordings during sleep for most subjects.
Panel 4 - Adult Asthmatics, clinically mild, moderate, and severe - 15 male, 34 female, age 18-50	Treadmill and hallway tests	1 typical summer week, 1 typical winter week; hourly activity/health diary during waking hours; lung function tests 3 times daily; HR recordings during waking hours on at least 3 days (including most active work day and day off).
Panel 5 - Adult Asthmatics from 2 neighborhoods of contrasting O_3 air quality - 10 male, 14 female, age 19-46	Treadmill and hallway tests	Similar to panel 4, personal NO_2 and acid exposure monitoring included. (Panels 4 and 5 were studied in different years, and had 10 subjects in common).
Panel 6 - Young Asthmatics - 7 male, 6 female, age 11-16	Laboratory tests on bicycles and treadmills	Similar to Panel 4, summer monitoring for 2 successive weeks, including 2 controlled exposure studies with few or no observable respiratory effects.
Panel 7 - Construction Workers - 7 male, age 26-34	Performed similar exercises as Panel 2 and 3, and also performed job-related tests including lifting and carrying a 9-kg pipe.	HR recordings and diary information during 1 typical summer work day.

Source: Linn et al., 1992

Table 5-7. Subject Panel Inhalation Rates (IR) by Mean IR, Upper Percentiles, and Self-Estimated Breathing Rates

Panel	Inhalation Rates (m^3/hr)					
	N[b]	Mean IR (m^3/hr)	99th Percentile	Mean Self-Estimated Breathing Rates (m^3/hr)[a]		
				Slow	Medium[c]	Fast[c]
Healthy						
1 - Adults	20	0.78	2.46	0.72	1.02	3.06
2 - Elementary School Students	17	0.90	1.98	0.84	0.96	1.14
3 - High School Students	19	0.84	2.22	0.78	1.14	1.62
7 - Construction Workers[c]	7	1.50	4.26	1.26	1.50	1.68
Asthmatics						
4 - Adults	49	1.02	1.92	1.02	1.68	2.46
5 - Adults[d]	25	1.20	2.40	1.20	2.04	4.02
6 - Elementary and High School Students	13	1.20	2.40	1.20	1.20	1.50

[a] Some subjects did not report medium and/or fast activity. Group means were calculated from individual means (i.e., give equal weight to each individual who recorded any time at the indicated activity level).
[b] Number of individuals in each survey panel.
[c] Construction workers recorded only on 1 day, mostly during work, while others recorded on ≥ 1 work or school day and ≥ 1 day off.
[d] Excluding subjects also in Panel 4.

Source: Linn et al., 1992.

During this period, ozone (O_3) levels were typically high. Initially, each subject was calibrated with a 25-minutes exercise test that included slow walking, fast walking, jogging, lifting, and carrying. All calibration tests were conducted in the mornings. Ventilation rates (VR) and heart rates (HR) were measured simultaneously during the test. The data were analyzed using the least squares regression to derive an equation for predicting VR at a given HR. Following the calibration tests and before beginning work, each subject recorded their change in activity (i.e. sitting/standing, walking, lifting/carrying, and "working at trade" - defined as tasks specific to the individual's job classification). Location, and self-estimated breathing rates ("slow" similar to slow walking, "medium" similar to fast walking, and "fast" similar to running) were also recorded in the diary. During work, an investigator recorded the diary information dictated by the subjects. HR was recorded minute by minute for each subject before work and during the entire work shift. Thus, VR ranges for each breathing rate and activity category were estimated from the HR recordings by employing the relationship between VR and HR obtained from the calibration tests.

A total of 182 hours of HR recordings were obtained during the survey from the 19 volunteers; 144 hours reflected actual working time according to the diary records. The lowest actual working hours recorded was 6.6 hours and the highest recorded for a complete work shift was 11.6 hours (Linn et al., 1993). Summary statistics for predicted VR distributions for all subjects, and for job or site defined subgroups are presented in Table 5-8. The data reflect all recordings before and during work, and at break times. For all subjects, the mean inhalation rate (IR) was 1.68 m^3/hr with a standard deviation of ± 0.72 (Table 5-8). Also, for most subjects, the 1st and 99th percentiles of HR were outside of the calibration range (calibration ranges are presented in Appendix Table 5A-2). Therefore, corresponding IR percentiles were extrapolated using the calibration data (Linn et al., 1993).

Table 5-8. Distributions of Individual and Group Inhalation/Ventilation Rate for Outdoor Workers

		Ventilation Rate (VR) (m^3/hr)		
		Percentile		
Population Group and Subgroup[a]	Mean ± SD	1	50	99
All Subjects (n^b = 19)	1.68 ± 0.72	0.66	1.62	3.90
Job				
GCW[c]/Laborers (n = 5)	1.44 ± 0.66	0.48	1.32	3.66
Iron Workers (n = 3)	1.62 ± 0.66	0.60	1.56	3.24
Carpenters (n = 11)	1.86 ± 0.78	0.78	1.74	4.14
Site				
Office Site (n = 7)	1.38 ± 0.66	0.60	1.20	3.72
Hospital Site (n = 12)	1.86 ± 0.78	0.72	1.80	3.96

[a] Each group or subgroup mean was calculated from individual means, not from pooled data.
[b] n = number of individuals performing specific jobs or number of individuals at survey sites.
[c] GCW - general construction worker.

Source: Linn et al., 1993.

The data presented in Table 5-9 represent distribution patterns of IR for each subject, total subjects, and job or site defined subgroups by self-estimated breathing rates (slow, medium, fast) or by type of job activity. All data include working and non-working hours. The mean inhalation rates for most individuals showed statistically significant increases with higher self-estimated breathing rates or with increasingly strenuous job activity (Linn et al., 1993). Inhalation rates were higher in hospital site workers when compared with office site workers (Table 5-9). In spite of their higher predicted VR, hospital site workers reported a higher percentage of slow breathing time (31 percent) than the office site workers (20 percent), and a lower percentage of fast breathing time, 3 percent and 5 percent, respectively (Linn et al., 1993). Therefore, individuals whose work was objectively heavier than average (from VR predictions) tended to describe their work as lighter than average (Linn et al., 1993). Linn et al. (1993) also concluded that during an O_3 pollution episode, construction workers should experience similar microenvironmental O_3 exposure concentrations as other healthy outdoor workers, but with approximately twice as high VR. Therefore, the inhaled dose of O_3 should be almost two times higher for typical heavy-construction workers than for typical healthy adults performing less strenuous outdoor jobs.

A limitation associated with this study is the small sample size. Another limitation of this study is that calibration data were not obtained at extreme conditions. Therefore, it was necessary to predict IR values outside the calibration range which may introduce an unknown uncertainty to the data set. Also, subjective self-estimated breathing rates (i.e., "macho effect") may be another source of uncertainty in the inhalation rates estimated. An advantage is that this study provides empirical data useful in exposure assessments for a subpopulation thought to be the most highly exposed common occupational group (outdoor workers).

Spier et al. - Activity Patterns in Elementary and High School Students Exposed To Oxidant Pollution - Spier et al. (1992) investigated activity patterns of 17 elementary school students (10-12 years old) and 19 high school students (13-17 years old) in suburban Los Angeles from late September to October (oxidant pollution season). Calibration tests were conducted in supervised outdoor exercise sessions. The exercise sessions consisted of 5 minutes for each: rest, slow walking, jogging, and fast walking. Heart rate (HR) and ventilation rate (VR) were measured during the last 2 minutes of each exercise. Individual VR and HR relationships for each individual were determined by fitting a regression line to HR values and log VR values. Each subject recorded their daily activities change in location, and breathing rates in diaries

Table 5-9. Individual Mean Inhalation Rate (m^3/hr) by Self-Estimated Breathing Rate or Job Activity Category for Outdoor Workers

	Self-Estimated Breathing Rate (m^3/hr)			Job Activity Category (m^3/hr)			
Population Group and Subgroup	Slow	Med	Fast	Sit/Std	Walk	Carry	Trade[b]
All Subjects (n = 19)	1.44	1.86	2.04	1.56	1.80	2.10	1.92
Job							
GCW[a]/Laborers (n = 5)	1.20	1.56	1.68	1.26	1.44	1.74	1.56
Iron Workers (n = 3)	1.38	1.86	2.10	1.62	1.74	1.98	1.92
Carpenters (n = 11)	1.62	2.04	2.28	1.62	1.92	2.28	2.04
Site							
Office Site (n = 7)	1.14	1.44	1.62	1.14	1.38	1.68	1.44
Hospital Site (n = 12)	1.62	2.16	2.40	1.80	2.04	2.34	2.16

[a] GCW - general construction worker
[b] Trade - "Working at Trade" (i.e., tasks specific to the individual's job classification)
Source: Linn et al., 1993

for 3 consecutive days. Self-estimated breathing rates were recorded as slow (slow walking), medium (walking faster than normal), and fast (running). HR was recorded during the 3 days once per minute by wearing a Heart watch. VR values for each self-estimated breathing rate and activity type were estimated from the HR recordings by employing the VR and HR equation obtained from the calibration tests.

The data presented in Table 5-10 represent HR distribution patterns and corresponding predicted VR for each age group during hours spent awake. At the same self-reported activity levels for both age groups, inhalation rates were higher for outdoor activities than for indoor activities. The total hours spent indoors by high school students (21.2 hours) were higher than for elementary school students (19.6 hours). The converse was true for outdoor activities; 2.7 hours for high school students, and 4.4 hours for elementary school students (Table 5-11). Based on the data presented in Tables 5-10 and 5-11, the average inhalation specific-activity rates for elementary (10-12 years) and high school (13-17 years) students were calculated in Table 5-12. For elementary school students, the average daily inhalation rates are 15.8 m^3/day for light activities, 4.62 m^3/day for moderate activities, and 0.98 m^3/day for heavy activities. Also, for high school students the daily inhalation rate during light, moderate, and heavy activities is estimated at 16.4 m^3/day, 3.1 m^3/day, and 0.54 m^3/day, respectively (Table 5-12).

A limitation of this study is the small sample size. Also, it may not be representative of all children in these age groups. Another limitation is that associated with the accuracy of the self-estimated breathing rates reported by younger age groups. This may affect the validity of the data set generated. An advantage of this study is that inhalation rates were determined for children and adolescents. These data are useful in estimating exposure for the younger population.

California Air Resources Board (CARB) - Measurement of Breathing Rate and Volume in Routinely Performed Daily Activities - The California Air Resources Board, CARB (1993) conducted research to accomplish two main objectives: (1) identification of mean and ranges of inhalation rates for various age/gender cohorts; and (2) derivation of simple linear and multiple

Table 5-10. Distribution of Predicted IR by Location and Activity Levels for Elementary and High School Students

Age (yrs)	Student	Location	Activity Level	% Recorded Time[a]	Inhalation Rates (m^3/hr) Mean ± SD	Percentile Rankings[b] 1st	50th	99.9th
10-12	EL[c] (n^d = 17)	Indoors	slow	49.6	0.84 ± 0.36	0.18	0.78	2.34
			medium	23.6	0.96 ± 0.42	0.24	0.84	2.58
			fast	2.4	1.02 ± 0.60	0.24	0.84	3.42
		Outdoors	slow	8.9	0.96 ± 0.54	0.36	0.78	4.32
			medium	11.2	1.08 ± 0.48	0.24	0.96	3.36
			fast	4.3	1.14 ± 0.60	0.48	0.96	3.60
13-17	HS[c] (n^d = 19)	Indoors	slow	70.7	0.78 ± 0.36	0.30	0.72	3.24
			medium	10.9	0.96 ± 0.42	0.42	0.84	4.02
			fast	1.4	1.26 ± 0.66	0.54	1.08	6.84[c]
		Outdoors	slow	8.2	0.96 ± 0.48	0.42	0.90	5.28
			medium	7.4	1.26 ± 0.78	0.48	1.08	5.70
			fast	1.4	1.44 ± 1.08	0.48	1.02	5.94

[a] Recorded time averaged about 23 hr per elementary school student and 33 hr. per high school student, over 72-hr. periods.
[b] Geometric means closely approximated 50th percentiles; geometric standard deviations were 1.2-1.3 for HR, 1.5-1.8 for VR.
[c] EL = elementary school student; HS = high school student.
[d] N = number of students that participated in survey.
[e] Highest single value.

Source: Spier et al., 1992.

Table 5-11. Average Hours Spent per Day in a Given Location and Activity Level for Elementary (EL) and High School (HS) Students

Student (EL[a], n[c] = 17; HS[b], N[c] = 19)	Location	Activity Level: Slow	Medium	Fast	Total Time Spent (hrs/day)
EL	Indoor	16.3	2.9	0.4	19.6
EL	Outdoor	2.2	1.7	0.5	4.4
HS	Indoor	19.5	1.5	0.2	21.2
HS	Outdoor	1.2	1.3	0.2	2.7

[a] Elementary school (EL) students were between 10-12 years old.
[b] High school (HS) students were between 13-17 years old.
[c] N corresponds to number of school students.

Source: Spier et al., 1992.

Table 5-12. Distribution Patterns of Daily Inhalation Rates for Elementary (EL) and High School (HS) Students Grouped by Activity Level

Students	Age (yrs)	Location	Activity type[a]	Mean IR[b] (m^3/day)	Percentile Rankings: 1st	50th	99.9th
EL (n[c] = 17)	10-12	Indoor	Light	13.7	2.93	12.71	38.14
			Moderate	2.8	0.70	2.44	7.48
			Heavy	0.4	0.096	0.34	1.37
EL		Outdoor	Light	2.1	0.79	1.72	9.50
			Moderate	1.84	0.41	1.63	5.71
			Heavy	0.57	0.24	0.48	1.80
HS (n = 19)	13-17	Indoor	Light	15.2	5.85	14.04	63.18
			Moderate	1.4	0.63	1.26	6.03
			Heavy	0.25	0.11	0.22	1.37
HS		Outdoor	Light	1.15	0.50	1.08	6.34
			Moderate	1.64	0.62	1.40	7.41
			Heavy	0.29	0.096	0.20	1.19

[a] For this report, activity type presented in Table 5-7 was redefined as light activity for slow, moderate activity for medium, and heavy activity for fast.
[b] Daily inhalation rate was calculated by multiplying the hours spent at each activity level (Table 5-11) by the corresponding inhalation rate (Table 5-10).
[c] Number of elementary (EL) and high school students (HS).

Source: Adapted from Spier et al., 1992 (Generated using data from Tables 5-10 and 5-11).

regression equations used to predict inhalation rates through other measured variables: heart rate (HR), breathing frequency (f_B), and oxygen consumption (V_{O2}). The survey population consisted of 160 individuals (both genders) from California of various ages (6-77 years) and ethnicity (CARB, 1993). CARB validated empirically derived equations for children engaged in selected field and laboratory studies. The test subjects were 40 children from 6 to 12 years old and twelve young children (3-5 years) were identified as subjects for pilot testing purposes (CARB, 1993).

Resting protocols conducted in the laboratory for all age groups consisted of three phases (25 minutes each) of lying, sitting, and standing. They were categorized as resting and sedentary activities. Two active protocols including moderate (walking) and heavy (jogging/running) phases were performed on a treadmill over a progressive continuum of intensities made up of 6 minute intervals, at 3 speeds ranging from slow to moderately fast. All protocols involved measuring VR, HR, f_B, and V_{O2}. Measurements were taken in the last 5 minutes of each phase of the resting protocol (25 minutes), and the last 3 minutes of the 6 minutes intervals at each speed designated in the active protocols.

In the field, all children completed spontaneous play protocols, while the older adolescent population (16-18 years) completed car driving and riding, car maintenance (males), and housework (females) protocols. All adult females (19-60 years) and most of the senior (60-77 years) females completed housework, yardwork, and car driving and riding protocols. Adult and senior males only completed car driving and riding, yardwork, and mowing protocols. HR, VR, and f_B were measured during each protocol and most protocols were conducted for 30 minutes. All the active field protocols were conducted twice.

During all activities in either the laboratory or field protocols, inhalation rate (IR) for the children's group revealed no significant gender differences, but those for the adult groups demonstrated gender differences. Therefore, IR data presented in Appendix Tables 5A-3 and 5A-4 were categorized as young children, children, adult female, and adult male by activity levels (resting, sedentary, light, moderate, and heavy). These categorized data for the laboratory protocols are shown in Table 5-13. Table 5-14 presents the mean inhalation rates by group and activity levels (light, sedentary, and moderate) in field protocols. A comparison of the data shown in Tables 5-13 and 5-14 suggest that during light and sedentary activities in laboratory and field protocols, similar inhalation rates were obtained for adult females and adult males. Accurate predictions of IR across all population groups and activity types were obtained by including body surface area (BSA), HR, and f_B in multiple regression analysis (CARB, 1993). CARB (1993) calculated BSA from measured height and weight using the equation:

$$BSA = Height^{(0.725)} \times Weight^{(0.425)} \times 71.84. \qquad \text{(Eqn. 5-3)}$$

Table 5-13. Summary of Average Inhalation Rates (m^3/hr) by Age Group and Activity Levels for Laboratory Protocols

Age	Resting[a]	Sedentary[b]	Light[c]	Moderate[d]	Heavy[e]
Young Children[f]	0.37	0.40	0.65	DNP[g]	DNP
Children[h]	0.45	0.47	0.95	1.74	2.23
Adult Females[i]	0.43	0.48	1.33	2.76	2.96[j]
Adult Males[k]	0.54	0.60	1.45	1.93	3.63

[a] Resting defined as lying (see Appendix Table 5A-3 for original data).
[b] Sedentary defined as sitting and standing (see Appendix Table 5A-3 for original data).
[c] Light defined as walking at speed level 1.5 - 3.0 mph (see Appendix Table 5A-3 for original data).
[d] Moderate defined as fast walking (3.3 - 4.0 mph) and slow running (3.5 - 4.0 mph) (see Appendix Table 5A-3 for original data).
[e] Heavy defined as fast running (4.5 - 6.0 mph) (see Appendix Table 5A-3 for original data).
[f] Young children (both genders) 3 - 5.9 yrs old.
[g] DNP. Group did not perform this protocol or N was too small for appropriate mean comparisons. All young children did not run.
[h] Children (both genders) 6 - 12.9 yrs old.
[i] Adult females defined as adolescent, young to middle aged, and older adult females.
[j] Older adults not included in mean value since they did not perform running protocols at particular speeds.
[k] Adult males defined as adolescent, young to middle aged, and older adult males.
Source: Adapted from CARB, 1993.

Table 5-14. Summary of Average Inhalation Rates (m^3/hr) by Age Group and Activity Levels in Field Protocols

Age	Light[a]	Sedentary[b]	Moderate[c]
Young Children[d]	DNP[e]	DNP	0.68
Children[f]	DNP	DNP	1.07
Adult Females[g]	1.10[h]	0.51	DNP
Adult Males[i]	1.40[i]	0.62	1.78[j]

[a] Light activity was defined as car maintenance (males), housework (females), and yard work (females) (see Appendix Table 5A-4 for original data).
[b] Sedentary activity was defined as car driving and riding (both genders) (see Appendix Table 5A-4 for original data).
[c] Moderate activity was defined as mowing (males); wood working (males); yard work (males); and play (children). (see Appendix Table 5A-4 for original data).
[d] Young children (both genders) = 3 - 5.9 yrs old.
[e] DNP. Group did not perform this protocol or N was too small for appropriate mean comparisons.
[f] Children (both genders) = 6 - 12.9 yrs old.
[g] Adult females defined as adolescent, young to middle aged, and older adult females.
[h] Older adults not included in mean value since they did not perform this activity.
[i] Adult males defined as adolescent, young to middle aged, and older adult males.
[j] Adolescents not included in mean value since they did not perform this activity.
Source: CARB, 1993.

A limitation associated with this study is that the population does not represent the general U.S. population. Also, the classification of activity types (i.e., laboratory and field protocols) into activity levels may bias the inhalation rates obtained for various age/gender cohorts. The estimated rates were based on short-term data and may not reflect long-term patterns. An advantage of this study is that it provides inhalation data for all age groups.

5.2.3. Relevant Inhalation Rate Studies

Shamoo et al. - Improved Quantitation of Air Pollution Dose Rates by Improved Estimation of Ventilation Rate- Shamoo et al. (1990) conducted this study to develop and validate new methods to accurately estimate ventilation rates for typical individuals during their normal activities. Two practical approaches were tested for estimating ventilation rates indirectly: (1) volunteers were trained to estimate their own ventilation rate (VR) at various controlled levels of exercise; and (2) individual VR and heart rate (HR) relationships were determined in another set of volunteers during supervised exercise sessions (Shamoo et al., 1990). In the first approach, the training session involved 9 volunteers (3 females and 6 males) from 21 to 37 years old. Initially the subjects were trained on a treadmill with regularly increasing speeds. VR measurements were recorded during the last minute of the 3-minute interval at each speed. VR was reported to the subjects as low (1.4 m^3/hr), medium (1.5-2.3 m^3/hr), heavy (2.4-3.8 m^3/hr), and very heavy (3.8 m^3/hr or higher) (Shamoo et al., 1990).

Following the initial test, treadmill training sessions were conducted on a different day in which 7 different speeds were presented each for 3 minutes in arbitrary order. VR was measured and the subjects were given feedback with the four ventilation ranges provided previously. After resting, a treadmill testing session was conducted in which seven speeds were presented in different arbitrary order from the training session. VR was measured and each subject estimated their own ventilation level at each speed. The correct level was then revealed to each subject after his/her own estimate. Subsequently, two 3-hour outdoor supervised exercise sessions were conducted in the summer on two consecutive days. Each hour consisted of 15 minutes each of rest, slow walking, jogging, and fast walking. The subjects' ventilation level and VR were recorded; however, no feedback was given to the subjects. Electrocardiograms were recorded via direct connection or telemetry and HR was measured concurrently with ventilation measurement for all treadmill sessions.

The second approach consisted of two protocol phases (indoor/outdoor exercise sessions and field testing). Twenty outdoor adult workers between 19-50 years old were recruited. Indoor and outdoor supervised exercises similar to the protocols in the first approach were conducted; however, there were no feedbacks. Also, in this approach, electrocardiograms were recorded and HR was measured concurrently with VR. During the field testing phase, subjects were trained to record their activities during three different 24-hour periods within one week. These periods included their most active working and non-working days. HR was measured quasi-continuously during the 24-hour periods that activities were recorded. The subjects recorded in a diary all changes in physical activity, location, and exercise levels during waking hours. Self-estimated activities in supervised exercises and field studies were categorized as slow (resting, slow walking or equivalent), medium (fast walking or equivalent), and fast (jogging or equivalent).

Inhalation rates were not presented in this study. In the first approach, about 68 percent of all self-estimates were correct for the 9 subjects sampled (Shamoo et al., 1990). Inaccurate self-estimates occurred in the younger male population who were highly physically fit and were competitive aerobic trainers. This subset of sample population tended to underestimate their own physical activity levels at higher VR ranges. Shamoo et al. (1990) attributed this to a "macho effect." In the second approach, a regression analysis was conducted that related the logarithm of VR to HR. The logarithm of VR correlated better with HR than VR itself (Shamoo et al., 1990).

A limitation associated with this study is that the population sampled is not representative of the general U.S. population. Also, ventilation rates were not presented. Training individuals to estimate their VR may contribute to uncertainty in the results because the estimates are subjective. Another limitation is that calibration data were not obtained at extreme conditions; therefore, the VR/HR relationship obtained may be biased. An additional limitation is that training subjects may be too labor-intensive for widespread use in exposure assessment studies. An advantage of this study is that HR recordings are useful in predicting ventilation rates which in turn are useful in estimating exposure.

Shamoo et al. - Activity Patterns in a Panel of Outdoor Workers Exposed to Oxidant Pollution - Shamoo et al. (1991) investigated summer activity patterns in 20 adult volunteers with potentially high exposure to ambient oxidant pollution. The selected volunteer subjects were 15 men and 5 women ages 19-50 years from the Los Angeles area. All volunteers worked outdoors at least 10 hours per week. The experimental approach involved two stages: (1) indirect objective estimation of ventilation rate (VR) from heart rate (HR) measurements; and (2) self estimation of inhalation/ventilation rates recorded by subjects in diaries during their normal activities.

The approach consisted of calibrating the relationship between VR and HR for each test subject in controlled exercise; monitoring by subjects of their own normal activities with diaries and electronic HR recorders; and then relating VR with the activities described in the diaries (Shamoo et al., 1991). Calibration tests were conducted for indoor and outdoor supervised exercises to determine individual relationships between VR and HR. Indoors, each subject was tested on a treadmill at rest and at increasing speeds. HR and VR were measured at the third minute at each 3-minute interval speed. In addition, subjects were tested while walking a 90-meter course in a corridor at 3 self-selected speeds (normal, slower than normal, and faster than normal) for 3 minutes.

Two outdoor testing sessions (one hour each) were conducted for each subject, 7 days apart. Subjects exercised on a 260-meter asphalt course. A session involved 15 minutes each of rest, slow walking, jogging, and fast walking during the first hour. The sequence was also repeated during the second hour. HR and VR measurements were recorded starting at the 8th minute of each 15-minute segment. Following the calibration tests, a field study was conducted in which subject's self-monitored their activities (by filling out activity diary booklets), self-estimated their breathing rates, and HR. Breathing rates were defined as sleep, slow (slow or normal walking); medium (fast walking); and fast (running) (Shamoo et al., 1991). Changes in location, activity, or breathing rates during three 24-hr periods within a week were recorded. These periods included their most active working and non-working days. Each subject wore Heart watches which recorded their HR once per minute during the field study. Ventilation rates were estimated for the following categories: sleep, slow, medium, and fast.

Calibration data were fit to the equation log (VR) = intercept + (slope x HR), each individual's intercept and slope were determined separately to provide a specific equation that predicts each subject's VR from measured HR (Shamoo et al., 1991). The average measured VRs were 0.48, 0.9, 1.68, and 4.02 m^3/hr for rest, slow walking or normal walking, fast walking and jogging, respectively (Shamoo et al., 1991). Collectively, the diary recordings showed that sleep occupied about 33 percent of the subject's time; slow activity 59 percent; medium activity 7 percent; and fast activity 1 percent. The diary data covered an average of 69 hours per subject (Shamoo et al., 1991). Table 5-15 presents the distribution pattern of predicted ventilation rates and equivalent ventilation rates (EVR) obtained at the four activity levels. EVR was defined as the VR per square meter of body surface area, and also as a percentage of the subjects average VR over the entire field monitoring period (Shamoo et al., 1991). The overall mean predicted VR was 0.42 m^3/hr for sleep; 0.71 m^3/hr for slow activity; 0.84 m^3/hr for medium activity; and 2.63 m^3/hr for fast activity. The mean predicted VR and standard deviation, and the percentage of time spent in each combination of VR, activity type (essential and non-essential), and location (indoor and outdoor) are presented

Table 5-15. Distribution Pattern of Predicted VR and EVR (Equivalent Ventilation Rate) for Outdoor Workers

		VR (m^3/hr)[a]		EVR[b] ($m^3/hr/m^2$ body surface)	
Self-Reported Activity Level	N[c]	Arithmetic Mean ± S.D.	Geometric Mean ± S.D.	Arithmetic Mean ± S.D.	Geometric Mean ± S.D.
Sleep	18,597	0.42 ± 0.16	0.39 ± 0.08	0.23 ± 0.08	0.22 ± 0.08
Slow	41,745	0.71 ± 0.4	0.65 ± 0.09	0.38 ± 0.20	0.35 ± 0.09
Medium	3,898	0.84 ± 0.47	0.76 ± 0.09	0.48 ± 0.24	0.44 ± 0.09
Fast	572	2.63 ± 2.16	1.87 ± 0.14	1.42 ± 1.20	1.00 ± 0.14

Percentile Rankings, VR

	1	5	10	50	90	95	99	99.9
Sleep	0.18	0.18	0.24	0.36	0.66	0.72	0.90	1.20
Slow	0.30	0.36	0.36	0.66	1.08	1.32	1.98	4.38
Medium	0.36	0.42	0.48	0.72	1.32	1.68	2.64	3.84
Fast	0.42	0.54	0.60	1.74	5.70	6.84	9.18	10.26

Percentile Rankings, EVR

	1	5	10	50	90	95	99	99.9
Sleep	0.12	0.12	0.12	0.24	0.36	0.36	0.48	0.60
Slow	0.18	0.18	0.24	0.36	0.54	0.66	1.08	2.40
Medium	0.18	0.24	0.30	0.42	0.72	0.90	1.38	2.28
Fast	0.24	0.30	0.36	0.90	3.24	3.72	4.86	5.52

[a] Data presented by Shamoo in liters/minute were converted to m^3/hr.
[b] EVR = VR per square meter of body surface area.
[c] Number of minutes with valid appearing heart rate records and corresponding daily records of breathing rate.
Source: Shamoo et al., 1991

in Table 5-16. Essential activities include income-related work, household chores, child care, study and other school activities, personal care and destination-oriented travel. Non-essential activities include sports and active leisure, passive leisure, some travel, and social or civic activities (Shamoo et al., 1991). Table 5-16 shows that inhalation rates were higher outdoors than indoors at slow, medium, and fast activity levels. Also, inhalation rates were higher for outdoor non-essential activities than for indoor non-essential activity levels at slow, medium, and fast self-reported breathing rates (Table 5-16).

An advantage of this study is that subjective activity diary data can provide exposure modelers with useful rough estimates of VR for groups of generally healthy people. A limitation of this study is that the results obtained show high within-person and between-person variability in VR at each diary-recorded level, indicating that VR estimates from diary reports could potentially be substantially misleading in individual cases. Another limitation of this study is that elevated HR data of slow activity at the second hour of the exercise session reflect persistent effects of exercise and/or heat stress. Therefore, predictions of VR from the VR/HR relationship may be biased.

Shamoo et al. - Effectiveness of Training Subjects to Estimate Their Level of Ventilation - Shamoo et al. (1992) conducted a study where nine non-sedentary subjects in good health were trained on a treadmill to estimate their own ventilation rates at four activity levels: low, medium, heavy, and very heavy. The purpose of the study was to train the subjects self-estimation of ventilation in the field and assess the effectiveness of the training (Shamoo et al., 1992). The subjects included 3 females and 6 males between 21 to 37 years of age. The tests were conducted in four stages. First, an initial treadmill pretest was conducted indoors at various speeds until the four ventilation levels were experienced by each subject; VR was measured and feedback was given to the subjects. Second, two treadmill training sessions which involved seven 3-minute segments of varying speeds based

Table 5-16. Distribution Pattern of Inhalation Rate by Location and Activity Type for Outdoor Workers

Location	Activity Type[a]	Self-reported Activity Level	% of Time	Inhalation rate (m^3/hr) ± S.D.	% of Avg.[b]
Indoor	Essential	Sleep	28.7	0.42 ± 0.12	69 ± 15
		Slow	29.5	0.72 ± 0.36	106 ± 43
		Medium	2.4	0.72 ± 0.30	129 ± 38
		Fast	0	0	0
Indoor	Non-essential	Slow	20.4	0.66 ± 0.36	98 ± 36
		Medium	0.9	0.78 ± 0.30	120 ± 50
		Fast	0.2	1.86 ± 0.96	278 ± 124
Outdoor	Essential	Slow	11.3	0.78 ± 0.36	117 ± 42
		Medium	1.8	0.84 ± 0.54	130 ± 56
		Fast	0	0	0
Outdoor	Non-essential	Slow	3.2	0.90 ± 0.66	136 ± 90
		Medium	0.8	1.26 ± 0.60	213 ± 91
		Fast	0.7	2.82 ± 2.28	362 ± 275

[a] Essential activities include income-related, work, household chores, child care, study and other school activities, personal care, and destination-oriented travel;
Non-essential activities include sports and active leisure, passive leisure, some travel, and social or civic activities.
[b] Statistic was calculated by converting each VR for a given subject to a percentage of her/his overall average.
Source: Shamoo et al., (1991).

on initial tests were conducted; VR was measured and feedback was given to the subjects. Another similar session was conducted; however, the subjects estimated their own ventilation level during the last 20 seconds of each segment and VR was measured during the last minute of each segment. Immediate feedback was given to the subject's estimate; and the third and fourth stages involved 2 outdoor sessions of 3 hours each. Each hour comprised 15 minutes each of rest, slow walking, jogging, and fast walking. The subjects estimated their own ventilation level at the middle of each segment. The subject's estimate was verified by a respirometer which measured VR in the middle of each 15-minute activity. No feedback was given to the subject.

For purposes of this study, inhalation rates were analyzed from the raw data that were provided to the authors by Shamoo et al. (1992). Table 5-17 presents the mean inhalation rates obtained at four ventilation levels and two microenvironments (i.e., indoors and outdoors) for all subjects. The mean inhalation rates for all subjects were 0.93, 1.92, 3.01, 4.80 m^3/hr for low, medium, heavy, and very heavy activities, respectively. The overall percent correct score obtained for all ventilation levels was 68 percent (Shamoo et al., 1992). Therefore, Shamoo et al. (1992) concluded that this training protocol was effective in training subjects to correctly estimate their minute ventilation levels.

Table 5-17. Actual Inhalation Rates Measured at Four Ventilation Levels

Subject	Location	Mean Inhalation Rate[a] (m^3/hr)[a] Low	Medium	Heavy	Very Heavy
All subjects	Indoor (Tm post)	1.23	1.83	3.13	4.13
	Outdoor	0.88	1.96	2.93	4.90
	Total	0.93	1.92	3.01	4.80

[a] Original data were presented in L/min. Conversion to m^3/hr was obtained as follows:

$$60\ \frac{\text{min}}{hr}\ x\ \frac{m^3}{1000L}\ x\ \frac{L}{\text{min}}$$

Source: Adapted from Shamoo et al., 1992

The population sample size used in this study was small and was not selected to represent the general U.S. population. The training approach employed may not be cost effective because it was labor intensive; therefore, this approach may not be viable in field studies especially for field studies within large sample sizes.

U.S. EPA - Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments - Due to a paucity of information in literature regarding equations used to develop statistical distributions of minute ventilation/ventilation rate at all activity levels for male and female children and adults, the U.S. EPA (1985) compiled measured values of minute ventilation for various age/gender cohorts from early studies. In more recent investigations, minute ventilations have been measured more as background information than as research objective itself and the available studies have been for specific subpopulations such as obese, asthmatics, or marathon runners. The data compiled by the U.S. EPA (1985) for each age/gender cohorts were obtained at various activity levels. These levels were categorized as light, moderate, or heavy according to the criteria developed by the EPA Office of Environmental Criteria and Assessment for the Ozone Criteria Document. These criteria were developed for a reference male adult with a body weight of 70 kg (U.S. EPA, 1985). The minute ventilation rates for adult males based on these activity level categories are detailed in Appendix Table 5A-5.

Table 5-18 presents a summary of inhalation rates by age, gender, and activity level (detailed data are presented in Appendix Table 5A-6). A description of activities included in each activity level is also presented in Table 5-18. Table 5-18 indicates that at rest, the average adult inhalation rate is 0.5 m^3/hr. The mean inhalation rate for children at rest, ages 6 and 10 years, is 0.4 m^3/hr each, respectively. Table 5-19 presents activity pattern data aggregated for three microenvironments by activity level for all age groups. The total average hours spent indoors was 20.4, outdoors was 1.77, and in transportation vehicle was 1.77. Based on the data presented in Tables 5-18 and 5-19, a daily inhalation rate was calculated for adults and children by using a time-activity-ventilation approach. These data are presented in Table 5-20. The calculated average daily inhalation rates are 16 m^3/day for adults. The average daily inhalation rate for children (6 and 10 yrs) is 18.9 m^3/day ([16.74 + 21.02]/2).

A limitation associated with this study is that many of the values used in the data compilation were from early studies. The accuracy and/or validity of the values used and data collection method were not presented in U.S. EPA (1985). This introduces uncertainty in the results obtained. An advantage of this study is that the data are actual measurement data for a large number of subjects and the data are presented for both adults and children.

International Commission on Radiological Protection - Report of the Task Group on Reference Man - The International Commission of Radiological Protection (ICRP) estimated daily inhalation rates for reference adult males, adult females, children (10 years old), infant (1 year old), and newborn babies by using a time-activity-ventilation approach. This approach for estimating inhalation rate over a specified period of time

Table 5-18. Summary of Human Inhalation Rates for Men, Women, and Children by Activity Level (m^3/hour)[a]

	n[b]	Resting[c]	n	Light[d]	n	Moderate[e]	n	Heavy[f]
Adult male	454	0.7	102	0.8	102	2.5	267	4.8
Adult female	595	0.3	786	0.5	106	1.6	211	2.9
Average adult[g]		0.5		0.6		2.1		3.9
Child, age 6	8	0.4	16	0.8	4	2.0	5	2.3
Child, age 10	10	0.4	40	1.0	29	3.2	43	3.9

[a] Values of inhalation rates for males, females, and children (male and female) presented in this table represent the mean of values reported for each activity level in 1985. (See Appendix Table 3A-6 for a detailed listing of the data from U.S. EPA, 1985.)
[b] n = number of observations at each activity level.
[c] Includes watching television, reading, and sleeping.
[d] Includes most domestic work, attending to personal needs and care, hobbies, and conducting minor indoor repairs and home improvements.
[e] Includes heavy indoor cleanup, performance of major indoor repairs and alterations, and climbing stairs.
[f] Includes vigorous physical exercise and climbing stairs carrying a load.
[g] Derived by taking the mean of the adult male and adult female values for each activity level.

Source: Adapted from U.S. EPA, 1985.

Table 5-19. Activity Pattern Data Aggregated for Three Microenvironments by Activity Level for all Age Groups

Microenvironment	Activity Level	Average Hours Per Day in Each Microenvironment at Each Activity Level
Indoors	Resting	9.82
	Light	9.82
	Moderate	0.71
	Heavy	0.098
	TOTAL	20.4
Outdoors	Resting	0.505
	Light	0.505
	Moderate	0.65
	Heavy	0.12
	TOTAL	1.77
In Transportation Vehicle	Resting	0.86
	Light	0.86
	Moderate	0.05
	Heavy	0.0012
	TOTAL	1.77

Source: Adapted from U.S. EPA, 1985.

Table 5-20. Summary of Daily Inhalation Rates Grouped by Age and Activity level

	Daily Inhalation Rate (m^3/day)[a]				
Subject	Resting	Light	Moderate	Heavy	Total Daily IR[b] (m^3/day)
Adult Male	7.83	8.95	3.53	1.05	21.4
Adult Female	3.35	5.59	2.26	0.64	11.8
Adult Average[c]	5.60	6.71	2.96	0.85	16
Child (age 6)	4.47	8.95	2.82	0.50	16.74
Child (age 10)	4.47	11.19	4.51	0.85	21.02

[a] In this report, inhalation rate was calculated by using the following equation:

$$IR = \frac{1}{T} \sum_{i=1}^{k} IR_i t_i$$

IR_i = inhalation rate at i^{th} activity (Table 5-18)
t_i = hours spent per day during i^{th} activity (Table 5-19)
k = number of activity periods
T = total time of the exposure period (e.g., a day)

[b] In this report, total daily inhalation rate was calculated by summing the specific activity daily inhalation rate.

Source: Generated using data from Tables 5-18 and 5-19.

was based on calculating a time weighted average of inhalation rates associated with physical activities of varying durations. ICRP (1981) compiled reference values (Appendix Table 5A-7) of minute volume/inhalation rates from various literature sources. ICRP (1981) assumed that the daily activities of a reference man and woman, and child (10 yrs) consisted of 8 hours of rest and 16 hours of light activities. It was also assumed that 16 hours were divided evenly between occupational and nonoccupational activities. It was assumed that a day consisted of 14 hours resting and 10 hours light activity for an infant (1 yr). A newborn's daily activities consisted of 23 hours resting and 1 hour light activity. Table 5-21 presents the daily inhalation rates obtained for all ages/genders. The estimated inhalation rates were 23 m^3/day for adult males, 21 m^3/day for adult females, 15 m^3/day for children (age 10 years), 3.8 m^3/day for infants (age 1 year), and 0.8 m^3/day for newborns.

Table 5-21. Daily Inhalation Rates Estimated From Daily Activities[a]

	Inhalation Rate (IR)		
Subject	Resting (m^3/hr)	Light Activity (m^3/hr)	Daily Inhalation Rate (DIR)[b] (m^3/day)
Adult Man	0.45	1.2	22.8
Adult Woman	0.36	1.14	21.1
Child (10 yrs)	0.29	0.78	14.8
Infant (1 yr)	0.09	0.25	3.76
Newborn	0.03	0.09	0.78

[a] Assumptions made were based on 8 hours resting and 16 hours light activity for adults and children (10 yrs); 14 hours resting and 10 hours light activity for infants (1 yr); 23 hours resting and 1 hour light activity for newborns.

[b]
$$DIR = \frac{1}{T} \sum_{i=1}^{K} IR_i t_i$$

IR_i = Corresponding inhalation rate at i^{th} activity
t_i = Hours spent during the i^{th} activity
k = Number of activity periods
T = Total time of the exposure period (i.e. a day)

Source: ICRP, 1981

A limitation associated with this study is that the validity and accuracy of the inhalation rates data used in the compilation were not specified. This may introduce some degree of uncertainty in the results obtained. Also, the approach used involved assuming hours spent by various age/gender cohorts in specific activities. These assumptions may over/under-estimate the inhalation rates obtained.

AIHC (1994) - The Exposure Factors Sourcebook - AIHC (1994) recommends an average adult inhalation rate of 18 m^3/day and presents values for children of various ages. These recommendations were derived from data presented in EPA (1989). The newer study by Layron (1993) is not considered. In addtion, the Sourcebook presents probability distributions derived by Brorby and Finley (1993). For each distribution, the @Risk formula is provided for direct use in the @Risk simulation software (Palisade, 1992). The organization of this document makes it very convenient to use in support of Monte Carlo analysis. The reviews of the supporting studies are very brief with little analysis of their strengths and weaknesses. The Sourcebook has been classified as a relevant rather than key study because it is not the primary source for the data used to make recommendations in this document. The Sourcebook is very similar to this document in the sense that it summarizes exposure factor data and recommends values. As such, it is clearly relevant as an alternative information source on inhalation rates as well as other exposure factors.

5.2.4. Recommendations

Recent peer reviewed scientific papers and an EPA report comprise the studies that were evaluated in this Chapter. These studies were conducted in the United States among both men and women of different age groups. All are widely available. The confidence ratings in the inhalation rate recommendations are shown in Table 5-22.

Table 5-22. Confidence in Inhalation Rate Recommendations

Considerations	Rationale	Rating
Study Elements		
• Peer Review	Peer reviewed journal articles EPA peer reviewed report	High
• Accessibility	Journals-wide circulation EPA report available from the National Technical Information Service	High
• Reproducibility	Information on questionnaires and interviews not provided.	Medium
• Focus on factor of interest	Studies focus on ventilation rates and factors influencing them.	High
• Data pertinent to U.S.	Sstudies conducted in the U.S.	High
• Primary data	Both data collection and re-analysis of existing data occurred.	Medium
• Currency	Recent studies were evaluated	High
• Adequacy of data collection period	Effort was made to collect data over time	High
• Validity of approach	Measurements made by indirect methods	Medium
• Representativeness of the population	An effort has been made to consider age and gender but not systematically.	Medium
• Characterization of variability	An effort has been made to address age and gender, but not systematically.	High
• Lack of bias in study design	Subjects selected randomly from volunteers and measured in the same way.	High
• Measurement error	Measurement error is well documented by statistics but procedures measure factor indirectly.	Medium
Other Elements		
• Number of studies	Five key studies and five relevant studies were evaluated	
• Agreement between researchers	General agreement among researchers using different experimental methods	High
Overall Rating	Several studies exist that attempt to estimate inhalation rates according to age, gender and activity.	High

Each study focused on ventilation rates and factors that may affect them. Studies were conducted among randomly selected volunteers. Efforts were made to include men, women, different age groups, and different kinds of activities. Measurement methods are indirect, but reproducible. Methods are well described (except for questionnaires) and experimental error is well documented. There is general agreement with these estimates among researchers.

The recommended inhalation rates for adults, children, and outdoor workers/athletes are based on the key studies described in this chapter (Table 5-23). Different survey designs and populations were utilized in the studies described in this Chapter. A summary of these designs, data generated, and their limitations/advantages are presented in Table 5-24. Excluding the study by Layton (1993), the population surveyed in all of the key studies described in this report were limited to the Los Angeles area. This regional population may not represent the general U.S. population and may result in biases. However, based on other aspects of the study design, these studies were selected as the basis for recommended inhalation rates.

The selection of inhalation rates to be used for exposure assessments depends on the age of the exposed population and the specific activity levels of this population during various exposure scenarios. The recommended values for adults, children (including infants), and outdoor workers/athletes for use in various exposure scenarios are discussed below.

Adults (19-65+ yrs) - For purposes of this recommendation, adults include young to middle age adults (19-64 yrs), and older adults (65+ yrs). The daily average inhalation rates for long term exposure for adults are: 11.3 m^3/day for women and 15.2 m^3/day for men. An upper percentile is not recommended. Additional research and analysis of activity pattern data and dietary data in the future is necessarry to attempt to calculate upper percentiles.

The recommended value for the general population average inhalation rate, 11.3 m^3/day for women and 15.2 m^3/day for men, is different than the 20 m^3/day which has commonly been assumed in past EPA risk assessments.

Table 5-23. Summary of Recommended Values for Inhalation

Population	Mean	Upper Percentile
Long-term Exposures		
Children		
< 1 year	4.5 m^3/day	---
Children		
1-12 years	8.7 m^3/day	---
Adult		
females	11.3 m^3/day	--
males	15.2 m^3/day	--
Short-term Exposures		
Adults and Children		
Rest	0.3 m^3/hr	---
Sedentary Activities	0.4 m^3/hr	---
Light Activities	1.0 m^3/hr	---
Moderate Activities	1.2 m^3/hr	---
Heavy Activites	1.9 m^3/hr	---
Outdoor Workers		
Hourly Average	1.3 m^3/hr	3.5 m^3/hr
Slow Activities	1.1 m^3/hr	
Moderate Activities	1.5 m^3/hr	
Heavy Activities	2.3 m^3/hr	

In addition, recommendations are presented for various ages and special populations (athletes, outdoor workers) which also differ from 20 m^3/day. Assessors are encouraged to use values which most accurately reflect the exposed population. If a risk assessment is being conducted where an inhalation rate other than 20 m^3/day applies to the population of concern, the assessors should consider if a dose-response relationship will be used which was derived assuming an inhalation rate of 20 m^3/day. If such an inconsistency exists, the assessor should adjust the dose-response relationship as described in the appendix to Chapter 1. IRIS does not use a 20 m^3/day assumption in the derivation of RfCs and RfDs, but does make this assumption in the derivation of some cancer slope factors or unit risks.

For exposure scenarios where the distribution of activity patterns is known, the following results, calculated from the studies referenced can be applied:

Table 5-24. Summary of Inhalation Rate Studies

Study	Population Surveyed	Survey Time Period	Data Generated	Limitations/Advantages
Layton 1993	NFCS survey: n≈30,000; NHANES survey: n≈20,000 Time Activity survey: n≈2,126		Daily IRs; IRs at 5 activity levels; and IR for short-term exposures at 5 activity levels.	Reported food biases in the dietary surveys employed; time activity survey was based on recall.
Linn et al., 1992	Panel 1 - 20 healthy outdoor workers, ages 19-50; Panel 2 - 17 healthy elementary school students, ages 10-12; Panel 3 - 19 healthy high school students, ages 13-17; Panel 4 - 49 adult asthmatics, ages 18-20; Panel 5 - 14 adult asthmatics, ages 19-46; Panel 6 - 13 young asthmatics, ages 11-16; Panel 7 - 7 construction workers, ages 26-34.	Late spring and early autumn. 3 diary days. Construction workers' diary day.	Mean and upper estimates of IR; Mean IR at 3 activity levels.	Small sample size; Calibration data not obtained over full HR range; activities based on short-term diary data.
Linn et al.; 1993	n = 19 construction workers.	(Mid-July-early November, 1991) Diary recordings before work, during work and break times	Distribution patterns of hourly IR by activity level.	Small sample population size; breathing rates subjective in nature; activities based on short-term diary data.
Spier et al., 1992	n = 26 students, ages 10-17.	(Late September - October) Involved 3 consecutive days of diary recording	Distribution patterns of hourly IR by activity levels and location	Activities based on short-term diary data; self-estimated breathing rate by younger population was biased; small sample population size.
CARB 1993	n = 160, ages 6-77.	Three 25 min phases of resting protocol in the lab 6 mins of active protocols in the lab. 30 min phases of field protocols repeated once.	Mean values of IR for adult males and females and children by their activity levels.	HR correlated poorly with IR.
Shamoo et al., 1990	n = 9 volunteer outdoor workers ages 21-37, n = 20 outdoor workers, 19-50 years old.	Involved 3-min indoor session/two 3-hr outdoor session at 4 activity levels	No IR data presented.	No useful data were presented for dose assessments studies.
Shamoo et al., 1991	n = 20 outdoor workers, ages 19-50	Diary recordings of three 24-hr. periods within a week.	Distribution patterns of IR and EVR by activity levels and location.	Small sample size; short-term diary data.
Shamoo et al., 1992	n = 9 non-sedentary subjects, ages 21-37.	3-min. intervals of indoor exercises/two 3-hr outdoor exercise sessions at 4 activity levels.	Actual measured ventilation rates presented.	Small sample size; training approach may not be cost-effective; VR obtained for outdoor workers which are sensitive subpopulation.
U.S. EPA, 1985	Based on data from several literature sources	--	Estimated IR for adult males, adult females and children (ages 6 and 10) by various activity levels.	Validity and accuracy of data set employed not defined; IR was estimated not measured.
ICRP, 1974	Based on data from other references	--	Reference daily IR for adult females, adult males, children (10 yrs), and infant (1 yr)	Validity and accuracy of data set employed not defined; IR was estimated not measured.

Note: IR = inhalation rate; HR = heart rate; f_B = breathing frequency; BSA = body-surface area; EVR = equivalent ventilation rate.

Summary of Inhalation Rates for Short-Term Exposure

Arithmetic Mean (m^3/hr)					Reference
		Activity level			
Rest	Sedentary	Light	Moderate	Heavy	
0.5	0.5	1.4	2.4	3.3	CARB, 1993 (Lab protocols)
-	0.6	1.2	1.8	-	CARB, 1993 (Field protocols)
0.4	0.4	0.7	1.4	3.6	Layton, 1993 (Short-term exposure)
0.4	-	0.6	1.5	3.0	Layton, 1993 (3rd approach)
-	-	1.7	2.2	2.7	Spier et al., 1992
-	-	0.8	1.1	1.6	Linn et al., 1992

Based on these key studies, the following recommendations are made: for short term exposures in which distribution of activity patterns are specified, the recommended average rates are 0.4 m^3/hr during rest; 0.5 m^3/hr for sedentary activities; 1.1 m^3/hr for light activities; 1.7 m^3/hr for moderate activities; and 2.8 m^3/hr for heavy activities.

Children (18 yrs old or less including infants) - For purposes of this recommendation, children are defined as males and females between the ages of 1-18 years old, while infants are individuals less than 1 year old. The inhalation rates for children are presented below according to different exposure scenarios.

For long-term dose assessments, the daily inhalation rates are summarized as follows:

Summary of Long Term Exposure Data

Age	Arithmetic Mean (m^3/day) M	F	M&F	Reference
less than 1 yr (1st approach)	4.5	4.5	---	Layton, 1993
1-11 yrs (1st approach)	9.8	9.5	--	Layton, 1993
0.5-10 yrs (2nd approach)	8.3	7.1	--	Layton, 1993
10-12 yrs (calculated)	--	--	21.4	Spier et al., 1992
12-18 yrs (1st approach)	16.0	12.0	--	Layton, 1993
10-18 yrs (2nd approach)	15.0	12.0	--	Layton, 1993

Based on the key study results (i.e., Layton, 1993), the recommended daily inhalation rate for infants (children less than 1 yr), during long-term dose assessments is 4.5 m^3/day. The mean daily inhalation rate obtained from the Spier et al. (1992) study is much higher than the values from the Layton (1993) study. This discrepancy can be attributed to the survey methodologies used by Spier et al. (1992), in which diary information and heart rate (HR) recordings were obtained only when the children were awake (i.e., during active hours). In contrast, inhalation rates in the Layton (1993) study were calculated either based on basal metabolic rate (BMR) which includes resting, or on food energy intake. Also, the two studies represent different age groups. Therefore, based on the Layton (1993) study, the recommended average daily inhalation rate for children between the ages of 1 and 12 years is 8.7 m^3/day. The same shortcomings as those discussed above can be used to reject the upper percentile estimate (64 m^3/day) obtained from the Spier et al. (1992) study.

For short-term exposures in which activity patterns are known, the data summarized below can be used:

Summary of Short-Term Exposure Data

Arithmetic mean (m^3/hr)					
		Activity level			
Rest	Sedentary	Light	Moderate	Heavy	Reference
0.4	0.4	0.8	-	-	CARB, 1993 (lab. protocols)
-	-	-	0.9	-	CARB, 1993 (field protocols)
0.2	0.3	0.5	1.0	2.5	Layton, 1993 (Short-term data)
-	-	1.8	2.0	2.2	Spier et al., 1992 (10-12 yrs)
-	-	0.8	1.0	1.1	Linn et al., 1992 (10-12 yrs)

For short term exposures, the recommended average hourly inhalation rates are based on these key studies. They are as follows: 0.3 m^3/hr during rest; 0.4 m^3/hr for sedentary activities; 1.0 m^3/hr for light activities; 1.2 m^3/hr for moderate activities; and 1.9 m^3/hr for heavy activities. The recommended short-term exposure data also includes infants (less than 1 yr).

Outdoor Worker/Athlete - Inhalation rate data for outdoor workers/athlete are limited. However, based on the key studies (Linn et al., 1992 and 1993), the recommended average hourly inhalation rate for outdoor workers is 1.3 m^3/hr and the upper-percentile rate is 3.5 m^3/hr (see Tables 5-7 and 5-8). The recommended average inhalation rates for outdoor workers based on their activity levels categorized as slow (light activities), medium (moderate activities), and fast (heavy activities) are 1.1 m^3/hr, 1.5 m^3/hr, and 2.3 m^3/hr, respectively. These values are based on the data from Linn et al. (1992 and 1993) (see Tables 5-7 and 5-9).

5.3. REFERENCES FOR CHAPTER 5

American Industrial Health Council (AIHC). (1994) Exposure factors sourcebook. AIHC, Washington, DC.

Basiotis, P.P.; Thomas, R.G.; Kelsay, J.L.; Mertz, W. (1989) Sources of variation in energy intake by men and women as determined from one year's daily dietary records. Am. J. Clin. Nutr. 50:448-453.

CARB. (1993) California Air Resources Board. Measurement of breathing rate and volume in routinely performed daily activities. Human Performance Lab. Contract No. A033-205. June 1993. 185 pgs.

Federal Register Notices (1980). November 28. 45(231): 79318-79379.

ICRP. (1981) International Commission on Radiological Protection. Report of the task group on reference man. New York: Pergammon Press.

Layton, D.W. (1993) Metabolically consistent breathing rates for use in dose assessments. Health Physics 64(1):23-36.

Linn, W.S.; Shamoo, D.A.; Hackney, J.D. (1992) Documentation of activity patterns in "high-risk" groups exposed to ozone in the Los Angeles area. In: Proceedings of the Second EPA/AWMA Conference on Tropospheric Ozone, Atlanta, Nov. 1991. pp. 701-712. Air and Waste Management Assoc., Pittsburgh, PA.

Linn, W.S.; Spier, C.E.; Hackney, J.D. (1993) Activity patterns in ozone-exposed construction workers. J. Occ. Med. Tox. 2(1):1-14.

Menzel, D.B.; Admur, M.O. (1986) Toxic responses of the respiratory system. In: Klaassen, C.; Admur, M.O.; Doull, J., eds. Toxicology, The Basic Science of Poisons. 3rd edition. New York: MacMillan Publishing Company.

Najjar, M.F.; Rowland, M. (1987) Anthropometric reference data and prevalence of overweight: United States. 1976-80. Hyattsville, MD: National Center for Health Statistics. U.S. Department of Health and Human Services: DHHS Publication No. (PHS)87-1688.

Sallis, J.F.; Haskell, W.L.; Wood, P.D.; Fortmann, S.P.; Rogers, T.; Blair, S.N.; Paffenbarger, Jr., R.S. (1985) Physical activity assessment methodology in the Five-City project. Am. J. Epidemiol. 121:91-106.

Shamoo, D.A.; Trim, S.C.; Little, D.E.; Linn, W.S.; Hackney, J.D. (1990) Improved quantitation of air pollution dose rates by improved estimation of ventilation rate. In: Total Exposure Assessment Methodology: A New Horizon, pp. 553-564. Air and Waste Management Assoc., Pittsburgh, PA.

Shamoo, D.A.; Johnson, T.R.; Trim, S.C.; Little, D.E.; Linn, W.S.; Hackney, J.D. (1991) Activity patterns in a panel of outdoor workers exposed to oxidant pollution. J. Expos. Anal. Environ. Epidem. 1(4):423-438.

Shamoo, D.A.; Trim, S.C.; Little, D.E.; Whynot, J.D.; Linn, W.S. (1992) Effectiveness of training subjects to estimate their level of ventilation. J. Occ. Med. Tox. 1(1):55-62.

Spier, C.E.; Little, D.E.; Trim, S.C.; Johnson, T.R.; Linn, W.S.; Hackney, J.D. (1992) Activity patterns in elementary and high school students exposed to oxidant pollution. J. Exp. Anal. Environ. Epid. 2(3):277-293.

U.S. EPA. (1985) Development of statistical distributions or ranges of standard factors used in exposure assessments. Washington, DC: Office of Health and Environmental Assessment; EPA report No. EPA 600/8-85-010. Available from: NTIS, Springfield, VA; PB85-242667.

APPENDIX 5-A

Ventilation Data

Table 5A-1. Statistics of the Age/Gender Cohorts Used to Develop Regression Equations for Predicting Basal Metabolic Rates (BMR) (from Schofield, 1985)

Gender/Age (y)	BMR MJ d^{-1}	±SD	CV[a]	Body Weight (kg)	N[b]	BMR Equation[c]	r[d]
Males							
Under 3	1.51	0.918	0.61	6.6	162	0.249 bw - 0.127	0.95
3 to < 10	4.14	0.498	0.12	21	338	0.095 bw + 2.110	0.83
10 to < 18	5.86	1.171	0.20	42	734	0.074 bw + 2.754	0.93
18 to < 30	6.87	0.843	0.12	63	2879	0.063 bw + 2.896	0.65
30 to < 60	6.75	0.872	0.13	64	646	0.048 bw + 3.653	0.6
60 +	5.59	0.928	0.17	62	50	0.049 bw + 2.459	0.71
Females							
Under 3	1.54	0.915	0.59	6.9	137	0.244 bw - 0.130	0.96
3 to < 10	3.85	0.493	0.13	21	413	0.085 bw + 2.033	0.81
10 to < 18	5.04	0.780	0.15	38	575	0.056 bw + 2.898	0.8
18 to < 30	5.33	0.721	0.14	53	829	0.062 bw + 2.036	0.73
30 to < 60	5.62	0.630	0.11	61	372	0.034 bw + 3.538	0.68
60 +	4.85	0.605	0.12	56	38	0.038 bw + 2.755	0.68

[a] Coefficient of variation (SD/mean)
[b] N = number of subjects
[c] Body weight (bw) in kg
[d] coefficient of correlation
Source: Layton, 1993.

Table 5A-2. Characteristics of Individual Subjects: Anthropometric Data, Job Categories, Calibration Results[a]

Subj. #	Age	Ht. (in.)	Wt. (lb.)	Ethnic Group[a]	Job[b]	Site[c]	Calibration HR Range[d]	Calibration r^{2e}
1761	26	71	180	Wht	GCW	Ofc	69-108	.91
1763	29	63	135	Asn	GCW	Ofc	80-112	.95
1764	32	71	165	Blk	Car	Ofc	56-87	.95
1765	30	73	145	Wht	GCW	Ofc	66-126	.97
1766	31	67	170	His	Car	Ofc	75-112	.89
1767	34	74	220	Wht	Car	Ofc	59-114	.98
1768	32	69	155	Blk	GCW	Ofc	62-152	.95
1769	32	77	230	Wht	Car	Hosp	69-132	.99
1770	26	70	180	Wht	Car	Hosp	63-106	.89
1771	39	66	150	Wht	Car	Hosp	88-118	.91
1772	32	71	260	Wht	Car	Hosp	83-130	.97
1773	39	69	170	Wht	Irn	Hosp	77-128	.95
1774	23	68	150	His	Car	Hosp	68-139	.98
1775	42	67	150	Wht	Irn	Hosp	76-118	.88
1776	29	70	180	His	Car	Hosp	68-152	.99
1778	35	76	220	Ind	Car	Hosp	70-129	.94
1779	40	70	175	Wht	Car	Hosp	72-140	.99
1780	37	75	242	His	Irn	Hosp	68-120	.98
1781	38	65	165	His	Lab	Hosp	66-121	.89
Mean	33	70	181				70-123	.94
S.D.	5	4	36				8-16	.04

[a] Abbreviations are interpreted as follows. Ethnic Group: Asn = Asian-Pacific, Blk = Black, His = Hispanic, Ind = American Indian, Wht = White
[b] Job: Car = carpenter, GCW = general construction worker, Irn = ironworker, Lab = laborer
[c] Site: Hosp = hospital buidling, Ofc = medical office complex. Calibration data
[d] Hr range = range of heart rates in calibration study
[e] r^2 = coefficient of determination (proportion of ventilation rate variability explainable by heart rate variability under calibration-study conditions, using quadratic prediction equation).
Source: Linn et al., 1993.

Table 5A-3. Mean Minute Ventilation (V_E, L/min) by Group and Activity for Laboratory Protocols

Activity		Young Children[a]	Children	Adult Females	Adult Males
Lying		6.19	7.51	7.12	8.93
Sitting		6.48	7.28	7.72	9.30
Standing		6.76	8.49	8.36	10.65
Walking	1.5 mph	10.25	DNP	DNP	DNP
	1.875 mph	10.53	DNP	DNP	DNP
	2.0 mph	DNP	14.13	DNP	DNP
	2.25 mph	11.68	DNP	DNP	DNP
	2.5 mph	DNP	15.58	20.32	24.13
	3.0 mph	DNP	17.79	24.20	DNP
	3.3 mph	DNP	DNP	DNP	27.90
	4.0 mph	DNP	DNP	DNP	36.53
Running	3.5 mph	DNP	26.77	DNP	DNP
	4.0 mph	DNP	31.35	46.03[b]	DNP
	4.5 mph	DNP	37.22	47.86[b]	57.30
	5.0 mph	DNP	DNP	50.78[b]	58.45
	6.0 mph	DNP	DNP	DNP	65.66[b]

[a] Young Children, male and female 3-5.9 yr olds; Children, male and female 6-12.9 yr olds; Adult Females, adolescent, young to middle-aged, and older adult females; Adult Males, adolescent, young to middle-aged, and older adult males; DNP, group did not perform this protocol or N was too small for appropriate mean comparisons

[b] Older adults not included in the mean value since they did not perform running protocol at particular speeds.

Source: CARB, 1993.

Table 5A-4.Mean Minute Ventilation (V_E, L/min) by Group and Activity for Field Protocols

Activity	Young Children[a]	Children	Adult Females	Adult Males
Play	11.31	17.89	DNP	DNP
Car Driving	DNP	DNP	8.95	10.79
Car Riding	DNP	DNP	8.19	9.83
Yardwork	DNP	DNP	19.23[e]	26.07[b]/31.89[c]
Housework	DNP	DNP	17.38	DNP
Car Maintenance	DNP	DNP	DNP	23.21[d]
Mowing	DNP	DNP	DNP	36.55[e]
Woodworking	DNP	DNP	DNP	24.42[e]

[a] Young Children, male and female 3-5.9 yr olds; Children, male and female 6-12.9 yr olds; Adult Females, adolescent, young to middle-aged, and older adult females; Adult Males, adolescent, young to middle-aged, and older adult males; DNP, group did not perform this protocol or N was too small for appropriate mean comparisons;

[b] Mean value for young to middle-aged adults only

[c] Mean value for older adults only

[d] Older adults not included in the mean value since they did not perform this activity.

[e] Adolescents not included in mean value since they did not perform this activity

Source: CARB, 1993.

Table 5A-5. Estimated Minute Ventilation Associated with Activity Level for Average Male Adult[a]

Level of work	L/min	Representative activities
Light	13	Level walking at 2 mph; washing clothes
Light	19	Level walking at 3 mph; bowling; scrubbing floors
Light	25	Dancing; pushing wheelbarrow with 15-kg load; simple construction; stacking firewood
Moderate	30	Easy cycling; pushing wheelbarrow with 75-kg load; using sledgehammer
Moderate	35	Climbing stairs; playing tennis; digging with spade
Moderate	40	Cycling at 13 mph; walking on snow; digging trenches
Heavy Heavy Very heavy	55 63 72	Cross-country skiing; rock climbing; stair climbing with load; playing squash or handball; chopping with axe
Very heavy	85	Level running at 10 mph; competitive cycling
Severe	100 +	Competitive long distance running; cross-country skiing

[a] Average adult assumed to weigh 70 kg.
Source: Adapted from U.S. EPA, 1985

Table 5A-6. Minute Ventilation Ranges by Age, Sex, and Activity Level

		Ventilation ranges (liters/minute)											
Age	Sex	Resting			Light			Moderate			Heavy		
		n	Range	Mean	n	Range	Mean	n	Range	Mean	n	Range	Mean
Infants	M/F	316	0.25 - 2.09	0.84					---			---	
2	F		---			---			---			---	
	M		---			---			---			---	
3	F		---			---			---			---	
	M		---			---			---			---	
4	F		---			---			---		2	32.0 - 32.5	32.3
	M		---			---			---		4	39.3 - 43.3	41.2
5	F		---			---			---		3	31.0 - 35.0	32.8
	M		---			---			---		3	30.9 - 42.6	37.5
6	F		---			---			---		2	35.9 - 38.9	37.4
	M	8	5.0 - 7.0	6.5	16	5.0 - 32.0	13.9	4	28.0 - 43.0	33.3	3	35.5 - 43.5	40.3
7	F		---			---			---		3	48.2 - 51.4	49.6
	M		---			---			---		2	44.1 - 55.8	50.0
8	F		---			---			---		4	51.2 - 67.6	57.6
	M		---			---			---		3	59.3 - 62.2	60.7
9	F		---			---			---		27	55.8 - 63.4	50.9
	M		---			---			---		7	59.5 - 75.2	65.7
10	F		---			---			---		21	46.2 - 71.1	60.4
	M	10	5.2 - 8.3	7.1	20	5.2 - 35.0	17.2	9	41.0 - 68.0	53.4	6	63.9 - 74.6	70.5
	F		---			---			---		7	49.7 - 80.9	63.5
	M		---		20	---	20.3	20	---	33.1	9	47.6 - 77.5	65.5
12	F	54	4.1 - 16.1	15.4		---		4	19.6 - 46.3	26.5	31	65.5 - 79.9	71.8
	M	56	7.2 - 16.3	15.4		---		6	18.5 - 46.3	34.1	9	58.1 - 84.7	67.7
13	F	5	7.2 - 15.4	9.9		---		5	18.5 - 46.3	30.3	7	67.6 - 102.6	87.7
	M	16	3.1 - 15.4	8.9	30	3.1 - 24.9	16.4	29	14.4 - 48.4	32.8	38	27.8 - 105.0	57.9
14	F	53	3.1 - 15.6	14.9		---		3	21.6 - 37.1	28.1	5	80.7 - 100.7	88.9
	M	77	3.1 - 27.8	14.2		---		24	24.7 - 55.0	39.7	16	42.2 - 121.0	86.9
15	F	1	---	6.2		---		1	---	26.8	6	68.4 - 97.1	87.1
	M	8	3.1 - 26.8	11.1		---		7	27.8 - 46.3	39.3	6	48.4 - 140.3	110.5
16	F	50	---	15.2		---	---		---		8	73.6 - 119.1	93.9
	M	50	---	15.6		---			---		3	79.6 - 132.2	102.5
17	F		---			---			---		2	91.9 - 95.3	93.6
	M	12	5.8 - 9.0	7.3		---		12	40.0 - 63.0	48.6	3	89.4 - 139.3	107.7
18	F		---			---			---			---	
	M		---			---			---		9	99.7 - 143.0	120.9
Adults	F	595	4.2 - 11.66	5.7	786	4.2 - 29.4	8.1	106	20.7 - 34.2	26.5	211	23.4 - 114.8	47.9
Adults	M	454	2.3 - 18.8	12.2	102	2.3 - 27.6	13.8	102	14.4 - 78.0	40.9	267	34.6 - 183.4	80.0

n = number of observations

Note: Values in liters/minute can be converted to units of m^3/hour by multiplying by the conversion factor, $\frac{60 \text{ minutes/hour}}{1000 \text{ liters/m}^3}$

Source: Adapted from U.S. EPA, 1985.

Table 5A-7. Reference Values Obtained From Various Literature Sources

Col.	1	2	3			4			5			6		
Line	Subject	W (kg)	Resting			Light Activity			Heavy Work			Maximal Work During Exercise		
			f	VT	V*	f	VT	V*	f	VT	V*	f	VT	V*
	Adult													
1	Man	68.5	12	750	7.4	17	1670	29	21	2030	43			
2	1.7 m^2 SA		12	500	6									
3	30y; 170 cm L		15	500	7.5	16	1250	20						
4	20-33 y	70.4										40	3050	111
5	Woman	54	12	340	4.5	19	860	16	30	880	25			
6	30 y; 160 cm L		15	400	6	20	940	19						
7	20-25 y; 165.8 cm L	60.3										46	2100	90
8	Pregnant (8th mo)		16	650	10									
	Adolescent													
9	male, 14-16 y		16	330	5.2							53	2520	113
10	male, 14-15 y	59.4												
11	female, 14-16 y		15	300	4.5									
12	female, 14-15 y; 164.9 cm L	56										52	1870	88
	Children													
13	10 y; 140 cm L		16	300	4.8	24	600	14						
14	males, 10-11 y	36.5										58	1330	71
15	males, 10-11 y; 140.6 cm L	32.5										61	1050	61
16	females, 4-6 y	20.8										70	600	40
17	females, 4-6 y; 111.6 cm L	18.4										66	520	34
18	Infant, 1 y		30	48	1.4[a]									
19	Newborn	2.5	34	15	0.5									
20	10 h-13 wk	2.5-5.3										68[b]	51[a,b]	3.5[b]
21	9.6 h	3.6	25	21	0.5									
22	6.6 d	3.7	29	21	0.6									

W = body weights referable to the dimension quoted in column 1; f = frequency (breaths/min); VT = tidal volume (ml); V* = minute volume (l/min); SA = surface area.

[a] Calculated from V* = f x VT.
[b] Crying.

Source: ICRP, 1981.

TABLE OF CONTENTS

6. DERMAL ROUTE

Dermal exposure can occur during a variety of activities in different environmental media and microenvironments (U.S. EPA, 1992). These include:

- Water (e.g., bathing, washing, swimming);
- Soil (e.g., outdoor recreation, gardening, construction);
- Sediment (e.g., wading, fishing);
- Liquids (e.g., use of commercial products);
- Vapors/fumes (e.g., use of commercial products); and
- Indoors (e.g., carpets, floors, countertops).

The major factors that must be considered when estimating dermal exposure include: the chemical concentration in contact with the skin, the extent of skin surface area exposed, the duration of exposure, and the rate of absorption of the chemical.

This chapter focuses on measurements of body surface areas and various factors needed to estimate dermal exposure to chemicals in water and soil. Useful information concerning estimates of body surface area can be found in "Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments" (U.S. EPA, 1985). "Dermal Exposure Assessment: Principles and Applications, (U.S. EPA, 1992) provides detailed information concerning dermal exposure using a stepwise guide in the exposure assessment process. Information concerning dermal exposure to pollutants in indoor environments is limited.

The available studies have been classified as either key or relevant based on their applicability to exposure assessment needs and summarized in this chapter. Recommended values are based on the results of the key studies. Relevant studies are presented to provide an added perspective on the state-of-knowledge pertaining to dermal exposure factors. All tables and figures presenting data from each study are shown at the end of this chapter.

6.1. EQUATION FOR DERMAL DOSE

The average daily dose (ADD) is the dose rate averaged over a pathway-specific period of exposure expressed as a daily dose on a per-unit-body-weight basis. The ADD is used for exposure to chemicals with non-carcinogenic non-chronic effects. For compounds with carcinogenic or chronic effects, the lifetime average daily dose (LADD) is used. The LADD is the dose rate averaged over a lifetime.

For dermal contact with chemicals in water, dermally absorbed average daily dose can be estimated by (U.S. EPA, 1992):

$$ADD = \frac{DA_{event} \times EV \times ED \times EF \times SA}{BW \times AT} \qquad \text{(Eqn. 6-1)}$$

where:

ADD	=	average daily dose (mg/kg-day);
DA_{event}	=	absorbed dose per event (mg/cm^2-event);
EV	=	event frequency (events/day);
ED	=	exposure duration (years);
EF	=	exposure frequency (days/year);
SA	=	skin surface area available for contact (cm^2);
BW	=	body weight (kg); and
AT	=	averaging time (days) for noncarcinogenic effects, AT = ED and for carcinogenic effects, AT = 70 years or 25,550 days.

This method is to be used to calculate the absorbed dose of a chemical in water. Total body surface area (SA) is assumed to be exposed to water for a period of time (ED). The DA_{event} is estimated with consideration for the permeability coefficient from water, the chemical concentration in water, and the event duration.

The approach to estimate DA_{event} is different for inorganic and organic compounds. The nonsteady-state approach to estimate the dermally absorbed dose from water is recommended as the preferred approach for organics which exhibit octanol-water partitioning (U.S. EPA, 1992). First, this approach more accurately reflects normal human exposure conditions since the short contact times associated with bathing and swimming generally mean that steady state will not occur. Second, the approach accounts for uptake that can occur after the actual exposure event due to absorption of residual chemical trapped in skin tissue. Use of the nonsteady-state model for organics has implications for selecting permeability coefficient (K_p) values (U.S. EPA, 1992). It is recommended that the traditional steady-state approach be applied to inorganics (U.S. EPA, 1992). Detailed information concerning how to estimate absorbed dose per event (DA_{event}) can be found in "Dermal Exposure Assessment: Principles and Applications" (U.S. EPA, 1992).

For dermal contact with contaminated soil, a variation of Equation 6-1 is used. Dermally absorbed dose is calculated using the equation below:

$$ADD = \frac{DA_{event} \times EF \times ED \times SA}{BW \times AT} \quad \text{(Eqn. 6-2)}$$

where:

ADD	=	average daily dose (mg/kg-day);
DA_{event}	=	absorbed dose per event (mg/cm^2-event);
SA	=	skin surface area available for contact (cm^2);
EF	=	exposure frequency (events/year);
ED	=	exposure duration (years);
BW	=	body weight (kg); and
AT	=	averaging time (days), for non-carcinogenic effects, AT = ED, and for carcinogenic effects, AT = 70 years or 25,550 days.

Estimation of the DA_{event} is based on the concentration of the chemical in soil, the adherence factor of soil to skin, and the absorption fraction.

The apparent simplicity of the absorption fraction (percent absorbed) makes this approach appealing. However, it is not practical to apply it to water contact scenarios, such as swimming, because of the difficulty in estimating the total material contacted (U.S. EPA, 1992). It is assumed that there is essentially an infinite amount of material available, and that the chemical will be replaced continuously, thereby increasing the amount of material (containing the chemical) available by some large unknown amount. Therefore, the permeability coefficient -based approach is recommended over the absorption fraction approach for determining the dermally absorbed dose of chemicals in aqueous media.

Before the absorption fraction approach can be used in soil contact scenarios, the contaminant concentration in soil must be established. Not all of the chemical in a layer of dirt applied to skin may be bioavailable, nor is it assumed to become an absorbed dose. Because of the lack of K_p data for compounds bound to soil, and reduced uncertainty in defining an applied dose, the absorption fraction-based approach is suggested for determining the dermally absorbed dose of chemicals in soil. More detailed explanation of the equations, assumptions, and approaches can be found in "Dermal Exposure Assessment: Principles and Applications" (U.S. EPA. 1992).

6.2. SURFACE AREA

6.2.1. Background

The total surface area of skin exposed to a contaminant must be determined using measurement or estimation techniques before conducting a dermal exposure assessment. Depending on the exposure scenario, estimation of the surface area for the total body or a specific body part can be used to calculate the contact rate for the pollutant. This section presents estimates for total body surface area and for body parts and presents information on the application of body surface area data.

6.2.2. Measurement Techniques

Coating, triangulation, and surface integration are direct measurement techniques that have been used to measure total body surface area and the surface area of specific body parts. Consideration has been given for differences due to age, gender, and race. The results of the various techniques have been summarized in "Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments" (U.S. EPA, 1985). The coating method consists of coating either the whole body or specific body regions with a substance of known or measured area. Triangulation consists of marking the area of the body into geometric figures, then calculating the figure areas from their linear dimensions. Surface integration is performed by using a planimeter and adding the areas.

The triangulation measurement technique developed by Boyd (1935) has been found to be highly reliable. It estimates the surface area of the body using geometric approximations that assume parts of the body resemble geometric solids (Boyd, 1935). More recently, Popendorf and Leffingwell (1976), and Haycock et al. (1978) have developed similar geometric methods that assume body parts correspond to geometric solids, such as the sphere and cylinder. A linear method proposed by DuBois and DuBois (1916) is based on the principle that the surface areas of the parts of the body are proportional, rather than equal to the surface area of the solids they resemble.

In addition to direct measurement techniques, several formulae have been proposed to estimate body surface area from measurements of other major body dimensions (i.e., height and weight) (U.S. EPA, 1985). Generally, the formulae are based on the principles that body density and shape are roughly the same and that the relationship of surface area to any dimension may be represented by the curve of central tendency of their plotted values or by the algebraic expression for the curve. A discussion and comparison of formulae to determine total body surface area are presented in Appendix 6A.

6.2.3. Key Body Surface Area Studies

U.S. EPA (1985) - Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments - U.S. EPA (1985) analyzed the direct surface area measurement data of Gehan and George (1970) using the Statistical Processing System (SPS) software package of Buhyoff et al. (1982). Gehan and George selected 401 measurements made by Boyd (1935) that were complete for surface area, height, weight, and age for their analysis. Boyd (1935) had reported surface area estimates for 1,114 individuals using coating, triangulation, or surface integration methods (U.S. EPA, 1985).

U.S. EPA (1985) used SPS to generate equations to calculate surface area as a function of height and weight. These equations were then used to calculate body surface area distributions of the U.S. population using the height and weight data obtained from the National Health and Nutrition Examination Survey (NHANES) II and the computer program QNTLS of Rochon and Kalsbeek (1983).

The equation proposed by Gehan and George (1970) was determined by U.S. EPA (1985) to be the best choice for estimating total body surface area. However, the paper by Gehan and George gave insufficient information to estimate the standard error about the regression. Therefore, U.S. EPA (1985) used the 401 direct measurements of children and adults and reanalyzed the data using the formula of Dubois and Dubois (1916) and SPS to obtain the standard error (U.S. EPA, 1985).

Regression equations were developed for specific body parts using the Dubois and Dubois (1916) formula and using the surface area of various body parts provided by Boyd (1935) and Van Graan (1969) in conjunction with SPS. Regression equations for adults were developed for the head, trunk (including the neck), upper extremities (arms and hands, upper arms, and forearms) and lower extremities (legs and feet, thighs, and lower legs) (U.S. EPA, 1985). Table 6-1 presents a summary of the equation parameters developed by the U.S. EPA (1985) for calculating surface area of adult body parts. Equations to estimate the body part surface area of children were not developed because of insufficient data.

Percentile estimates of total surface area and surface area of body parts developed by U.S. EPA (1985) using the regression equations and NHANES II height and weight data are presented in Tables 6-2 and 6-3 for adult males and adult females, respectively. The calculated mean surface areas of body parts for men and women are presented in Table 6-4. The standard deviation, the minimum value, and the maximum value for each body part are included. The median total body surface area for men and women and the corresponding standard errors about the regressions are also given. It has been assumed that errors associated with height and weight are negligible (U.S. EPA, 1985). The data in Table 6-5 present the percentage of total body surface by body part for men and women.

Percentile estimates for total surface area of male and female children presented in Tables 6-6 and 6-7 were calculated using the total surface area regression equation, NHANES II height and weight data, and using QNTLS. Estimates are not included for children younger than 2 years old because NHANES height data are not available for this age group. For children, the error associated with height and weight cannot be assumed to be zero because of their relatively small sizes. Therefore, the standard errors of the percentile estimates cannot be estimated, since it cannot be assumed that the errors associated with the exogenous variables (height and weight) are independent of that associated with the model; there are insufficient data to determine the relationship between these errors.

Measurements of the surface area of children's body parts are summarized as a percentage of total surface area in Table 6-8. Because of the small sample size, the data cannot be assumed to represent the average percentage of surface area by body part for all children. Note that the percent of total body surface area contributed by the head decreases from childhood to adult, while the percent contributed by the leg increases.

Phillips et al. (1993) - Distributions of Total Skin Surface Area to Body Weight Ratios - Phillips et al. (1993) observed a strong correlation (0.986) between body surface area and body weight. They studied the effect of using these factors as independent variables in the LADD equation. They concluded that, because of the correlation between these two variables, the use of body surface area to body weight (SA/BW) ratios in human exposure assessments is more appropriate than treating these factors as independent variables. Direct measurement (coating, triangulation, and surface integration) data from the scientific literature were used to calculate body surface area to body weight (SA/BW) ratios for three age groups (infants aged 0 to 2 years, children aged 2.1 to 17.9 years, and adults 18 years and older). These ratios were calculated by dividing body surface areas by corresponding body weights for the 401 individuals analyzed by Gehan and George (1970) and summarized by U.S. EPA (1985). Distributions of SA/BW ratios were developed and summary statistics were calculated for each of the three age groups and the combined data set. Summary statistics for these populations are presented in Table 6-9. The shapes of these SA/BW distributions were determined using D'Agostino's test. The results indicate that the SA/BW ratios for infants are lognormally distributed and the SA/BW ratios for adults and all ages combined are normally distributed (Figure 6-1). SA/BW ratios for children were neither normally nor lognormally distributed. According to Phillips et al. (1993), SA/BW ratios should be used to calculate LADDs by replacing the body surface area factor in the numerator of the LADD equation with the SA/BW ratio and eliminating the body weight factor in the denominator of the LADD equation.

The effect of gender and age on SA/BW distribution was also analyzed by classifying the 401 observations by gender and age. Statistical analyses indicated no significant differences between SA/BW ratios for males and females. SA/BW ratios were found to decrease with increasing age.

6.2.4. Relevant Surface Area Studies

Murray and Burmaster (1992) - Estimated Distributions for Total Body Surface Area of Men and Women in the United States - In this study, distributions of total body surface area for men and women ages 18 to 74 years were estimated using Monte Carlo simulations based on height and weight distributions. Four different formulae for estimating body surface area as a function of height and weight were employed: Dubois and Dubois (1916); Boyd (1935); U.S. EPA (1989); and Costeff (1966). The formulae of Dubois and Dubois (1916); Boyd (1935); and U.S. EPA (1989) are based on height and weight. They are discussed in Appendix 6A. The formula developed by Costeff (1966) is based on 220 observations that estimate body surface area based on weight only. This formula is:

$$SA = 4W + 7/W + 90 \qquad \text{(Eqn. 6-3)}$$

where:

SA = Surface Area (m^2); and
W = Weight (kg).

Formulae were compared and the effect of the correlation between height and weight on the body surface area distribution was analyzed.

Monte Carlo simulations were conducted to estimate body surface area distributions. They were based on the bivariate distributions estimated by Brainard and Burmaster (1992) for height and natural logarithm of weight and the formulae described above. A total of 5,000 random samples each for men and women were selected from the two correlated bivariate distributions. Body surface area calculations were made for each sample, and for each formula, resulting in body surface area distributions. Murray and Burmaster (1992), found that the body surface area frequency distributions were similar for the four models (Table 6-10). Using the U.S. EPA (1985) formula, the median surface area values were calculated to be 1.96 m^2 for men and 1.69 m^2 for women. The median value for women is identical to that generated by U.S. EPA (1985) but differs for men by approximately 1 percent. Body surface area was found to have lognormal distribution for both men and women (Figure 6-2). It was also found that assuming correlation between height and weight influences the final distribution by less than 1 percent.

AICH (1994) - Exposure Factors Sourcebook - The Exposure Factors Sourcebook (AIHC, 1994) provides similar body surface area data as presented here. Consistent with this document, average and percentile values are presented on the basis of age and gender. In addition, the Sourcebook presents point estimates of exposed skin surface areas for various scenarios on the basis of several published studies. Finally, the Sourcebook presents probability distributions based on U.S. EPA (1989) and as derived by Brainard and Burmaster et al. (1991); Versar (1991); and Brorby and Finley (1993). For each distribution, the @Risk formula is provided for direct use in the @Risk simulation software (Palisade, 1992). The organization of this document, makes it very convenient to use in support of Monte Carlo analysis. The reviews of the supporting studies are very brief with little analysis of their strengths and weaknesses. The Sourcebook has been classified as a relevant rather than key study because it is not the primary source for the data used to make recommendations in this document. The Sourcebook is very similar to this document in the sense that it summarizes exposure factor data and recommends values. As such, it is clearly relevant as an alternative information source on body surface area as well as other exposure factors.

6.2.5. Application of Body Surface Area Data

In many settings, it is likely that only certain parts of the body are exposed. All body parts that come in contact with a chemical must be considered to estimate the total surface area of the body exposed. The data in Table 6-4 may be used to estimate the total surface area of the particular body part(s). For example, to assess exposure to a chemical in a cleaning product for which only the hands are exposed, surface area values for hands from Table 6-4 can be used. For exposure to both hands and arms, mean surface areas for these parts from Table 6-4 may be summed to estimate the total surface area exposed. The mean surface area of these body parts for men and women is as follows:

	Surface Area (m^2)	
	Men	Women
Arms (includes upper arms and forearms)	0.228	0.210
Hands	0.084	0.075
Total area	0.312	0.285

Therefore, the total body part surface area that may be in contact with the chemical in the cleaning product in this example is 0.312 m^2 for men and 0.285 m^2 for women.

A common assumption is that clothing prevents dermal contact and subsequent absorption of contaminants. This assumption may be false in cases where the chemical may be able to penetrate clothing, such as in a fine dust or liquid suspension. Studies using personal patch monitors placed beneath clothing of pesticide workers exposed to fine mists and vapors show that a significant proportion of dermal exposure may occur at anatomical sites covered by clothing (U.S. EPA, 1992). In addition, it has been demonstrated that a "pumping" effect can occur which causes material to move under loose clothing (U.S. EPA, 1992). Furthermore, studies have demonstrated that hands cannot be considered to be protected from exposure even if waterproof gloves are worn (U.S. EPA, 1992). This may be due to contamination to the interior surface of the gloves when donning or removing them during work activities (U.S. EPA, 1992). Depending on the task, pesticide workers have been shown to experience 12 percent to 43 percent of their total exposure through their hands, approximately 20 percent to 23 percent through their heads and necks, and 36 percent to 64 percent through their torsos and arms, despite the use of protective gloves and clothing (U.S. EPA, 1992).

For swimming and bathing scenarios, past exposure assessments have assumed that 75 percent to 100 percent of the skin surface is exposed (U.S. EPA, 1992). As shown in Table 6-4, total adult body surface areas can vary from about 17,000 cm^2 to 23,000 cm^2. The mean is reported as approximately 20,000 cm^2.

For default purposes, adult body surface areas of 20,000 cm^2 (central estimate) to 23,000 cm^2 (upper percentile) are recommended in U.S. EPA (1992). Tables 6-2 and 6-3 can also be used when the default values are not preferred. Central and upper-percentile values for children should be derived from Table 6-6 or 6-7.

Unlike exposure to liquids,clothing may or may not be effective in limiting the extent of exposure to soil. The 1989 Exposure Factors Handbook presented two adult clothing scenarios for outdoor activities (U.S. EPA, 1989):

> **Central tendency mid range:** Individual wears long sleeve shirt, pants, and shoes. The exposed skin surface is limited to the head and hands (2,000 cm^2).
>
> **Upper percentile:** Individual wears a short sleeve shirt, shorts, and shoes. The exposed skin surface is limited to the head, hands, forearms, and lower legs (5,300 cm^2).

The clothing scenarios presented above, suggest that roughly 10 percent to 25 percent of the skin area may be exposed to soil. Since some studies have suggested that exposure can occur under clothing, the upper end of this range was selected in *Dermal Exposure Assessment: Principles and Applications* (U.S. EPA, 1992) for deriving defaults. Thus, taking 25 percent of the total body surface area results in defaults for adults of 5,000 cm^2 to 5,800 cm^2. These values were obtained from the body surface areas in Table 6-2 after rounding to 20,000 cm^2 and 23,000 cm^2, respectively. The range of defaults for children can be derived by multiplying the 50th and 95th percentiles by 0.25 for the ages of interest.

When addressing soil contact exposures, assessors may want to refine estimates of surface area exposed on the basis of seasonal conditions. For example, in moderate climates, it may be reasonable to assume that 5 percent of the skin is exposed during the winter, 10 percent during the spring and fall, and 25 percent during the summer.

The previous discussion, has presented information about the area of skin exposed to soil. These estimates of exposed skin area should be useful to assessors using the traditional approach of multiplying the soil adherence factor by exposed skin area to estimate the total amount of soil on skin. The next section recommends a new form of the soil adherence factor which is specific to activity and body part and is designed to be combined with the total surface area of that body part. No reduction of body part area is made for clothing coverage using this approach. Thus, assessors who adopt this approach, should not use the defaults presented above for soil exposed skin area. Rather, they should use Table 6-4 to obtain total surface areas of specific body parts. See detailed discussion below.

6.3. DERMAL ADHERENCE TO SOIL

6.3.1. Background

Soil adherence to the surface of the skin is a required parameter to calculate dermal dose when the exposure scenario involves dermal contact with a chemical in soil. A number of studies have attempted to determine the magnitude of dermal soil adherence. These studies are described in detail in U.S. EPA (1992). This section summarizes recent studies that estimate soil adherence to skin for use as exposure factors.

6.3.2. Key Dermal Adherence to Soil Study

Kissel et al. (1996a) - Factors Affecting Soil Adherence to Skin in Hand-Press Trials: Investigation of Soil Contact and Skin Coverage - Kissel et al. (1996a) conducted soil adherence experiments using five soil types (descriptor) obtained locally in the Seattle, Washington, area: sand (211), loamy sand (CP), loamy sand (85), sandy loam (228), and silt loam (72). All soils were analyzed by hydrometer (settling velocity) to determine composition. Clay contents ranged from 0.5 to 7.0 percent. Organic carbon content, determined by combustion, ranged from 0.7 to 4.6 percent. Soils were dry sieved to obtain particle size ranges of <150, 150-250, and >250 μm. For each soil type, the amount of soil adhering to an adult female hand, using both sieved and unsieved soils, was determined by measuring the difference in soil sample weight before and after the hand was pressed into a pan containing the test soil. Loadings were estimated by dividing the recovered soil mass by total hand area, although loading occurred primarily on only one side of the hand. Results showed that generally, soil adherence to hands could be directly correlated with moisture content, inversely correlated with particle size, and independent of clay content or organic carbon content.

Kissel et al. (1996a) used a fluorescent marking technique and video imaging to assess the percentage of skin coverage in several soil contact trials in a greenhouse setting, and an irrigation pipe laying trial (Table 6-11). The investigators concluded that adjusted loadings, averaged over fluorescing areas only, may be two to three orders of magnitude larger than average loadings, if average loadings are small.

Further experiments by Kissel et al. (1996a) estimated soil adherence associated with various indoor and outdoor activities: greenhouse gardening, tae kwon do karate, soccer, rugby, reed gathering, irrigation installation, truck farming, and playing in mud. A summary of field studies by activity, gender, age, field conditions, and clothing worn is presented in Table 6-12. Subjects body surfaces (forearms, hands, lower legs in all cases, faces, and/or feet; pairs in some cases) were washed before and after monitored activities. Paired samples were pooled into single ones. Mass recovered was converted to loading using allometric models of surface area. These data are presented in Table 6-13.

6.3.3. Relevant Dermal Adherence to Soil Studies

Lepow et al. (1975) - Investigations into Sources of Lead in the Environment of Urban Children - This study was conducted to identify the behavioral and environmental factors contributing to elevated lead levels in ten preschool children. The study was performed over 6-25 months. Samples of dirt from the hands of subjects were collected during the course of play around the areas where they lived. Preweighed self-adhesive labels were used to sample a standard area on the palm of the hands of 16 male and female children. The labels were pressed on a single area, often pressed several times, to obtain an adequate sample. In the laboratory, labels were equilibrated in a desiccant cabinet for 24 hours (comparable to the preweighed desiccation), then the total weight was recorded. The mean weight of dirt from the 22 hand sample labels was 11 mg. This corresponds to 0.51 mg/cm^2. Lepow et al. (1975) reported that this amount (11 mg) represented only a small fraction (percent not specified) of the total amount of surface dirt present on the hands, because much of the dirt may be trapped in skin folds and creases or there may be a patchy distribution of dirt on hands.

Roels et al. (1980) - Exposure to Lead by the Oral and the Pulmonary Routes of Children Living in the Vicinity of a Primary Lead Smelter - Roels et al. (1980) examined blood lead levels among 661 children, 9-14 years old, who lived in the vicinity of a large lead smelter in Brussels, Belgium. During five different study periods, lead levels were assessed by rinsing the childrens' hands in 500 mL dilute nitric acid. The amount of lead on the hands was divided by the concentration of lead in soil to estimate the amount of soil adhering to the hands. The mean soil amount adhering to the hands was 0.159 grams.

Sedman (1989)- The Development of Applied Action Levels for Soil Contact: A Scenario for the Exposure of Humans to Soil in a Residential Setting - Sedman (1989) used the estimate from Roels et al. (1980), 0.159 g, and the average surface area of the hand of an 11 year old, 307 cm^2 to estimate the amount of soil adhering per unit area of skin to be 0.9 mg/cm^2. This assumed that approximately 60 percent (185 cm^2) of the lead on the hands was recovered by the method employed by Roels et al. (1980).

Sedman (1989) used estimates from Lepow et al. (1975), Roels et al. (1980), and Que Hee et al. (1985) to develop a maximum soil load that could occur on the skin. A rounded arithmetic mean of 0.5 mg/cm^2 was calculated from these three studies. According to Sedman (1989), this was near the maximum load of soil that could occur on the skin but it is unlikely that most skin surfaces would be covered with this amount of soil (Sedman, 1989).

Que Hee et al. (1985) - Evolution of Efficient Methods to Sample Lead Sources, Such as House Dust and Hand Dust, in the Homes of Children - Que Hee et al. (1985) used soil having particle sizes ranging from ≤ 44 to 833 µm diameters, fractionated into six size ranges, to estimate the amount that adhered to the palm of the hand assumed to be approximately 160 cm^2 (test subject approximately 14 years old with an average total body surface area of 16,000 cm^2 and a total hand surface area of 400 cm^2). The amount of soil that adhered to skin was determined by applying approximately 5 g of soil for each size fraction, removing excess soil by shaking the hands, and then measuring the difference in weight before and after application. Several assumptions were made to apply these results to other soil types and exposure scenarios: (a) the soil is composed of particles of the indicated diameters; (b) all soil types and particle sizes adhere to the skin to the degree observed in this study; and an equivalent weight of particles of any diameter adhere to the same surface area of skin. On average, 31.2 mg of soil adhered to the palm of the hand. From this experiment it was assumed that 0.2 mg of soil adhered to 1 cm^2 of skin.

Driver et al. (1989) - Soil Adherence to Human Skin - Driver et al. (1989) conducted soil adherence experiments using various soil types collected from sites in Virginia. A total of five soil types were collected: Hyde, Chapanoke, Panorama, Jackland, and Montalto. Both top soils and subsoils were collected for each soil type. The soils were also characterized by cation exchange capacity, organic content, clay mineralogy, and particle size distribution. The soils were dry sieved to obtain particle sizes of ≤250 µm and ≤150 µm. For each soil type, the amount of soil adhering to adult male hands, using both sieved and unsieved soils, was determined gravimetrically (i.e., measuring the difference in soil sample weight before and after soil application to the hands).

An attempt was made to measure only the minimal or "monolayer" of soil adhering to the hands. This was done by mixing a pre-weighed amount of soil over the entire surface area of the hands for a period of approximately 30 seconds, followed by removal of excess soil by gently rubbing the hands together after contact with the soil. Excess soil that was removed from the hands was collected, weighed, and compared to the original soil sample weight. The authors measured average adherence of 1.40 mg/cm^2 for particle sizes less than 150 µm, 0.95 mg/cm^2 for particle sizes less than 250 µm, and 0.58 mg/cm^2 for unsieved soils. Analysis of variance statistics showed that the most important factor affecting adherence variability was particle size ($p < 0.001$). The next most important factor is soil type and subtype ($p < 0.001$). The interaction of soil type and particle size was also significant, but at a lower significance level ($p < 0.01$).

Driver et al. (1989) found statistically significant increases in soil adherence with decreasing particle size; whereas, Que Hee et al. (1985) found relatively small changes with changes in particle size. The amount of soil adherence found by Driver et al. (1989) was greater than that reported by Que Hee et al. (1985).

Yang et al. (1989) - In vitro and In vivo Percutaneous Absorption of Benzo[a]pyrene from Petroleum Crude - Fortified Soil in the Rat - Yang et al. (1989) evaluated the percutaneous absorption of benzo[a]pyrene (BAP) in petroleum crude oil sorbed on soil using a modified in vitro technique. This method was used in preliminary experiments to determine the minimum amount of soil adhering to the skin of rats. Based on these results, percutaneous absorption experiments with the crude-sorbed soil were conducted with soil particles of < 150 μm only. This particle size was intended to represent the composition of the soil adhering to the skin surface. Approximately 9 mg/cm^2 of soil was found to be the minimum amount required for a "monolayer" coverage of the skin surface in both in vitro and in vivo experiments. This value is larger than the < 1 mg/cm^2 of soil (dust) reported for human skin in the studies of Lepow et al., 1975; Roels et al., 1980; and Que Hee et al., 1985. Differences between the rat and human soil adhesion findings may be the result of differences in rat and human skin texture, the types of soils used, soil moisture content or possibly the methods of measuring soil adhesion (Yang et al., 1985).

6.4. RECOMMENDATIONS

6.4.1. Body Surface Area

Body surface area estimates are based on direct measurements. Re-analysis of data collected by Boyd (1935) by several investigators (Gehan and George, 1970; U.S. EPA, 1985; Murray and Burmaster, 1992; Phillips et al., 1993) constitutes much of this literature. Methods are highly reproducible and the results are widely accepted. The representativeness of these data to the general population is somewhat limited since variability due to race or gender have not been systematically addressed.

Individual body surface area studies are summarized in Table 6-14 and the recommendations for body surface area are summarized in Table 6-15. Table 6-16 presents the confidence ratings for various aspects of the recommendations for body surface area. The U.S. EPA (1985) study is based on generally accepted measurements that enjoy widespread usage, summarizes and compares previous reports in the literature, provides statistical distributions for adults, and provides data for total body surface area and body parts by gender for adults and children. However, the results are based on 401 selected measurements from the original 1,114 made by Boyd (1935). More than half of the measurements are from children. Therefore, these estimates may be subject to selection bias and may not be representative of the general population nor specific ethnic groups. Phillips et al. (1993) analyses are based on direct measurement data that provide distributions of body surface area to calculate LADD. Results are consistent with previous efforts to estimate body surface area. Analyses are based on 401 measurements selected from the original 1,114 measurements made by Boyd (1935) and data were not analyzed for specific body parts. The study by Murray and Burmaster (1992) provides frequency distributions for body surface area for men and women and produces results that are similar to those obtained by the U.S. EPA (1985), but do not provide data for body parts nor can results be applied to children.

For most dermal exposure scenarios concerning adults, it is recommended that the body surface areas presented in Table 6-4 be used after determining which body parts will be exposed. Table 6-4 was selected because these data are straightforward determinations for most scenarios. However, for others, additional considerations may need to be addressed. For example, (1) the type of clothing worn could have a significant effect on the surface area exposed, and (2) climatic conditions will also affect the type of clothing worn and, thus, the skin surface area exposed.

Frequency, event, and exposure duration for water activities and soil contact are presented in Activity Patterns, Volume III, Chapter 14 of this report. For each parameter, recommended values were derived for average and upper percentile values. Each of these considerations are also discussed in more detail in U.S. EPA (1992). Data in Tables 6-2 and 6-3 can be used when surface area distributions are preferred. A range of recommended values for estimates of the skin surface area of children may be taken from Tables 6-6 and 6-7 using the 50th and 95th percentile values for age(s) of concern. The recommended 50th and 90th percentile values for adult skin surface area provided in U.S. EPA (1992) are:

	Water Contact	
	50th	95th
Bathing and Swimming	20,000 cm^2	23,000 cm^2
	Soil Contact	
	50th	95th
Outdoor Activities	5,000 cm^2	5,800 cm^2

6.4.2. Dermal Adherence to Soil

Table 6-18 summarizes the relevant and key studies addressing soil adherence to skin. Both Lepow et al. (1975) and Roels et al. (1980) monitored typical exposures in children over long periods of time. They attempted to estimate typical exposure by recovery of accumulated soil from hands at specific time intervals. The efficiency of their sample collection methods is not known and may be subject to error. Only children were studied which may limit generalizing these results to adults. Later studies (Que Hee et al., 1985 and Driver et al., 1989) attempted to characterize both soil properties and sample collection efficiency to estimate adherence of soil to skin. However, the experimental conditions used to expose skin to soil may not reflect typical dermal exposure situations. This provides useful information about the influence of soil characteristics on skin adherence, but the intimate contact of skin with soil required under the controlled experimental conditions in the studies by Driver et al. (1989) and Que Hee et al. (1985) may have exaggerated the amount of adherence over what typically occurs.

More recently, Kissel et al. (1996a; 1996b) have related dermal adherence to soil characteristics and to specific activities. In all cases, experimental design and measurement methods are straightforward and reproducible, but application of results is limited. Both controlled experiments and field studies are based on a limited number of measurements. Specific situations have been selected to assess soil adherence to skin. Consequently, variation due to individuals, protective clothing, temporal, or seasonal factors remain to be studied in more detail. Therefore, caution is required in interpretation and application of these results for exposure assessments.

The studies all have uncertainties, but suggest the following generalizations about soil adherence:

- Soil properties influence adherence. Adherence increases with moisture content, decreases with particle size, but is relatively unaffected by clay or organic carbon content.

- Adherence levels vary considerably across different parts of the body. The highest levels were found on common contact points such as hands, knees, and elbows; the least was detected on the face.

- Adherence levels vary with activity. In general, the highest levels of soil adherence were seen in outdoor workers such as farmers and irrigation system installers, followed by outdoor recreation, and gardening activities. Very high adherence levels were seen in individuals contacting wet soils such as might occur during wading or other shore area recreational activities.

In consideration, of these general observations and the recent data from Kissel et al. (1996a, 1996b), this document recommends a new approach for estimating soil adherence to skin. First use Table 6-12 to select the activity which best approximates the exposure scenario of concern. Next, use Table 6-13 to select soil loadings on exposed skin surfaces which correspond to the activity of interest. This table contains soil loading estimates for various body parts. The estimates were derived from soil adherence measurements of body parts of individuals engaged in specific activities described in Table 6-12. These results provide the best estimate of central loadings, but are based on limited data. Therefore, they have a high degree of uncertainty such that considerable judgment must be used when selecting them for an assessment. The confidence ratings for various aspects of this recommendation are summarized in Table 6-17. Insufficient data are available to develop a distribution or a probability function for soil loadings.

Past EPA guidance has recommended assuming that soil exposure occurs primarily to exposed body surfaces and used typical clothing scenarios to derive estimates of exposed skin area. The approach recommended above for estimating soil adherence addresses this issue in a different manner. This change was motivated by two developments. First, increased acceptance that soil and dust particles can get under clothing and be deposited on skin. Second, recent studies of soil adherence have measured soil on entire body parts (whether or not they were covered by clothing) and averaged the amount of soil adhering to skin over the area of entire body part. The soil adherence levels resulting from these new studies must be combined with the surface area of the entire body part (not merely unclothed surface area) to estimate the amount of contaminant on skin. An important caveat, however, is that this approach assumes that clothing in the exposure scenario of interest matches the clothing in the studies used to derive these adherence levels such that the same degree of protection provided by clothing can be assumed in both cases. If clothing differs significantly between the studies reported here and the exposure scenarios under investigation, considerable judgment is needed to adjust either the adherence level or surface area assumption.

The dermal adherence value represents the amount of soil on the skin at the time of measurement. Assuming that the amount measured on the skin represents its accumulation between washings and that people wash at least once per day, these adherence values can be interpreted as daily contact rates (U.S. EPA, 1992). However, this is not recommended because the residence time of soils on skin has not been studied. Instead, it is recommended that these adherence values be interpreted on an event basis (U.S. EPA, 1992).

6.5. REFERENCES FOR CHAPTER 6

American Industrial Health Council (AIHC). (1994) Exposure factors sourcebook. AIHC, Washington, DC.

Boyd, E. (1935) The growth of the surface area of the human body. Minneapolis, Minnesota: University of Minnesota Press.

Brainard, J.B.; Burmaster, D.E. (1992) Bivariate distributions for height and weight, men and women in the United States. Risk Analysis 12(2):267-275.

Brorby, G.; Finley B. (1993) Standard probability density functions for routine use in environmental health risk assessment. Presented at the Society of Risk Analysis Annual Meeting, December 1993, Savannah, GA.

Buhyoff, G.J.; Rauscher, H.M.; Hull, R.B.; Killeen, K.; Kirk, R.C. (1982) User's Manual for Statistical Processing System (version 3C.1). Southeast Technical Associats, Inc.

Costeff, H. (1966) A simple empirical formula for calculating approximate surface area in children. Arch. Dis. Childh. 41:681-683.

Driver, J.H.; Konz, J.J.; Whitmyre, G.K. (1989) Soil adherence to human skin. Bull. Environ. Contam. Toxicol. 43:814-820.

Dubois, D.; Dubois, E.F. (1916) A formula to estimate the approximate surface area if height and weight be known. Arch. of Intern. Med. 17:863-871.

Gehan, E.; George, G.L. (1970) Estimation of human body surface area from height and weight. Cancer Chemother. Rep. 54(4):225-235.

Geigy Scientific Tables (1981) Nomograms for determination of body surface area from height and mass. Lentner, C. (ed.). CIBA-Geigy Corporation, West Caldwell, NJ. pp. 226-227.

George, S.L.; Gehan, E.A.; Haycock, G.B.; Schwartz, G.J. (1979) Letters to the editor. The Journal of Pediactrics. 94(2):342.

Haycock, G.B.; Schwartz, G.J.; Wisotsky, D.H. (1978) Geometric method for measuring body surface area: A height-weight formula validated in infants, children, and adults. J. Ped. 93(1):62-66.

Kissel, J.; Richter, K.; Duff, R.; Fenske, R. (1996a) Factors Affecting Soil Adherence to Skin in Hand-Press Trials. In press: Bull. Environ. Contamin. Toxicol.

Kissel, J.; Richter, K.; Fenske, R. (1996b) Field measurements of dermal soil loading attributable to various activities: Implications for exposure assessment. Risk Anal. 16(1):116-125.

Lepow, M.L.; Bruckman, L.; Gillette, M.; Markowitz, S.; Rubino, R.; Kapish, J. (1975) Investigations into sources of lead in the environment of urban children. Environ. Res. 10:415-426.

Murray, D.M.; Burmaster, D.E. (1992) Estimated distributions for total surface area of men and women in the United States. J. Expos. Anal. Environ. Epidemiol. 3(4):451-462.

Palisade. (1992) @Risk users guide. Palisade Corporation, Newfield, NY.

Phillips, L.J.; Fares, R.J.; Schweer, L.G. (1993) Distributions of total skin surface area to body weight ratios for use in dermal exposure assessments. J. Expos. Anal. Environ. Epidemiol. 3(3):331-338.

Popendorf, W.J.; Leffingwell, J.T. (1976) Regulating OP pesticide residues for farmworker protection. In: Residue Review 82. New York, NY: Springer-Verlag New York, Inc., 1982. pp. 125-201.

Que Hee, S.S.; Peace, B.; Clark, C.S.; Boyle, J.R.; Bornschein, R.L.; Hammond, P.B. (1985) Evolution of efficient methods to sample lead sources, such as house dust and hand dust, in the homes of children. Environ. Res. 38: 77-95.

Rochon, J.; Kalsbeck, W.D. (1983) Variance estimation from multi-stage sample survey data: the jackknife repeated replicate approach. Presented at 1983 SAS Users Group Conference, New Orleans, Louisiania, January 1983.

Roels, H.A.; Buchet, J.P.; Lauwenys, R.R.; Branx, P.; Claeys-Thoreau, F.; Lafontaine, A.; Verduyn, G. (1980) Exposure to lead by oral and pulmonary routes of children living in the vicinity of a primary lead smelter. Environ. Res. 22:81-94.

Sedman, R.M. (1989) The development of applied action levels for soil contact: a scenario for the exposure of humans to soil in a residential setting. Environ. Health Perspect. 79:291-313.

Sendroy, J.; Cecchini, L.P. (1954) Determination of human body surface area from height and weight. Journal of Applied Physiology. 7(1):3-12.

U.S. EPA. (1985) Development of statistical distributions or ranges of standard factors used in exposure assessments. Washington, DC: Office of Research and Development, Office of Health and Environmental Assessment. U.S. EPA No. 600/8-85-010. Available from: NTIS, Springfield, VA. PB85-242667.

U.S. EPA. (1989) Risk assessment guidance for superfund. Human health evaluation manual: Part A. Interim Final. Washington, DC: Office of

Solid Waste and Emergency Response. NTIS: PB-90-155581.

U.S. EPA. (1992) Dermal exposure assessment: principles and applications. Washington, DC: Office of Research and Development, Office of Health and Environmental Assessment/OHEA. U.S. EPA/600/8-9-91.

Van Graan, C.H. (1969) The determination of body surface area. Supplement to the South African J. of Lab. and Clin. Med. 8-2-69.

Versar, Inc. (1991) Analysis of the impact of exposure assumptions on risk assessment of chemicals in the environment, phase II: uncertainty analyses of existing exposure assessment methods. Draft Report. Prepared for Exposure Assessment Task Group, Chemical Manufacturers Association, Washington, DC.

Yang, J.J.; Roy, T.A.; Krueger, A.J.; Neil, W.; Mackerer, C.R. (1989) In vitro and in vivo percutaneous absorption of benzo[a]pyrene from petroleum crude-fortified soil in the rat. Bull. Environ. Contam. Toxicol. 43: 207-214.

Table 6-1. Summary of Equation Parameters for Calculating Adult Body Surface Area

Body Part	N	Equation for surface areas (m^2): a_o	W^{a1}	H^{a2}	P	R^2	S.E.
Head							
Female	57	0.0256	0.124	0.189	0.01	0.302	0.00678
Male	32	0.0492	0.339	-0.0950	0.01	0.222	0.0202
Trunk							
Female	57	0.188	0.647	-0.304	0.001	0.877	0.00567
Male	32	0.0240	0.808	-0.0131	0.001	0.894	0.0118
Upper Extremities							
Female	57	0.0288	0.341	0.175	0.001	0.526	0.00833
Male	48	0.00329	0.466	0.524	0.001	0.821	0.0101
Arms							
Female	13	0.00223	0.201	0.748	0.01	0.731	0.00996
Male	32	0.00111	0.616	0.561	0.001	0.892	0.0177
Upper Arms							
Male	6	8.70	0.741	-1.40	0.25	0.576	0.0387
Forearms							
Male	6	0.326	0.858	-0.895	0.05	0.897	0.0207
Hands							
Female	12[b]	0.0131	0.412	0.0274	0.1	0.447	0.0172
Male	32	0.0257	0.573	-0.218	0.001	0.575	0.0187
Lower Extremities[c]	105	0.00286	0.458	0.696	0.001	0.802	0.00633
Legs	45	0.00240	0.542	0.626	0.001	0.780	0.0130
Thighs	45	0.00352	0.629	0.379	0.001	0.739	0.0149
Lower legs	45	0.000276	0.416	0.973	0.001	0.727	0.0149
Feet	45	0.000618	0.372	0.725	0.001	0.651	0.0147

[a] $SA = a_o\ W^{a1}\ H^{a2}$
W = Weight in kilograms; H = Height in centimeters; P = Level of significance; R^2 = Coefficient of determination;
SA = Surface Area; S.E. = Standard error; N = Number of observations
[b] One observation for a female whose body weight exceeded the 95 percentile was not used.
[c] Although two separate regressions were marginally indicated by the F test, pooling was done for consistency with individual components of lower extremities.
Source: U.S. EPA, 1985.

Table 6-2. Surface Area of Adult Males in Square Meters

	Percentile									
Body part	5	10	15	25	50	75	85	90	95	S.E.[a]
Total	1.66	1.72	1.76	1.82	1.94	2.07	2.14	2.20	2.28	0.00374
Head	0.119	0.121	0.123	0.124	0.130	0.135	0.138	0.140	0.143	0.0202
Trunk[b]	0.591	0.622	0.643	0.674	0.739	0.807	0.851	0.883	0.935[c]	0.0118
Upper extremities	0.321	0.332	0.340	0.350	0.372	0.395	0.408	0.418	0.432[c]	0.00101
Arms	0.241	0.252	0.259	0.270	0.291	0.314[c]	0.328[c]	0.339[c]	0.354[c]	0.00387
Forearms	0.106	0.111	0.115	0.121	0.131	0.144[c]	0.151[c]	0.157[c]	0.166[c]	0.0207
Hands	0.085	0.088	0.090	0.093	0.099	0.105	0.109	0.112	0.117	0.0187
Lower extremities	0.653	0.676	0.692	0.715	0.761	0.810	0.838	0.858	0.888[c]	0.00633
Legs	0.539	0.561	0.576	0.597	0.640	0.686[c]	0.714[c]	0.734[c]	0.762[c]	0.0130
Thighs	0.318	0.331	0.341	0.354	0.382	0.411[c]	0.429[c]	0.443[c]	0.463[c]	0.0149
Lower legs	0.218	0.226	0.232	0.240	0.256	0.272	0.282	0.288	0.299	0.0149
Feet	0.114	0.118	0.120	0.124	0.131	0.138	0.142	0.145	0.149	0.0147

[a] Standard error for the 5-95 percentile of each body part.
[b] Trunk includes neck.
[c] Percentile estimates exceed the maximum measured values upon which the equations are based.
Source: U.S. EPA, 1985.

Table 6-3. Surface Area of Adult Females in Square Meters

	Percentile									
Body part	5	10	15	25	50	75	85	90	95	S.E.[a]
Total	1.45	1.49	1.53	1.58	1.69[c]	1.82	1.91	1.98	2.09	0.00374
Head	0.106	0.107	0.108	0.109	0.111	0.113	0.114	0.115	0.117	0.00678
Trunk[b]	0.490	0.507	0.518	0.538	0.579	0.636	0.677	0.704	0.752	0.00567
Upper extremities	0.260	0.265	0.269	0.274	0.287	0.301	0.311	0.318	0.329	0.00833
Arms	0.210	0.214	0.217	0.221	0.230	0.238[c]	0.243[c]	0.247[c]	0.253[c]	0.00996
Hands	0.0730	0.0746	0.0757	0.0777	0.0817	0.0868[c]	0.0903[c]	0.0927[c]	0.0966[c]	0.0172
Lower extremities	0.564	0.582	0.595	0.615	0.657	0.704	0.736	0.757	0.796	0.00633
Legs	0.460	0.477	0.488	0.507	0.546	0.592	0.623	0.645	0.683[c]	0.0130
Thighs	0.271	0.281	0.289	0.300	0.326	0.357	0.379	0.394	0.421[c]	0.0149
Lower legs	0.186	0.192	0.197	0.204	0.218	0.233	0.243	0.249	0.261	0.0149
Feet	0.100	0.103	0.105	0.108	0.114	0.121	0.126	0.129	0.134	0.0147

[a] Standard error for the 5-95 percentile of each body part.
[b] Trunk includes neck.
[c] Percentile estimates exceed the maximum measured values upon which the equations are based.
Source: U.S. EPA, 1985.

Table 6-4. Surface Area by Body Part for Adults (m^2)

Body part	Men						Women					
	N[b]	Mean	(sd)[a]	Min.	-	Max.	N	Mean	(sd)	Min.	-	Max.
Head	32	0.118	(0.0160)	0.090	-	0.161	57	0.110	(0.00625)	0.0953	-	0.127
Trunk (Incl. Neck)	32	0.569	(0.104)	0.306	-	0.893	57	0.542	(0.0712)	0.437	-	0.867
Upper extremities	48	0.319	(0.0461)	0.169	-	0.429	57	0.276	(0.0241)	0.215	-	0.333
Arms	32	0.228	(0.0374)	0.109	-	0.292	13	0.210	(0.0129)	0.193	-	0.235
Upper arms	6	0.143	(0.0143)	0.122	-	0.156	-	-	-	-	-	-
Forearms	6	0.114	(0.0127)	0.0945	-	0.136	-	-	-	-		-
Hands	32	0.084	(0.0127)	0.0596	-	0.113	12	0.0746	(0.00510)	0.0639		0.0824
Lower extremities	48	0.636	(0.0994)	0.283	-	0.868	57	0.626	(0.0675)	0.492	-	0.809
Legs	32	0.505	(0.0885)	0.221	-	0.656	13	0.488	(0.0515)	0.423	-	0.585
Thighs	32	0.198	(0.1470)	0.128	-	0.403	13	0.258	(0.0333)	0.258	-	0.360
Lower legs	32	0.207	(0.0379)	0.093	-	0.296	13	0.194	(0.0240)	0.165	-	0.229
Feet	32	0.112	(0.0177)	0.0611	-	0.156	13	0.0975	(0.00903)	0.0834	-	0.115
TOTAL		1.94	(0.00374)[c]	1.66	-	2.28[d]		1.69	(0.00374)[c]	1.45	-	2.09[d]

[a] standard deviation.
[b] number of observations.
[c] median (standard error).
[d] percentiles (5th - 95th).
Source: Adapted from U.S. EPA, 1985.

Table 6-5. Percentage of Total Body Surface Area by Part for Adults

	Men						Women					
Body part	N[a]	Mean	(s.d.)[b]	Min.	-	Max.	N	Mean	(s.d.)	Min.	-	Max.
Head	32	7.8	(1.0)	6.1	-	10.6	57	7.1	(0.6)	5.6	-	8.1
Trunk	32	35.9	(2.1)	30.5	-	41.4	57	34.8	(1.9)	32.8	-	41.7
Upper extremities	48	18.8	(1.1)	16.4	-	21.0	57	17.9	(0.9)	15.6	-	19.9
Arms	32	14.1	(0.9)	12.5	-	15.5	13	14.0	(0.6)	12.4	-	14.8
Upper arms	6	7.4	(0.5)	6.7	-	8.1	-	-	-	-	-	-
Forearms	6	5.9	(0.3)	5.4	-	6.3	-	-	-	-		-
Hands	32	5.2	(0.5)	4.6	-	7.0	12	5.1	(0.3)	4.4		5.4
Lower extremities	48	37.5	(1.9)	33.3	-	41.2	57	40.3	(1.6)	36.0	-	43.2
Legs	32	31.2	(1.6)	26.1	-	33.4	13	32.4	(1.6)	29.8	-	35.3
Thighs	32	18.4	(1.2)	15.2	-	20.2	13	19.5	(1.1)	18.0	-	21.7
Lower legs	32	12.8	(1.0)	11.0	-	15.8	13	12.8	(1.0)	11.4	-	14.9
Feet	32	7.0	(0.5)	6.0	-	7.9	13	6.5	(0.3)	6.0	-	7.0

[a] Number of observations.
[b] Standard deviation.
Source: Adapted from U.S. EPA, 1985.

Table 6-6. Total Body Surface Area of Male Children in Square Meters[a]

Age (yr)[b]	Percentile 5	10	15	25	50	75	85	90	95
2 < 3	0.527	0.544	0.552	0.569	0.603	0.629	0.643	0.661	0.682
3 < 4	0.585	0.606	0.620	0.636	0.664	0.700	0.719	0.729	0.764
4 < 5	0.633	0.658	0.673	0.689	0.731	0.771	0,796	0.809	0.845
5 < 6	0.692	0.721	0.732	0.746	0.793	0.840	0.864	0.895	0.918
6 < 7	0.757	0.788	0.809	0.821	0.866	0.915	0.957	1.01	1.06
7 < 8	0.794	0.832	0.848	0.877	0.936	0.993	1.01	1.06	1.11
8 < 9	0.836	0.897	0.914	0.932	1.00	1.06	1.12	1.17	1.24
9 < 10	0.932	0.966	0.988	1.00	1.07	1.13	1.16	1.25	1.29
10 < 11	1.01	1.04	1.06	1.10	1.18	1.28	1.35	1.40	1.48
11 < 12	1.00	1.06	1.12	1.16	1.23	1.40	1.47	1.53	1.60
12 < 13	1.11	1.13	1.20	1.25	1.34	1.47	1.52	1.62	1.76
13 < 14	1.20	1.24	1.27	1.30	1.47	1.62	1.67	1.75	1.81
14 < 15	1.33	1.39	1.45	1.51	1.61	1.73	1.78	1.84	1.91
15 < 16	1.45	1.49	1.52	1.60	1.70	1.79	1.84	1.90	2.02
16 < 17	1.55	1.59	1.61	1.66	1.76	1.87	1.98	2.03	2.16
17 < 18	1.54	1.56	1.62	1.69	1.80	1.91	1.96	2.03	2.09
3 < 6	0.616	0.636	0.649	0.673	0.728	0.785	0.817	0.842	0.876
6 < 9	0.787	0.814	0.834	0.866	0.931	1.01	1.05	1.09	1.14
9 < 12	0.972	1.00	1.02	1.07	1.16	1.28	1.36	1.42	1.52
12 < 15	1.19	1.24	1.27	1.32	1.49	1.64	1.73	1.77	1.85
15 < 18	1.50	1.55	1.59	1.65	1.75	1.86	1.94	2.01	2.11

[a] Lack of height measurements for children < 2 years in NHANES II precluded calculation of surface areas for this age group.
[b] Estimated values calculated using NHANES II data.
Source: U.S. EPA, 1985.

Table 6-7. Total Body Surface Area of Female Children in Square Meters[a]

Age (yr)[b]	Percentile 5	10	15	25	50	75	85	90	95
2 < 3	0.516	0.532	0.544	0.557	0.579	0.610	0.623	0.637	0.653
3 < 4	0.555	0.570	0.589	0.607	0.649	0.688	0.707	0.721	0.737
4 < 5	0.627	0.639	0.649	0.666	0.706	0.758	0.777	0.794	0.820
5 < 6	0.675	0.700	0.714	0.735	0.779	0.830	0.870	0.902	0.952
6 < 7	0.723	0.748	0.770	0.791	0.843	0.914	0.961	0.989	1.03
7 < 8	0.792	0.808	0.819	0.854	0.917	0.977	1.02	1.06	1.13
8 < 9	0.863	0.888	0.913	0.932	1.00	1.05	1.08	1.11	1.18
9 < 10	0.897	0.948	0.969	1.01	1.06	1.14	1.22	1.31	1.41
10 < 11	0.981	1.01	1.05	1.10	1.17	1.29	1.34	1.37	1.43
11 < 12	1.06	1.09	1.12	1.16	1.30	1.40	1.50	1.56	1.62
12 < 13	1.13	1.19	1.24	1.27	1.40	1.51	1.62	1.64	1.70
13 < 14	1.21	1.28	1.32	1.38	1.48	1.59	1.67	1.75	1.86
14 < 15	1.31	1.34	1.39	1.45	1.55	1.66	1.74	1.76	1.88
15 < 16	1.38	1.49	1.43	1.47	1.57	1.67	1.72	1.76	1.83
16 < 17	1.40	1.46	1.48	1.53	1.60	1.69	1.79	1.84	1.91
17 < 18	1.42	1.49	1.51	1.56	1.63	1.73	1.80	1.84	1.94
3 < 6	0.585	0.610	0.630	0.654	0.711	0.770	0.808	0.831	0.879
6 < 9	0.754	0.790	0.804	0.845	0.919	1.00	1.04	1.07	1.13
9 < 12	0.957	0.990	1.03	1.06	1.16	1.31	1.38	1.43	1.56
12 < 15	1.21	1.27	1.30	1.37	1.48	1.61	1.68	1.74	1.82
15 < 18	1.40	1.44	1.47	1.51	1.60	1.70	1.76	1.82	1.92

[a] Lack of height measurements for children < 2 years in NHANES II precluded calculation of surface areas for this age group.
[b] Estimated values calculated using NHANES II data.
Source: U.S. EPA, 1985.

Table 6-8. Percentage of Total Body Surface Area by Body Part for Children

Age (yr)	N M:F	Percent of Total											
		Head		Trunk		Arms		Hands		Legs		Feet	
		Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max
< 1	2:0	18.2	18.2-18.3	35.7	34.8-36.6	13.7	12.4-15.1	5.3	5.21-5.39	20.6	18.2-22.9	6.54	6.49-6.59
1 < 2	1:1	16.5	16.5-16.5	35.5	34.5-36.6	13.0	12.8-13.1	5.68	5.57-5.78	23.1	22.1-24.0	6.27	5.84-6.70
2 < 3	1:0	14.2		38.5		11.8		5.30		23.2		7.07	
3 < 4	0:5	13.6	13.3-14.0	31.9	29.9-32.8	14.4	14.2-14.7	6.07	5.83-6.32	26.8	26.0-28.6	7.21	6.80-7.88
4 < 5	1:3	13.8	12.1-15.3	31.5	30.5-32.4	14.0	13.0-15.5	5.70	5.15-6.62	27.8	26.0-29.3	7.29	6.91-8.10
5 < 6													
6 < 7	1:0	13.1		35.1		13.1		4.71		27.1		6.90	
7 < 8													
8 < 9													
9 < 10	0:2	12.0	11.6-12.5	34.2	33.4-34.9	12.3	11.7-12.8	5.30	5.15-5.44	28.7	28.5-28.8	7.58	7.38-7.77
10 < 11													
11 < 12													
12 < 13	1:0	8.74		34.7		13.7		5.39		30.5		7.03	
13 < 14	1:0	9.97		32.7		12.1		5.11		32.0		8.02	
14 < 15													
15 < 16													
16 < 17	1:0	7.96		32.7		13.1		5.68		33.6		6.93	
17 < 18	1:0	7.58		31.7		17.5		5.13		30.8		7.28	

N: Number of subjects, male to female ratios.

Source: U.S. EPA 1985.

Table 6-9. Descriptive Statistics for Surface Area/Body Weight (SA/BW) Ratios (m^2/kg)

Age (yrs.)	Mean	Range Min-Max	SD[a]	SE[b]	Percentiles 5	10	25	50	75	90	95
0-2	0.0641	0.0421-0.1142	0.0114	7.84e-4	0.0470	0.0507	0.0563	0.0617	0.0719	0.0784	0.0846
2.1 - 17.9	0.0423	0.0268-0.0670	0.0076	1.05e-3	0.0291	0.0328	0.0376	0.0422	0.0454	0.0501	0.0594
≥ 18	0.0284	0.0200-0.0351	0.0028	7.68e-6	0.0238	0.0244	0.0270	0.0286	0.0302	0.0316	0.0329
All ages	0.0489	0.0200-0.1142	0.0187	9.33e-4	0.0253	0.0272	0.0299	0.0495	0.0631	0.0740	0.0788

[a] Standard deviation.
[b] Standard error of the mean.
Source: Phillips et al., 1993.

Table 6-10. Statistical Results for Total Body Surface Area Distributions (m^2)

	Men: U.S. EPA	Boyd	DuBois and DuBois	Costeff
Mean	1.97	1.95	1.94	1.89
Median	1.96	1.94	1.94	1.89
Mode	1.96	1.91	1.90	1.90
Standard Deviation	0.19	0.18	0.17	0.16
Skewness	0.27	0.26	0.23	0.04
Kurtosis	3.08	3.06	3.02	2.92
	Women: U.S. EPA	**Boyd**	**DuBois and DuBois**	**Costeff**
Mean	1.73	1.71	1.69	1.71
Median	1.69	1.68	1.67	1.68
Mode	1.68	1.62	1.60	1.66
Standard Deviation	0.21	0.20	0.18	0.21
Skewness	0.92	0.88	0.77	0.69
Kurtosis	4.30	4.21	4.01	3.52

Source: Murray and Burmaster, 1992

Table 6-11. Skin Coverage with Soil by Body Part and Activity

Exposure Trial	N[a]	Percent Skin Coverage by Body Part: Hands	N[a]	Lower legs	N[a]	Forearms	N[a]	Face
Children playing in wet soil	24	80	18	20	18	10	13	0
Adults transplanting plants in wet soil	28	70	24	10	26	0	15	0
Pipe laying trials	3	36-52 (M)[b]	3	6-12 (M)	--	--	--	0
dry soil, 15-30 min. duration	3	54-62 (W)[b]	3	15-33 (W)	--	--	--	0
Pipe laying trials	4	75-82 (M)	4	12-25 (M)	--	--	--	0
wet soil, 15-30 min. duration	3	56-86 (W)	3	4-14 (W)	--	--	--	0

[a] N = number of subjects
[b] M = men; W = women
Source: Kissel et al., 1995.

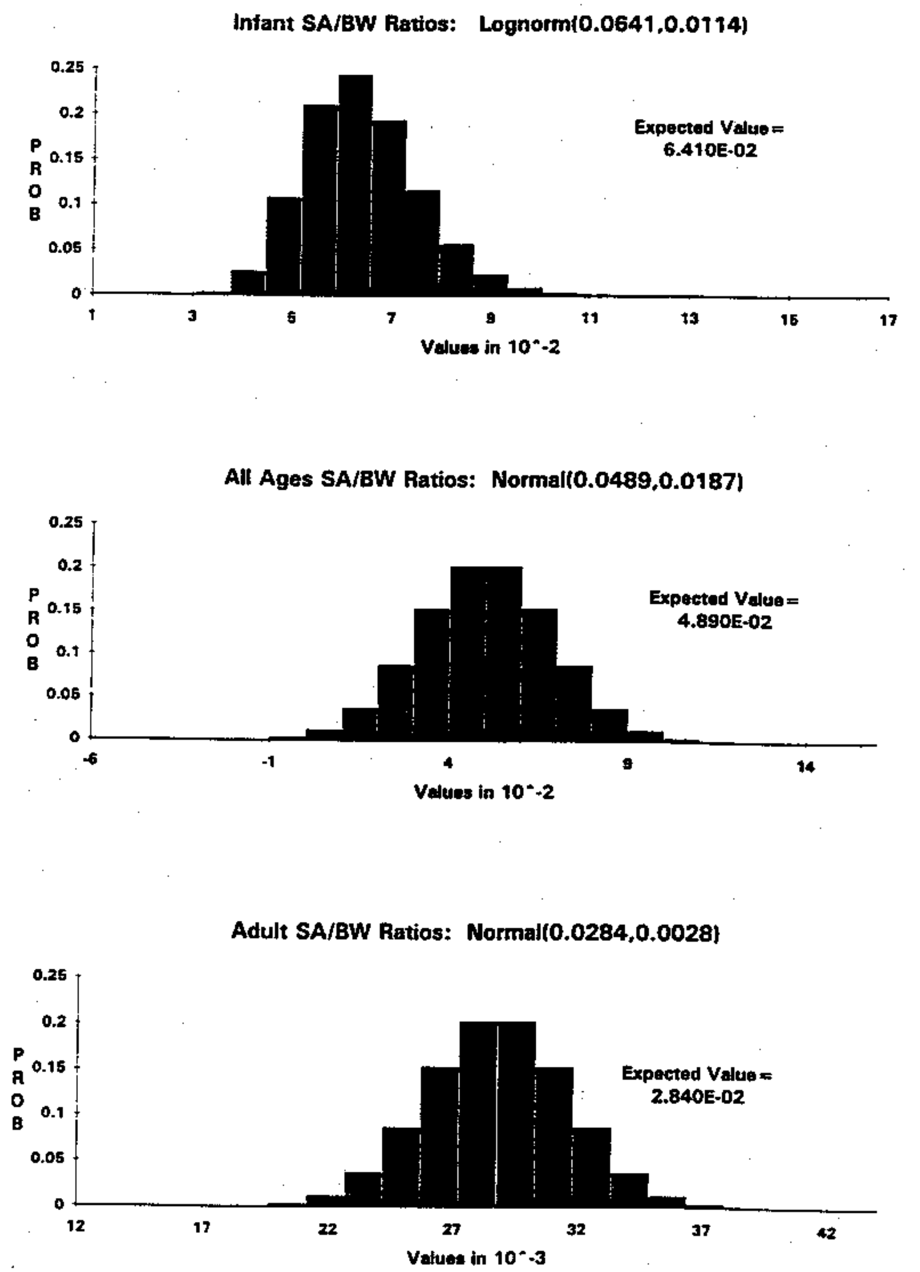
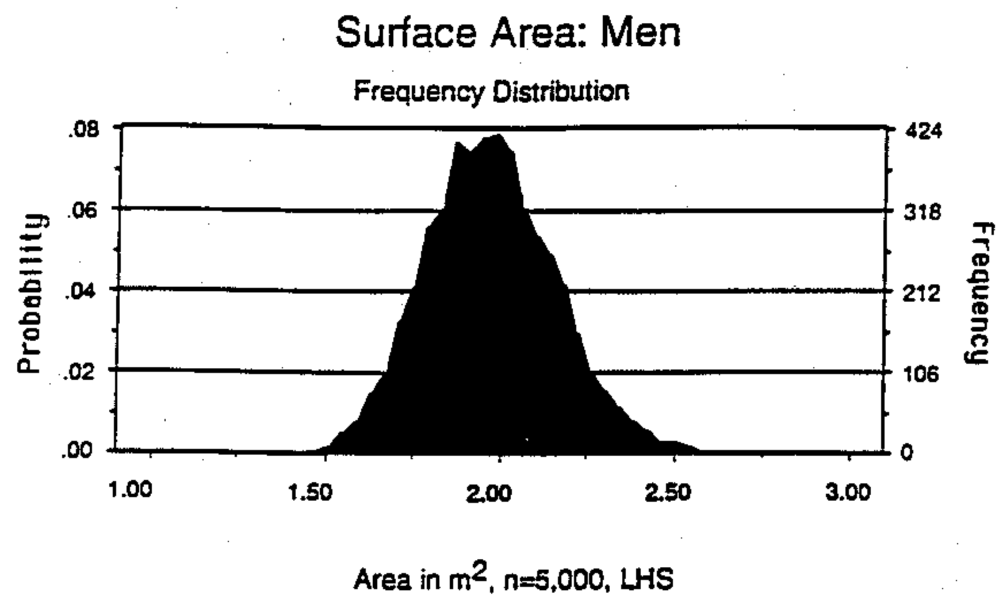


Figure 6-1. SA/BW Distributions for Infants, Adults, and All Ages Combined

Source: Phillips et al., 1993.



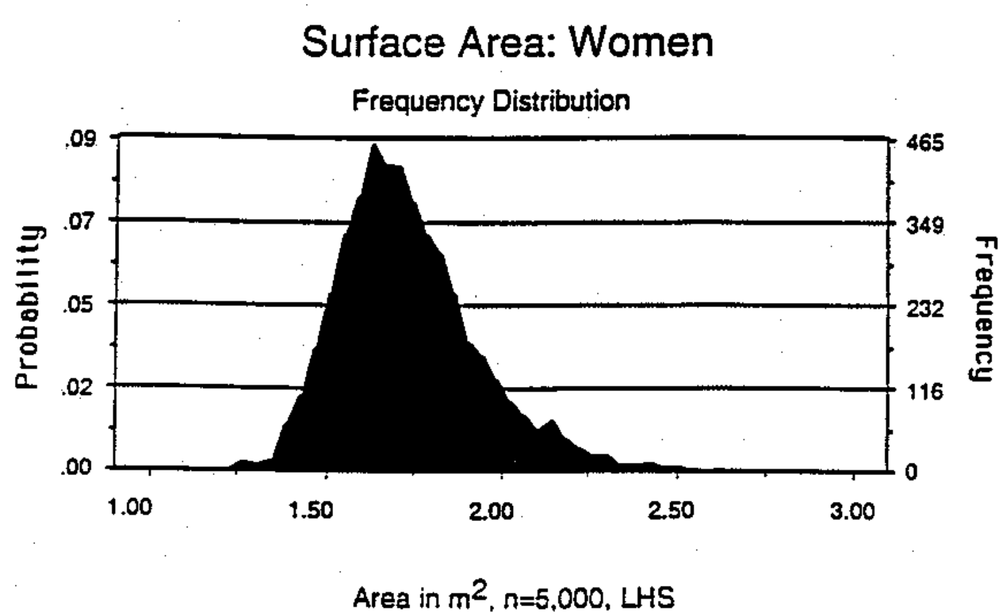


Figure 6-2. Frequency Distributions for the Surface Area of Men and Women

Source: Murray and Burmaster, 1992.

Table 6-12. Summary of Field Studies

Activity	Month	Duration (hr)	*n*	Male	Female	Ages	Conditions	Clothing
Outdoor								
Soccer No. 1	November	0.67	8	8	0	13-15	Half grass-half bare earth	6 of 8 long sleeve shirts 4 of 8 long pants 3 of 4 short pants & shin guards
Soccer No. 2	March	1.5	8	0	8	24-34	Allweather field (sand-ground tires)	All in short sleeve shirts, shorts, kneee socks, shin guards
Soccer No. 3	November	1.5	7	0	7	24-34	Allweather field (sand-ground tires)	All in short sleeve shirts, shorts, kneee socks, shin guards
Grounds Keeper No. 1	March	1.5	2	1	1	29-52	Campus grounds, urban horticulture center, arboretum	All in long pants, intermittent use of gloves
Grounds Keeper No. 2	March	4.25	5	3	2	22-37	Campus grounds, urban horticulture center, arboretum	All in long pants, intermittent use of gloves
Grounds Keeper No. 3	March	8	7	5	2	30-62	Campus grounds, urban horticulture center, arboretum	All in long pants, intermittent use of gloves
Grounds Keeper No. 4	August	4.25	7	4	3	22-38	Campus grounds, urban horticulture center, arboretum	10 of 15 short sleeve shirts, intermittent use of gloves
Grounds Keeper No. 5	August	8	8	6	2	19-64	Campus grounds, urban horticulture center, arboretum	10 of 15 short sleeve shirts, intermittent use of gloves
Irrigation Installers	October	3	6	6	0	23-41	Landscaping, surface restoration	All in long pants, 3 of 6 short sleeve or no sleeve shirts
Rugby Players	March	1.75	8	8	0	20-22	Mixed grass-bare wet field	All in short sleeve shirts, shorts, sock lenghts variable
Farmers No. 1	May	2	4	2	2	39-44	Manual weeding, mechanical cultivation	All in long pants, heavy shoes, short sleeve shirts, no gloves
Farmers No. 2	July	2	6	4	2	18-43	Manual weeding, mechanical cultivation	2 of 6 shorts, 4 of 6 long pants, 1 of 6 long sleeve shirt, no gloves
Reed Gatherers	August	2	4	0	4	42-67	Tidal flats	2 of 4 short sleeve shirts/knee length pants, all wore shoes
Kids-in-mud No. 1	September	0.17	6	5	1	9-14	Lake shoreline	All in short sleeve T shirts, shorts, barefoot
Kids-in-mud No. 2	September	0.33	6	5	1	9-14	Lake shoreline	All in short sleeve T shirts, shorts, barefoot
Totals			92	57	35			
Indoor								
Tae Kwon Do	February	1.5	7		1	8-42	Carpeted floor	All in long sleeve-long pants martial arts uniform, sleeves rolled back, barefoot
Greenhouse Workers	March	5.25	2		1	37-39	Plant watering, spraying, soil blending, sterilization	Not given
Totals			9	7	2			

[a] N = number of subjects
Source: Kissel et al., 1996

Table 6-13. Mean Soil Adherence by Activity and Body Region

Activity	N[a]	Body Part (mg/cm^2) Hands	Arms	Legs	Face	Feet
Outdoor						
Soccer No. 1	8	0.11 0.066-0.18	0.011 0.0058-0.019	0.031 0.010-0.093	0.012 0.0083-0.016	--
Soccer No. 2	8	0.035 0.011-0.11	0.0043 0.0022-0.0083	0.014 0.0034-0.055	0.016 0.011-0.022	--
Soccer No. 3	7	0.019 0.013-0.028	0.0029 0.0014-0.0060	0.0081 0.0052-0.013	0.012 0.0078-0.018	--
Grounds Keeper No. 1	2	0.15	0.0050	--	0.0021	0.018
Grounds Keeper No. 2	5	0.098 0.040-0.24	0.0021 0.00065-0.0067	0.0012 0.00063-0.0021	0.010 0.0045-0.023	--
Grounds Keeper No. 3	7	0.030 0.014-0.065	0.0023 0.0012-0.0043	0.0009 0.00044-0.0019	0.0047 0.0021-0.010	0.0041 --
Grounds Keeper No. 4	7	0.046 0.025-0.082	0.014 0.0079-0.023	0.0008 0.00035-0.0018	0.0029 0.0018-0.0044	0.018 --
Grounds Keeper No. 5	8	0.032 0.021-0.049	0.023 0.0098-0.052	0.0010 0.0008-0.0014	0.0037 0.0019-0.0073	--
Irrigation Installers	6	0.19 0.12-0.31	0.018 0.0053-0.062	0.0054 0.0029-0.010	0.0063 0.0047-0.0086	--
Rugby Players	8	0.40 0.26-0.62	0.27 0.18-0.40	0.36 0.23-0.55	0.059 0.026-0.13	--
Farmers No. 1	4	0.41 0.20-0.84	0.059 0.0094-0.37	0.0059 0.0012-0.028	0.018 0.011-0.030	--
Farmers No. 2	6	0.47 0.33-0.69	0.13 0.056-0.29	0.037 0.0088-0.16	0.041 0.013-0.13	--
Reed Gatherers	4	0.66 0.25-1.7	0.036 0.011-0.12	0.16 0.0047-5.4	--	0.63 0.028-14
Kids-in-mud No. 1	6	35 15-84	11 1.7-73	36 18-75	--	24 6.2-9.3
Kids-in-mud No. 2	6	58 24-140	11 2.6-44	9.5 4.0-23	--	6.7 0.47-94
Indoor						
Tae Kwon Do	7	0.0062 0.0036-0.011	0.0019 0.0006-0.0062	0.0020 0.0011-0.0034	--	0.0024 0.0012-0.0049
Greenhouse Workers	2	0.043 --	0.0064 --	0.0015 --	0.0051 --	--

[a] N = number of subjects
Source: Kissel et al., 1996

Table 6-14. Surface Area Studies

Study	Surface Area				
	No. of Individuals	Type of Surface Area Measurement	Recommended Formulae Used	Population Surveyed	Comments
KEY STUDIES					
Boyd (1935)	231	Direct measurements using data for coating, surface integration, and triangulation methods only	$SA=0.0178*W^{0.500}*H^{0.4838}$	Children Adults	Reviewed all methods and data used to measure or estimate SA
Dubois & Dubois (1916)	9	Linear	$SA=0.0178*W^{0.425}*H^{0.725}$	Children Adults	Direct measurement
Gehan & George (1970)	401	Based on Boyd, 1935	$SA=0.0235*W^{0.51456}*H^{0.42246}$	Children Adults	Used 401 observations from Boyd's data where direct measurement for SA, height, and weight were compiled. Used least squares method to develop constants for equation. > 50 percent of data were for children < 5 years old.
Phillips et al. (1993)	Based on data from USEPA (1985): 401 individuals	NA	calculated surface area to body weight ratios	Children Adults	Developed distributions of SA/BW and calculated summary and statistics for 3 age groups and the combined data set
U.S. EPA (1985)		Based on Gehan & George (1970)	$SA=0.0239*W^{0.517}*H^{0.417}$	Children Adults	Provides statistical distribution data for total SA and SA of body parts
RELEVANT STUDY					
Murray & Burmaster (1992)	Based on data from USEPA: 401 DuBois & Dubois: 9 Boyd: 231 Costaff: 220	Calculated based on regression equation using the data of USEPA, 1985	Various	Children Adults	Analysis of and comparision of four models developed by Dubois & Dubois (1916), Boyd (1935), U.S. EPA (1985), and Costeff (1966). Presents frequency distribtions

[a] Based on height weight data presented in report.

Table 6-15. Summary of Recommended Values for Skin Surface Area

Surface Area	Central Tendency	Upper Percentile	Multiple Percentiles
Adults			
Whole body and body parts	see Table 6-4	see Tables 6-2 and 6-3	see Tables 6-2 and 6-3
Bathing/swimming	20,000 cm^2	23,000 cm^2	---
Outdoor soil contact	5,000 cm^2	5,800 cm^2	---
Children			
Whole body	---	see Tables 6-6 and 6-7	see Tables 6-6 and 6-7
Body parts	---	see Table 6-8	see Table 6-8

Table 6-16. Confidence in Body Surface Area Measurement Recommendations

Considerations	Rationale	Rating
Study Elements		
• Level of Peer Review	Peer reviewed journal articles EPA report was peer reviewed before distribution	High
• Accessibility	Journals - wide circulation EPA report - available from National Technical Information Service	High
• Reproducibility	Experimental methods well-described	High
• Focus on factor of interest	Experiments measured skin area directly	High
• Data pertinent to U.S.	Experiments conducted in the U.S.	High
• Primary data	Re-analysis of primary data in more detail by two different investigators	Low
• Currency	Neither rapidly changing nor controversial area; estimates made in 1935 deemed to be accurate and subsequently used by others	Low
• Adequacy of data collection period	Not relevant to exposure factor; parameter not time dependent	NA
• Validity of approach	Approach used by other investigators; not challenged in other studies	High
• Representativeness of the population	Not statistically representative of U.S. population	Medium
• Characterization of variability	Individual variability due to age, race, or gender not studied	Low
• Lack of bias in study design	Objective subject selection and measurement methods used; results reproduced by others with different methods	High
• Measurement error	Measurement variations are low; adequately described by normal statistics	Low/Medium
Other Elements		
• Number of studies	1 experiment; two independent re-analyses of this data set	Medium
• Agreement among researchers	Consistent results obtained with different analyses; but from a single set of measurements	Medium
Overall Rating	This factor can be directly measured. It is not subject to dispute. Influence of age, race, or gender have not been detailed adequately in these studies	High

Table 6-17. Confidence in Dermal Adherence Recommendations		
Considerations	Rationale	Rating
Study Elements		
• Level of Peer Review	Peer reviewed journal articles	High
• Accessibility	Articles published in widely circulated journals	High
• Reproducibility	Reports clearly describe experimental method	High
• Focus on factor of interest	Studies have goal to determine soil adherence to skin	High
• Data pertinent to U.S.	Experiments conducted in the U.S.	High
• Primary data	Experiments directly measure soil adherence to skin; exposure and dose of chemicals in soil measured indirectly or estimated from soil contact	High
• Currency	New studies in rapidly changing area	High
• Adequacy of data collection period	Seasonal factors may be important but have not been studied adequately	Medium
• Validity of approach	Skin rinsing technique is a widely employed procedure	High
• Representativeness of the population	Studies, limited to Seattle, WA, may not be representative of other locales	Low
• Characterization of variability	Variability in soil adherence is affected by many factors including soil properties, activity and individual behavior patterns	Low
• Lack of bias in study design	Studies attempt to measure soil adherence in selected activities and conditions to identify important activities and groups	High
• Measurement error	Experimental error is low and well controlled but application of results to other similar activities may be subject to variation	Low/High
Other Elements		
• Number of studies	Controlled experiments being conducted by a few laboratories; activity patterns being studied by only one laboratory	Medium
• Agreement among researchers	Results from key study consistent with earlier estimates from relevant studies and assumptions, but limited to hand data	Medium
Overall Rating	Limited data is difficult to extrapolate from experiments and field observations to general conditions	Low

Table 6-18. Summary of Soil Adherence Studies

Study	Size Fraction (μm)	Soil Adherence (mg/cm^2)	Population Surveyed	Comments
KEY STUDIES				
Kissel et al., 1995	--	Various	28 adults 24 children	Data presented for soil loadings by body part. See Table 6-13.
RELEVANT STUDIES				
Driver et al., 1989	< 150 < 250 unsieved	1.40 0.95 0.58	Adults Adults Adults	Used 5 soil types and 2-3 soil horizons (top soils and subsoils); placed soil over entire hand of test subject, excess removed by shaking the hands.
Lepow et al., 1975	--	0.5	10 children	Dirt from hands collected during play. Represents only fraction of total present, some dirt may be trapped in skin folds.
Que Hee et al., 1985	--	1.5	1 adult	Assumed exposed area = 20 cm^2. Test subject was 14 years old.
Roels et al., 1980	--	0.9-1.5	661 children	Subjects lived near smelter in Brussels, Belgium. Mean amount adhering to soil was 0.159 g.
Sedman, 1989	--	0.9; 0.5	Children	Used estimate of Roels (1980) and average surface of hand of an 11 year old; used estimates of Lepow, Roels, and Que Hee to develop mean of 0.5 mg/cm^2.
Yang et al., 1989	< 150	9	Rats	Rat skin "monolayer" (i.e., minimal amount of soil covering the skin); in vitro and in vivo experiments.

APPENDIX 6A

Formulae for Total Body Surface Area

APPENDIX 6A

FORMULAE FOR TOTAL BODY SURFACE AREA

Most formulae for estimating surface area (SA), relate height to weight to surface area. The following formula was proposed by Gehan and George (1970):

$$SA = KW^{2/3} \qquad \text{(Eqn. 6A-1)}$$

where:

SA = surface area in square meters;
W = weight in kg; and
K = constant.

While the above equation has been criticized because human bodies have different specific gravities and because the surface area per unit volume differs for individuals with different body builds, it gives a reasonably good estimate of surface area.

A formula published in 1916 that still finds wide acceptance and use is that of DuBois and DuBois. Their model can be written:

$$SA = a_0 \, H^{a_1} \, W^{a_2} \qquad \text{(Eqn. 6A-2)}$$

where:

SA = surface area in square meters;
H = height in centimeters; and
W = weight in kg.

The values of a_0 (0.007182), a_1 (0.725), and a_2 (0.425) were estimated from a sample of only nine individuals for whom surface area was directly measured. Boyd (1935) stated that the Dubois formula was considered a reasonably adequate substitute for measuring surface area. Nomograms for determining surface area from height and mass presented in Volume I of the Geigy Scientific Tables (1981) are based on the DuBois and DuBois formula. In addition, a computerized literature search conducted for this report identified several articles written in the last 10 years in which the DuBois and DuBois formula was used to estimate body surface area.

Boyd (1935) developed new constants for the DuBois and DuBois model based on 231 direct measurements of body surface area found in the literature. These data were limited to measurements of surface area by coating methods (122 cases), surface integration (93 cases), and triangulation (16 cases). The subjects were Caucasians of normal body build for whom data on weight, height, and age (except for exact age of adults) were complete. Resulting values for the constants in the DuBois and DuBois model were $a_0 = 0.01787$, $a_1 = 0.500$, and $a_2 = 0.4838$. Boyd also developed a formula based exclusively on weight, which was inferior to the DuBois and DuBois formula based on height and weight.

Gehan and George (1970) proposed another set of constants for the DuBois and DuBois model. The constants were based on a total of 401 direct measurements of surface area, height, and weight of all postnatal subjects listed in Boyd (1935). The methods used to measure these subjects were coating (163 cases), surface integration (222 cases), and triangulation (16 cases).

Gehan and George (1970) used a least-squares method to identify the values of the constants. The values of the constants chosen are those that minimize the sum of the squared percentage errors of the predicted values of surface area. This approach was used because the importance of an error of 0.1 square meter depends on the surface area of the individual. Gehan and George (1970) used the 401 observations summarized in Boyd (1935) in the least-squares method. The following estimates of the constants were obtained: $a_0 = 0.02350$, $a_1 = 0.42246$, and $a_2 = 0.51456$. Hence, their equation for predicting surface area (SA) is:

$$SA = 0.02350\ H^{0.42246}\ W^{0.51456} \qquad \text{(Eqn. 6A-3)}$$

or in logarithmic form:

$$\ln SA = -3.75080 + 0.42246 \ln H + 0.51456 \ln W \qquad \text{(Eqn. 6A-4)}$$

where:

SA = surface area in square meters;
H = height in centimeters; and
W = weight in kg.

This prediction explains more than 99 percent of the variations in surface area among the 401 individuals measured (Gehan and George, 1970).

The equation proposed by Gehan and George (1970) was determined by the U.S. EPA (1985) as the best choice for estimating total body surface area. However, the paper by Gehan and George gave insufficient information to estimate the standard error about the regression. Therefore, the 401 direct measurements of children and adults (i.e., Boyd, 1935) were reanalyzed in U.S. EPA (1985) using the formula of Dubois and Dubois (1916) and the Statistical Processing System (SPS) software package to obtain the standard error.

The Dubois and Dubois (1916) formula uses weight and height as independent variables to predict total body surface area (SA), and can be written as:

$$SA_i = a_0\ H_i^{a1}\ W_i^{a2}\ e_i \qquad \text{(Eqn. 6A-5)}$$

or in logarithmic form:

$$\ln (SA)_i = \ln a_0 + a_1 \ln H_i + a_2 \ln W_i + \ln e_i \qquad \text{(Eqn. 6A-6)}$$

where:

Sai = surface area of the i-th individual (m^2);
Hi = height of the i-th individual (cm);
Wi = weight of the i-th individual (kg);

a_0, a_1, and a_2 = parameters to be estimated; and
e_i = a random error term with mean zero and constant variance.

Using the least squares procedure for the 401 observations, the following parameter estimates and their standard errors were obtained:

$$a_0 = -3.73\ (0.18),\ \ a_1 = 0.417\ (0.054),\ \ a_2 = 0.517\ (0.022)$$

The model is then:

$$SA = 0.0239\ H^{0.417}\ W^{0.517} \qquad \text{(Eqn. 6A-7)}$$

or in logarithmic form:

$$\ln SA = -3.73 + 0.417 \ln H + 0.517 \ln W \qquad \text{(Eqn. 6A-8)}$$

with a standard error about the regression of 0.00374. This model explains more than 99 percent of the total variation in surface area among the observations, and is identical to two significant figures with the model developed by Gehan and George (1970).

When natural logarithms of the measured surface areas are plotted against natural logarithms of the surface predicted by the equation, the observed surface areas are symmetrically distributed around a line of perfect fit, with only a few large percentage deviations. Only five subjects differed from the measured value by 25 percent or more. Because each of the five subjects weighed less than 13 pounds, the amount of difference was small. Eighteen estimates differed from measurements by 15 to 24 percent. Of these, 12 weighed less than 15 pounds each, 1 was overweight (5 feet 7 inches, 172 pounds), 1 was very thin (4 feet 11 inches, 78 pounds), and 4 were of average build. Since the same observer measured surface area for these 4 subjects, the possibility of some bias in measured values cannot be discounted (Gehan and George 1970).

Gehan and George (1970) also considered separate constants for different age groups: less than 5 years old, 5 years old to less than 20 years old, and greater than 20 years old. The different values for the constants are presented below:

Table 6A-1. Estimated Parameter Values for Different Age Intervals

Age group	Number of persons	a_0	a_1	a_2
All ages	401	0.02350	0.42246	0.51456
< 5 years old	229	0.02667	0.38217	0.53937
≥ 5 - < 20 years old	42	0.03050	0.35129	0.54375
≥ 20 years old1	30	0.01545	0.54468	0.46336

The surface areas estimated using the parameter values for all ages were compared to surface areas estimated by the values for each age group for subjects at the 3rd, 50th, and 97th percentiles of weight and height. Nearly all differences in surface area estimates were less than 0.01 square meter, and the largest difference was 0.03

m^2 for an 18-year-old at the 97th percentile. The authors concluded that there is no advantage in using separate values of a_0, a_1, and a_2 by age interval.

Haycock et al. (1978) without knowledge of the work by Gehan and George (1970), developed values for the parameters a_0, a_1, and a_2 for the DuBois and DuBois model. Their interest in making the DuBois and DuBois model more accurate resulted from their work in pediatrics and the fact that DuBois and DuBois (1916) included only one child in their study group, a severely undernourished girl who weighed only 13.8 pounds at age 21 months. Haycock et al. (1978) used their own geometric method for estimating surface area from 34 body measurements for 81 subjects. Their study included newborn infants (10 cases), infants (12 cases), children (40 cases), and adult members of the medical and secretarial staffs of 2 hospitals (19 cases). The subjects all had grossly normal body structure, but the sample included subjects of widely varying physique ranging from thin to obese. Black, Hispanic, and white children were included in their sample. The values of the model parameters were solved for the relationship between surface area and height and weight by multiple regression analysis. The least squares best fit for this equation yielded the following values for the three coefficients: $a_0 = 0.024265$, $a_1 = 0.3964$, and $a_2 = 0.5378$. The result was the following equation for estimating surface area:

$$SA = 0.024265\ H^{0.3964}\ W^{0.5378} \qquad \text{(Eqn. 6A-9)}$$

expressed logarithmically as:

$$\ln SA = \ln 0.024265 + 0.3964 \ln H + 0.5378 \ln W \qquad \text{(Eqn. 6A-10)}$$

The coefficients for this equation agree remarkably with those obtained by Gehan and George (1970) for 401 measurements.

George et al. (1979) agree that a model more complex than the model of DuBois and DuBois for estimating surface area is unnecessary. Based on samples of direct measurements by Boyd (1935) and Gehan and George (1970), and samples of geometric estimates by Haycock et al. (1978), these authors have obtained parameters for the DuBois and DuBois model that are different than those originally postulated in 1916. The DuBois and DuBois model can be written logarithmically as:

$$\ln SA = \ln a_0 + a_1 \ln H + a_2 \ln W \qquad \text{(Eqn. 6A-11)}$$

The values for a_0, a_1, and a_2 obtained by the various authors discussed in this section are presented to follow:

Table 6A-2. Summary of Surface Area Parameter Values for the DuBois and DuBois Model

Author (year)	Number of persons	a_0	a_1	a_2
DuBois and DuBois (1916)	9	0.007184	0.725	0.425
Boyd (1935)	231	0.01787	0.500	0.4838
Gehan and George (1970)	401	0.02350	0.42246	0.51456
Haycock et al. (1978)	81	0.024265	0.3964	0.5378

The agreement between the model parameters estimated by Gehan and George (1970) and Haycock et al. (1978) is remarkable in view of the fact that Haycock et al. (1978) were unaware of the previous work. Haycock et al. (1978) used an entirely different set of subjects, and used geometric estimates of surface area rather than direct measurements. It has been determined that the Gehan and George model is the formula of choice for estimating total surface area of the body since it is based on the largest number of direct measurements.

Nomograms

Sendroy and Cecchini (1954) proposed a graphical method whereby surface area could be read from a diagram relating height and weight to surface area. However, they do not give an explicit model for calculating surface area. The graph was developed empirically based on 252 cases, 127 of which were from the 401 direct measurements reported by Boyd (1935). In the other 125 cases the surface area was estimated using the linear method of DuBois and DuBois (1916). Because the Sendroy and Cecchini method is graphical, it is inherently less precise and less accurate than the formulae of other authors discussed above.

TABLE OF CONTENTS

Page No.

7. BODY WEIGHT STUDIES

There are several physiological factors needed to calculate potential exposures which include skin surface (see Volume I, Chapter 6), life expectancy (see Volume I, Chapter 8), and body weight. The average daily dose is based on the average body weight over the exposure period. If exposure occurs only during childhood years, the average child body weight during the exposure period should be used to estimate risk (U.S. EPA, 1989).

The purpose of this section is to describe published studies on body weight for the general U.S. population. The studies have been classified as either key or relevant studies. The classifications of these studies are based on the criteria described in Volume I, Section 1.3.1. Recommended values are based on the results of key studies, but relevant studies are also presented to provide the reader with added perspective on the current state of knowledge pertaining to body weight.

7.1. KEY BODY WEIGHT STUDY

NCHS - Anthropometric Reference Data and Prevalence of Overweight, United States, 1976-80 - Statistics on anthropometric measurements, including body weight, for the U.S. population were collected by the National Center for Health Statistics (NCHS) through the second National Health and Nutrition Examination Survey (NHANES II). NHANES II was conducted on a nationwide probability sample of approximately 28,000 persons, aged 6 months to 74 years, from the civilian, non-institutionalized population of the United States. Of the 28,000 persons, 20,322 were interviewed and examined, resulting in a response rate of 73.1 percent. The survey began in February 1976 and was completed in February 1980. The sample was selected so that certain subgroups thought to be at high risk of malnutrition (persons with low incomes, preschool children, and the elderly) were oversampled. The estimates were weighted to reflect national population estimates. The weighting was accomplished by inflating examination results for each subject by the reciprocal of selection probabilities adjusted to account for those who were not examined, and post stratifying by race, age, and sex (NCHS, 1987).

The NHANES II collected standard body measurements of sample subjects, including height and weight, that were made at various times of the day and in different seasons of the year. This technique was used because one's weight may vary between winter and summer and may fluctuate with recency of food and water intake and other daily activities (NCHS, 1987). Mean body weights of adults, by age, and their standard deviations are presented in Table 7-1 for men, women, and both sexes combined. Mean body weights and standard deviations for children, ages 6 months to 19 years, are presented in Table 7-2 for boys, girls, and boys and girls combined. Percentile distributions of the body weights of adults by age and race for males are presented in Table 7-3, and for females in Table 7-4. Data for children by age are presented in Table 7-5 for males, and for females in Table 7-6.

Table 7-1. Body Weights of Adults[a] (kilograms)

Age (years)	Men		Women		Men and Women
	Mean (kg)	Std. Dev.	Mean (kg)	Std. Dev.	Mean (kg)
18 < 25	73.8	12.7	60.6	11.9	67.2
25 < 35	78.7	13.7	64.2	15.0	71.5
35 < 45	80.9	13.4	67.1	15.2	74.0
45 < 55	80.9	13.6	68.0	15.3	74.5
55 < 65	78.8	12.8	67.9	14.7	73.4
65 < 75	74.8	12.8	66.6	13.8	70.7
18 < 75	78.1	13.5	65.4	14.6	71.8

Note: 1 kg = 2.2046 pounds.
[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.
Source: Adapted from National Center for Health Statistics (NCHS), 1987.

Table 7-2. Body Weights of Children[a] (kilograms)

Age	Boys		Girls		Boys and Girls
	Mean (kg)	Std. Dev.	Mean (kg)	Std. Dev.	Mean (kg)
6-11 months	9.4	1.3	8.8	1.2	9.1
1 year	11.8	1.9	10.8	1.4	11.3
2 years	13.6	1.7	13.0	1.5	13.3
3 years	15.7	2.0	14.9	2.1	15.3
4 years	17.8	2.5	17.0	2.4	17.4
5 years	19.8	3.0	19.6	3.3	19.7
6 years	23.0	4.0	22.1	4.0	22.6
7 years	25.1	3.9	24.7	5.0	24.9
8 years	28.2	6.2	27.9	5.7	28.1
9 years	31.1	6.3	31.9	8.4	31.5
10 years	36.4	7.7	36.1	8.0	36.3
11 years	40.3	10.1	41.8	10.9	41.1
12 years	44.2	10.1	46.4	10.1	45.3
13 years	49.9	12.3	50.9	11.8	50.4
14 years	57.1	11.0	54.8	11.1	56.0
15 years	61.0	11.0	55.1	9.8	58.1
16 years	67.1	12.4	58.1	10.1	62.6
17 years	66.7	11.5	59.6	11.4	63.2
18 years	71.1	12.7	59.0	11.1	65.1
19 years	71.7	11.6	60.2	11.0	66.0

Note: 1 kg = 2.2046 pounds.
[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.
Source: Adapted from National Center for Health Statistics (NCHS), 1987.

Table 7-3. Weight in Kilograms for Males 18-74 Years of Age--Number Examined, Mean, Standard Deviation, and Selected Percentiles, by Race and Age: United States, 1976-1980[a]

Race and Age	Number of Persons Examined	Mean (kg)	Standard Deviation	Percentile 5th	10th	15th	25th	50th	75th	85th	90th	95th
All races[b]												
18-74 years	5,916	78.1	13.5	58.6	62.3	64.9	68.7	76.9	85.6	91.3	95.7	102.7
18-24 years	988	73.8	12.7	56.8	60.4	61.9	64.8	72.0	80.3	85.1	90.4	99.5
25-34 years	1,067	78.7	13.7	59.5	62.9	65.4	69.3	77.5	85.6	91.1	95.1	102.7
35-44 years	745	80.9	13.4	59.7	65.1	67.7	72.1	79.9	88.1	94.8	98.8	104.3
45-54 years	690	80.9	13.6	50.8	65.2	67.2	71.7	79.0	89.4	94.5	99.5	105.3
55-64 years	1,227	78.8	12.8	59.9	63.8	66.4	70.2	77.7	85.6	90.5	94.7	102.3
65-74 years	1,199	74.8	12.8	54.4	58.5	61.2	66.1	74.2	82.7	87.9	91.2	96.6
White												
18-74 years	5,148	78.5	13.1	59.3	62.8	65.5	69.4	77.3	85.6	91.4	95.5	102.3
18-24 years	846	74.2	12.8	56.8	60.5	62.0	65.0	72.4	80.6	85.5	91.0	100.0
25-34 years	901	79.0	13.1	59.9	63.7	65.9	69.8	78.0	85.6	91.3	95.3	102.7
35-44 years	653	81.4	12.8	62.3	66.6	68.8	72.9	80.1	88.2	94.6	98.7	104.1
45-54 years	617	81.0	13.4	62.0	66.1	67.3	71.9	79.0	89.4	94.2	99.0	104.5
55-64 years	1,086	78.9	12.4	60.5	64.5	66.6	70.6	78.2	85.6	90.4	94.5	101.7
65-74 years	1,045	75.4	12.4	55.5	59.5	62.5	67.0	74.7	83.0	87.9	91.2	96.0
Black												
18-74 years	649	77.9	15.2	58.0	61.1	63.6	67.2	75.3	85.4	92.9	98.3	105.4
18-24 years	121	72.2	12.0	58.3	60.9	62.3	64.9	70.8	77.1	81.8	83.7	93.6
25-34 years	139	78.2	16.3	58.7	63.4	64.9	68.4	75.3	84.4	90.6	92.2	106.3
35-44 years	70	82.5	15.4	*[c]	61.7	65.2	69.7	83.1	94.8	100.4	104.2	*
45-54 years	62	82.4	14.5	*	64.7	67.0	73.2	81.8	93.0	100.0	102.5	*
55-64 years	129	78.6	14.7	56.8	61.4	64.3	68.0	77.0	86.5	93.8	98.6	104.7
65.74 years	128	73.3	15.3	52.5	56.7	58.0	61.0	71.2	81.1	90.8	97.3	105.1

Note: 1 kg = 2.2046 pounds.
[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.
[b] Includes all other races not shown as separate categories.
[c] Data not available.

Source: National Center for Health Statistics, 1987.

Table 7-4. Weight in Kilograms for Females 18-74 Years of Age--Number Examined, Mean, Standard Deviation, and Selected Percentiles, by Race and Age: United States, 1976-1980[a]

Race and Age	Number of Persons Examined	Mean (kg)	Standard Deviation	Percentile 5th	10th	15th	25th	50th	75th	85th	90th	95th
All races[b]												
18-74 years	6,588	65.4	14.6	47.7	50.3	52.2	55.4	62.4	72.1	79.2	84.4	93.1
18-24 years	1,066	60.6	11.9	46.6	49.1	50.6	53.2	58.0	65.0	70.4	75.3	82.9
25-34 years	1,170	64.2	15.0	47.4	49.6	51.4	54.3	60.9	69.6	78.4	84.1	93.5
35-44 years	844	67.1	15.2	49.2	52.0	53.3	56.9	63.4	73.9	81.7	87.5	98.9
45-54 years	763	68.0	15.3	48.5	51.3	53.3	57.3	65.5	75.7	82.1	87.6	96.0
55-64 years	1,329	67.9	14.7	48.6	51.3	54.1	57.3	65.2	75.3	82.3	87.5	95.1
65-74 years	1,416	66.6	13.8	47.1	50.8	53.2	57.4	64.8	73.8	79.8	84.4	91.3
White												
18-74 years	5,686	64.8	14.1	47.7	50.3	52.2	55.2	62.1	71.1	77.9	83.3	91.5
18-24 years	892	60.4	11.6	47.3	49.5	50.8	53.3	57.9	64.8	69.7	74.3	82.4
25-34 years	1,000	63.6	14.5	47.3	49.5	51.3	54.0	60.6	68.9	76.3	81.5	89.7
35-44 years	726	66.1	14.5	49.3	51.8	52.9	56.3	62.4	71.9	79.7	85.8	94.9
45-54 years	647	67.3	14.4	48.6	51.3	53.4	57.0	65.0	74.8	81.1	85.6	94.5
55-64 years	1,176	67.2	14.4	48.5	50.7	53.7	57.1	64.7	74.5	81.8	86.2	92.8
65-74 years	1,245	66.2	13.7	47.2	50.7	52.9	57.2	64.3	72.9	79.2	84.3	91.2
Black												
18-74 years	782	71.2	17.3	48.8	51.6	55.1	59.1	67.8	80.6	87.4	94.9	105.1
18-24 years	147	63.1	13.9	46.2	49.0	50.6	53.8	60.4	70.0	75.8	79.1	89.3
25-34 years	145	69.3	16.7	48.3	50.8	53.1	57.8	65.3	80.2	87.1	91.5	102.7
35-44 years	103	75.3	18.4	50.7	55.2	57.2	63.0	70.2	85.2	95.3	103.5	113.1
45-54 years	100	77.7	18.8	55.1	60.3	60.8	64.5	74.3	83.6	94.5	98.2	117.5
55-64 years	135	75.8	16.4	54.2	55.2	57.6	65.4	74.6	83.4	91.9	95.5	108.5
65.74 years	152	72.4	13.6	52.9	56.4	60.3	64.0	70.0	82.2	84.4	86.5	98.1

Note: 1 kg = 2.2046 pounds.

[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.

[b] Includes all other races not shown as separate categories.

Source: National Center for Health Statistics, 1987.

Table 7-5. Weight in Kilograms for Males 6 Months-19 Years of Age--Number Examined, Mean, Standard Deviation, and Selected Percentiles, by Sex and Age: United States, 1976-1980[a]

Age	Number of Persons Examined	Mean (kg)	Standard Deviation	Percentile 5th	10th	15th	25th	50th	75th	85th	90th	95th
6-11 Months	179	9.4	1.3	7.5	7.6	8.2	8.6	9.4	10.1	10.7	10.9	11.4
1 years	370	11.8	1.9	9.6	10.0	10.3	10.8	11.7	12.6	13.1	13.6	14.4
2 years	375	13.6	1.7	11.1	11.6	11.8	12.6	13.5	14.5	15.2	15.8	16.5
3 years	418	15.7	2.0	12.9	13.5	13.9	14.4	15.4	16.8	17.4	17.9	19.1
4 years	404	17.8	2.5	14.1	15.0	15.3	16.0	17.6	19.0	19.9	20.9	22.2
5 years	397	19.8	3.0	16.0	16.8	17.1	17.7	19.4	21.3	22.9	23.7	25.4
6 years	133	23.0	4.0	18.6	19.2	19.8	20.3	22.0	24.1	26.4	28.3	30.1
7 years	148	25.1	3.9	19.7	20.8	21.2	22.2	24.8	26.9	28.2	29.6	33.9
8 years	147	28.2	6.2	20.4	22.7	23.6	24.6	27.5	29.9	33.0	35.5	39.1
9 years	145	31.1	6.3	24.0	25.6	26.0	27.1	30.2	33.0	35.4	38.6	43.1
10 years	157	36.4	7.7	27.2	28.2	29.6	31.4	34.8	39.2	43.5	46.3	53.4
11 years	155	40.3	10.1	26.8	28.8	31.8	33.5	37.3	46.4	52.0	57.0	61.0
12 years	145	44.2	10.1	30.7	32.5	35.4	37.8	42.5	48.8	52.6	58.9	67.5
13 years	173	49.9	12.3	35.4	37.0	38.3	40.1	48.4	56.3	59.8	64.2	69.9
14 years	186	57.1	11.0	41.0	44.5	46.4	49.8	56.4	63.3	66.1	68.9	77.0
15 years	184	61.0	11.0	46.2	49.1	50.6	54.2	50.1	64.9	68.7	72.8	81.3
16 years	178	67.1	12.4	51.4	54.3	56.1	58.7	64.4	73.6	78.1	82.2	91.2
17 years	173	66.7	11.5	50.7	53.4	54.8	578.7	65.8	72.0	76.8	82.3	88.9
18 years	164	71.1	12.7	54.1	56.6	60.3	61.9	70.4	76.6	80.0	83.5	95.3
19 years	148	71.7	11.6	55.9	57.9	60.5	63.8	69.5	77.9	84.3	86.8	92.1

Note: 1 kg = 2.2046 pounds.
[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.

Source: National Center for Health Statistics, 1987.

Table 7-6. Weight in Kilograms for Females 6 Months-19 Years of Age--Number Examined, Mean, Standard Deviation, and Selected Percentiles, by Sex and Age: United States, 1976-1980[a]

Age	Number of Persons Examined	Mean (kg)	Standard Deviation	Percentile								
				5th	10th	15th	25th	50th	75th	85th	90th	95th
6-11 Months	177	8.8	1.2	6.6	7.3	7.5	7.9	8.9	9.4	10.1	10.4	10.9
1 years	336	10.8	1.4	8.8	9.1	9.4	9.9	10.7	11.7	12.4	12.7	13.4
2 years	336	13.0	1.5	10.8	11.2	11.6	12.0	12.7	13.8	14.5	14.9	15.9
3 years	366	14.9	2.1	11.7	12.3	12.9	13.4	14.7	16.1	17.0	17.4	18.4
4 years	396	17.0	2.4	13.7	14.3	14.5	15.2	16.7	18.4	19.3	20.2	21.1
5 years	364	19.6	3.3	15.3	16.1	16.7	17.2	19.0	21.2	22.8	24.7	26.6
6 years	135	22.1	4.0	17.0	17.8	18.6	19.3	21.3	23.8	26.6	28.9	29.6
7 years	157	24.7	5.0	19.2	19.5	19.8	21.4	23.8	27.1	28.7	30.3	34.0
8 years	123	27.9	5.7	21.4	22.3	23.3	24.4	27.5	30.2	31.3	33.2	36.5
9 years	149	31.9	8.4	22.9	25.0	25.8	27.0	29.7	33.6	39.3	43.3	48.4
10 years	136	36.1	8.0	25.7	27.5	29.0	31.0	34.5	39.5	44.2	45.8	49.6
11 years	140	41.8	10.9	29.8	30.3	31.3	33.9	40.3	45.8	51.0	56.6	60.0
12 years	147	46.4	10.1	32.3	35.0	36.7	39.1	45.4	52.6	58.0	60.5	64.3
13 years	162	50.9	11.8	35.4	39.0	40.3	44.1	49.0	55.2	60.9	66.4	76.3
14 years	178	54.8	11.1	40.3	42.8	43.7	47.4	53.1	60.3	65.7	67.6	75.2
15 years	145	55.1	9.8	44.0	45.1	46.5	48.2	53.3	59.6	62.2	65.5	76.6
16 years	170	58.1	10.1	44.1	47.3	48.9	51.3	55.6	62.5	68.9	73.3	76.8
17 years	134	59.6	11.4	44.5	48.9	50.5	52.2	58.4	63.4	68.4	71.6	81.8
18 years	170	59.0	11.1	45.3	49.5	50.8	52.8	56.4	63.0	66.0	70.1	78.0
19 years	158	60.2	11.0	48.5	49.7	51.7	53.9	57.1	64.4	70.7	74.8	78.1

Note: 1 kg = 2.2046 pounds.
[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.

Source: National Center for Health Statistics, 1987.

Results shown in Tables 7-3 and 7-4 indicate that the mean weight for adult males is 78.1 kg and for adult females, 65.4 kg. It also shows that the mean weight for White males (78.5 kg) is greater than for Black males (77.9 kg). Additionally, mean weights are greater for Black females (71.2 kg) than for White females (64.8 kg). From Table 7-2, the mean body weights for girls and boys are approximately the same from ages 6 months to 14 years. Starting at years 15-19, the difference in mean body weight ranges from 6 to 11 kg.

7.2. RELEVANT BODY WEIGHT STUDIES

Burmaster et al. (Submitted 2/19/94 to Risk Analysis for Publication) - Lognormal Distributions of Body Weight as a Function of Age for Female and Male Children in the United States - Burmaster et al. (1994), performed data analysis to fit normal and lognormal distributions to the body weights of female and male children at age 6 months to 20 years (Burmaster et al., 1994).

Data used in this analysis were from the second survey of the National Center for Health Statistics, NHANES II, which included responses from 4,079 females and 4,379 males 6 months to 20 years of age in the U.S. (Burmaster et al., 1994). The NHANES II data had been statistically adjusted for non-response and probability of selection, and stratified by age, sex, and race to reflect the entire U.S. population prior to reporting (Burmaster et al., 1994). Burmaster et al. (1994) conducted exploratory and quantitative data analyses, and fit normal and lognormal distributions to percentiles of body weight for children. Cumulative distribution functions (CDFs) were plotted for female and male body weights on both linear and logarithmic scales.

Two models were used to assess the probability density functions (PDFs) of children's body weight. Linear and quadratic regression lines were fitted to the data. A number of goodness-of-fit measures were conducted on data generated by the two models. Burmaster et al. (1994) found that lognormal distributions give strong fits to the body weights of children, ages 6 months to 20 years. Statistics for the lognormal probability plots are presented in Tables 7-7 and 7-8. These data can be used for further analyses of body weight distribution (i.e., application of Monte Carlo analysis).

Brainard and Burmaster - Bivariate Distributions for Height and Weight of Men and Women in the United States - Brainard and Burmaster (1992) examined data on the height and weight of adults published by the U.S. Public

Table 7-7. Statistics for Probability Plot Regression Analyses Female's Body Weights 6 Months to 20 Years of Age

Age	Lognormal Probability Plots Linear Curve	
	μ_2[a]	σ_2[a]
6 months to 1 year	2.16	0.145
1 to 2 years	2.38	0.128
2 to 3 years	2.56	0.112
3 to 4 years	2.69	0.137
4 to 5 years	2.83	0.133
5 to 6 years	2.98	0.163
6 to 7 years	3.10	0.174
7 to 8 years	3.19	0.174
8 to 9 years	3.31	0.156
9 to 10 years	3.46	0.214
10 to 11 years	3.57	0.199
11 to 12 years	3.71	0.226
12 to 13 years	3.82	0.213
13 to 14 years	3.92	0.216
14 to 15 years	3.99	0.187
15 to 16 years	4.00	0.156
16 to 17 years	4.06	0.167
17 to 18 years	4.08	0.165
18 to 19 years	4.07	0.147
19 to 20 years	4.10	0.149

[a] μ_2, σ_2 - correspond to the mean and standard deviation, respectively, of the lognormal distribution of body weight (kg).
Source: Burmaster et al., 1994.

Table 7-8. Statistics for Probability Plot Regression Analyses Male's Body Weights 6 Months to 20 Years of Age

Age	Lognormal Probability Plots Linear Curve	
	μ_2[a]	σ_2[a]
6 months to 1 year	2.23	0.132
1 to 2 years	2.46	0.119
2 to 3 years	2.60	0.120
3 to 4 years	2.75	0.114
4 to 5 years	2.87	0.133
5 to 6 years	2.99	0.138
6 to 7 years	3.13	0.145
7 to 8 years	3.21	0.151
8 to 9 years	3.33	0.181
9 to 10 years	3.43	0.165
10 to 11 years	3.59	0.195
11 to 12 years	3.69	0.252
12 to 13 years	3.78	0.224
13 to 14 years	3.88	0.215
14 to 15 years	4.02	0.181
15 to 16 years	4.09	0.159
16 to 17 years	4.20	0.168
17 to 18 years	4.19	0.167
18 to 19 years	4.25	0.159
19 to 20 years	4.26	0.154

[a] μ_2, σ_2 - correspond to the mean and standard deviation, respectively, of the lognormal distribution of body weight (kg).
Source: Burmaster et al., 1994.

Health Service and fit bivariate distributions to the tabulated values for men and women, separately.

Height and weight of 5,916 men and 6,588 women in the age range of 18 to 74 years were taken from the NHANES II Study and statistically adjusted to represent the U.S. population aged 18 to 74 years with regard to age structure, sex, and race. Estimation techniques were used to fit normal distributions to the cumulative marginal data and goodness-of-fit tests were used to test the hypothesis that height and lognormal weight follow a normal distribution for each sex. It was found that the marginal distributions, of height and lognormal weight for both men and women, are Gaussian (normal) in form. This conclusion was reached by visual observation and the high R^2 values for best-fit lines obtained using linear regression. The R^2 values for men's height and lognormal weight are reported to be 0.999. The R^2 values for women's height and lognormal weight are 0.999 and 0.985, respectively.

Brainard and Burmaster (1992) fit bivariate distributions to estimated numbers of men and women aged 18 to 74 years in cells representing 1 inch height intervals and 10 pound weight intervals. Adjusted height and lognormal weight data for men were fit to a single bivariate normal distribution with an estimated mean height of 1.75 meters (69.2 inches) and an estimated mean weight of 78.6 kg (173.2 pounds). For women, height and lognormal weight data were fit to a pair of superimposed bivariate normal distributions (Brainard and Burmaster, 1992). The average height and weight for women were estimated from the combined bivariate analyses. Mean height for women was estimated to be 1.62 meters (63.8 inches) and mean weight was estimated to be 65.8 kg (145.0 pounds). For women, a calculation using a single bivarite normal distribution gave poor results (Brainard and Burmaster, 1992). According to Brainard and Burmaster, the distributions are suitable for use in Monte Carlo simulation.

AIHC - Exposure Factors Sourcebook - The Exposure Factors Sourcebook (AIHC, 1994) provides similar body weight data as presented here. Consistent with this document, an average adult body weight of 72 kg is recommended on the basis of the NHANES II data (NCHS, 1987). These data are also used to derive probability distributions for adults and children. In addition, the Sourcebook presents probability distributions derived by Brainard and Burmaster (1992), Versar (1991) and Brorby and Finley (1993). For each distribution, the @Risk formula is provided for direct use in the @Risk simulation software (Palisade, 1992). The organization of this document, makes it very convenient to use in support of Monte Carlo analysis. The reviews of the supporting studies are very brief with little analysis of their strengths and weaknesses. The Sourcebook has been classified as a relevant rather than key study because it is not the primary source for the data used to make recommendations in this document. The Sourcebook is very similar to this document in the sense that it summarizes exposure factor data and recommends values. As such, it is clearly relevant as an alternative information source on body weights as well as other exposure factors.

7.3. RECOMMENDATIONS

The key study described in this section was used in selecting recommended values for body weight. The general description of both the key and relevant studies are summarized in Table 7-9. The recommendations for body weight are summarized in Table 7-10. Table 7-11 presents the confidence ratings for body weight recommendations. The mean body weight for all adults (male and female, all age groups) combined is 71.8 kg as shown in Table 7-1. The mean values for each age group in Table 7-1 were derived by adding the body weights for men and women and dividing by 2. If age and sex distribution of the exposed population is known, the mean body weight values in Table 7-1 can be used. If percentile data are needed or if race is a factor, Tables 7-3 and 7-4 can be used to select the appropriate data for percentiles or mean values. For children, appropriate mean values for weights may be selected from Table 7-2. If percentile values are needed, these data are presented in Table 7-5 for male children and in Table 7-6 for female children. This recommended value is different than the 70 kg commonly assumed in EPA risk assessments. Assessors are encouraged to use values which most accurately reflect the exposed population. When using values other than 70 kg, however, the assessors should consider if the dose estimate will be used to estimate risk by combining with a dose-response relationship which was derived assuming a body weight of 70 kg. If such an inconsistency exists, the assessor should adjust the dose-response relationship as described in the appendix to Chapter 1. The Integrated Risk Information System (IRIS) does not use a 70 kg body weight assumption in the derivation of RfCs and RfDs, but does make this assumption in the derivation of cancer slope factors and unit risks.

7.4. REFERENCES FOR CHAPTER 7

American Industrial Health Council (AIHC). (1994) Exposure factors sourcebook. AIHC, Washington, DC.

Brainard, J.; Burmaster, D. (1992) Bivariate distributions for height and weight of men and women in the United States. Risk Analysis 12(2):267-275.

Brorby, G.; Finley, G. (1993) Standard probability density functions for routine use in environmental health risk assessment. Presented at the Society of Risk Analysis Annual Meeting, December 1993, Savannah, GA.

Burmaster, D.E.; Lloyd, K.J.; Crouch, E.A.C. (1994) Lognormal distributions of body weight as a function of age for female and male children in the United States. Submitted 2/19/94 to Risk Analysis for publication.

National Center for Health Statistics (NCHS) (1987) Anthropometric reference data and prevalence of overweight, United States, 1976-80. Data from the National Health and Nutrition Examination Survey, Series 11, No. 238. Hyattsville, MD: U.S. Department of Health and Human Services, Public Health Service, National Center for Health Statistics. DHHS Publication No. (PHS) 87-1688.

Palisade. (1992) @Risk Users Guide. Palisade Corporation, Newfield, NY.

U.S. EPA (1989) Risk assessment guidance for Superfund, Volume I: Human health evaluation manual. Washington, DC: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. EPA/540/1-89/002.

Versar, Inc. (1991) Analysis of the impact of exposure assumptions on risk assessment of chemicals in the environment, phase II: uncertainty analyses of existing exposure assessment methods. Draft Report. Prepared for Exposure Assessment Task Group, Chemical Manufacturers Association, Washington, DC.

Table 7-9. Summary of Body Weight Studies

Study	Number of Subjects	Population	Comments
KEY STUDY			
NCHS, 1987 (NHANES II)	20,322	U.S. general population	Based on civilian non-institutionalized population aged 6 months to 74 years. Response was 73.1 percent.
RELEVANT STUDIES			
Brainard and Burmaster, 1992	12,501 (5,916 men and 6,588 women)	U.S. general population	Used data from NHANES II to fit bivarite distributions to women and men age 18 to 74 years.
Burmaster et al., 1994	8,458 (4,079 females and 4,379 males)	U.S. general population	Used data from NHANES II to develop fitted distributions for children aged 6 to 20 years old. Adjusted for non-response by age, gender, and race.

Table 7-10. Summary of Recommended Values for Body Weight

Population	Mean	Upper Percentile	Multiple Percentiles
Adults	71.8 kg (See Table 7-1)	See Tables 7-3 and 7-4	See Tables 7-3 and 7-4
Children	See Table 7-2	See Tables 7-5 and 7-6	See Tables 7-5 and 7-6

Table 7-11. Confidence in Body Weight Recommendations

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	NHANES II was the source of data for this study. This is a published study which received a high level of peer review.	High
• Accessibility	The study is widely available to the public.	High
• Reproducibility	Results can be reproduced by analyzing NHANES II data.	High
• Focus on factor of interest	The study focused on body weight, the exposure factor of interest.	High
• Data pertinent to US	Data represents the U.S. population.	High
• Primary data	The primary data was generated from the NHANES II study, thus this data is secondary.	Medium
• Currency	The study was published in 1987.	Medium
• Adequacy of data collection period	The study included data collected from 1976 to 1980. Body weight measurements were taken at various times of the day and at different seasons of the year.	High
• Validity of approach	Direct body weight were measured. Subgroups at risk for malnutrition were over-sampled. Weighting was accomplished by inflating examination results for those not examined and were stratified by race, age, and sex.	High
• Study size	The sample size consisted of 28,000 persons.	High
• Representativeness of the population	Data collected focused on the U.S. population.	High
• Characterization of variability	The study characterized variability regarding age, sex and race (for Blacks, Whites and total populations). The study also sampled persons with low income.	High
• Lack of bias in study design (high rating is desirable)	There are no apparent biases in the study design.	High
• Measurement error	Measurement error should be low since body weights were performed in a mobile examination center using standardized procedures and equipment. Also, measurements were taken at various times of the day to account for weight fluctuations as a result of recent food or water intake.	High
Other Elements		
• Number of studies	One	Low
• Agreement between researchers	The agreement is 100% since the recommendation is based on one key study.	High
Overall Rating		**High**

TABLE OF CONTENTS

Page No.

8. LIFETIME

The length of an individual's life is an important factor to consider when evaluating cancer risk because the dose estimte is averaged over an individual's lifetime. Since the averaging time is found in the denominator of the dose equation, a shorter lifetime would result in a higher potential risk estimate, and conversely, a longer life expectancy would produce a lower potential risk estimate.

8.1. KEY STUDY ON LIFETIME

Statistical data on life expectancy are published annually by the U.S. Department of Commerce in the publication: "Statistical Abstract of the United States." The latest year for which statistics are available is 1993. Available data on life expectancies for various subpopulations born in the years 1970 to 1993 are presented in Table 8-1. Data for 1993 show that the life expectancy for an average person born in the United States in 1993 is 75.5 years (U.S. Bureau of the Census, 1995). The table shows that the overall life expectancy has averaged approximately 75 years since 1982. The average life expectancy for males in 1993 was 72.1 years, and 78.9 years for females. The data consistently show an approximate 7 years difference in life expectancy for males and females from 1970 to present. Table 8-1 also indicates that life expectancy for white males (73.0 years) is consistently longer than for Black males (64.7 years). Additionally, it indicates that life expectancy for White females (79.5 years) is longer than for Black females (73.7), a difference of almost 6 years.

8.2. RECOMMENDATIONS

Current data suggest that 75 years would be an appropriate value to reflect the average life expectancy and is the recommended value. If gender is a factor considered in the assessment, note that the average life expectancy value for females is higher than for males. It is recommended that the assessor use the appropriate value of 72.1 years for males or 78.9 years for females. If race is a consideration in assessing exposure for male individuals, note that the life expectancy is about 8 years longer for Whites than for Blacks. It is recommended that the assessor use the values of 73 years and 64.7 years for White males and Black males, respectively. Table 8-2 presents the confidence rating for life expectancy recommendations.

This recommended value is different than the 70 years commonly assumed in EPA risk assessments. Assessors are encouraged to use values which most accurately reflect the exposed population. When using values other than 70 years, however, the assessors should consider if the dose estimate will be used to estimate risk by combining with a dose-response relationship which was derived assuming a lifetime of 70 years. If such an inconsistency exists, the assessor should adjust the dose-response relationship by multiplying by (lifetime/70). Integrated Risk Information System (IRIS) does not use a 70 year lifetime assumption in the derivation of RfCs and RfDs, but does make this assumption in the derivation of some cancer slope factors or unit risks.

8.3. REFERENCES FOR CHAPTER 8

U.S. Bureau of the Census. (1995) Statistical abstracts of the United States.

Table 8-1. Expectation of Life at Birth, 1970 to 1993, and Projections, 1995 to 2010[a]

YEAR		TOTAL			WHITE			BLACK AND OTHER[b]			BLACK		
		Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
1970		70.8	67.1	74.7	71.7	68.0	75.6	65.3	61.3	69.4	64.1	60.0	68.3
1975		72.6	68.8	76.6	73.4	69.5	77.3	68.0	63.7	72.4	66.8	62.4	71.3
1980		73.7	70.0	77.4	74.4	70.7	78.1	69.5	65.3	73.6	68.1	63.8	72.5
1981		74.1	70.4	77.8	74.8	71.1	78.4	70.3	66.2	74.4	68.9	64.5	73.2
1982		74.5	70.8	78.1	75.1	71.5	78.7	70.9	66.8	74.9	69.4	65.1	73.6
1983		74.6	71.0	78.1	75.2	71.6	78.7	70.9	67.0	74.7	69.4	65.2	73.5
1984		74.7	71.1	78.2	75.3	71.8	78.7	71.1	67.2	74.9	69.5	65.3	73.6
1985		74.7	71.1	78.2	75.3	71.8	78.7	71.0	67.0	74.8	69.3	65.0	73.4
1986		74.7	71.2	78.2	75.4	71.9	78.8	70.9	66.8	74.9	69.1	64.8	73.4
1987		74.9	71.4	78.3	75.6	72.1	78.9	71.0	66.9	75.0	69.1	64.7	73.4
1988		74.9	71.4	78.3	75.6	72.2	78.9	70.8	66.7	74.8	68.9	64.4	73.2
1989		75.1	71.7	78.5	75.9	72.5	79.2	70.9	66.7	74.9	68.8	64.3	73.3
1990		75.4	71.8	78.8	76.1	72.7	79.4	71.2	67.0	75.2	69.1	64.5	73.6
1991		75.5	71.0	78.9	76.3	72.9	79.6	71.5	67.3	75.5	69.3	64.6	73.8
1992		75.8	72.3	79.1	76.5	73.2	79.8	71.8	67.7	75.7	69.6	65.0	73.9
1993		75.5	72.1	78.9	76.3	73.0	79.5	71.5	67.4	75.5	69.3	64.7	73.7
Projections[c]	1995	76.3	72.8	79.7	77.0	73.7	80.3	72.5	68.2	76.8	70.3	65.8	74.8
	2000	76.7	73.2	80.2	77.6	74.3	80.9	72.9	68.3	77.5	70.2	65.3	75.1
	2005	77.3	73.8	80.7	78.2	74.9	81.4	73.6	69.1	78.1	70.7	65.9	75.5
	2010	77.9	74.5	81.3	78.8	75.6	81.0	74.3	69.9	78.7	71.3	66.5	76.0

[a] Excludes deaths of nonresidents of the United States
[b] Racial denotations were not described in the data source.
[c] Based on middle mortality assumptions; for details, see U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 1104.

Source: Bureau of the Census, 1995.

Table 8-2. Confidence in Lifetime Expectancy Recommendations

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	Data is published and has received extensive peer review.	High
• Accessibility	The study was widely available to the public (Census data).	High
• Reproducibility	Results can be reproduced by analyzing Census data.	High
• Focus on factor of interest	Statistical data on life expectancy were published in this study.	High
• Data pertinent to US	The study focused on the U.S. population.	High
• Primary data	Primary data was analyzed.	High
• Currency	The study was published in 1995 and discusses life expectancy trends from 1970 to 1993. The study has also made projections for 1995 until the year 2010.	High
• Adequacy of data collection period	The data analyzed was collected over a period of years.	High
• Validity of approach	Census data is collected and analyzed over a period of years.	High
• Study size	This study was based on U.S. Census data thus the population study size is expected to be greater than 100.	High
• Representativeness of the population	The data is representative of the U.S. population.	High
• Characterization of variability	Data was averaged by gender and race but only for Blacks and Whites; no other nationalities were represented within the section.	Medium
• Lack of bias in study design (High rating is desirable)	There are no apparent biases.	High
• Measurement error	Measurement error may be attributed to portions of the population that avoid or provide misleading information on census surveys.	Medium
Other Elements		
• Number of studies	One	Low
• Agreement between researchers	Recommendation was based on only one study, but it is widely accepted.	High
Overall Rating		**HIGH**

TABLE OF CONTENTS

Page No.

9. INTAKE OF FRUITS AND VEGETABLES
9.1. BACKGROUND

Ingestion of contaminated fruits and vegetables is a potential pathway of human exposure to toxic chemicals. Fruits and vegetables may become contaminated with toxic chemicals by several different pathways. Ambient pollutants from the air may be deposited on or absorbed by the plants, or dissolved in rainfall or irrigation waters that contact the plants. Pollutants may also be absorbed through plant roots from contaminated soil and ground water. The addition of pesticides, soil additives, and fertilizers may also result in food contamination.

The primary source of information on consumption rates of fruits and vegetables among the United States population is the U.S. Department of Agriculture's (USDA) Nationwide Food Consumption Survey (NFCS) and the USDA Continuing Survey of Food Intakes by Individuals (CSFII). Data from the NFCS have been used in various studies to generate consumer-only and per capita intake rates for both individual fruits and vegetables and total fruits and total vegetables. CSFII data from the 1989-1991 survey have been analyzed by EPA to generate per capita intake rates for various food items and food groups.

Consumer-only intake is defined as the quantity of fruits and vegetables consumed by individuals who ate these food items during the survey period. Per capita intake rates are generated by averaging consumer-only intakes over the entire population of users and non-users. In general, per capita intake rates are appropriate for use in exposure assessment for which average dose estimates for the general population are of interest because they represent both individuals who ate the foods during the survey period and individuals who may eat the food items at some time, but did not consume them during the survey period. Total fruit intake refers to the sum of all fruits consumed in a day including canned, dried, frozen, and fresh fruits. Likewise, total vegetable intake refers to the sum of all vegetables consumed in a day including canned, dried, frozen, and fresh vegetables. For the purposes of this Handbook, the distinctions between fruits and vegetables are those commonly used, not the botanical definitions. For example, in this report, tomatoes are considered vegetables, although technically they are fruits.

Intake rates may be presented on either an as consumed or dry weight basis. As consumed intake rates (g/day) are based on the weight of the food in the form that it is consumed. In contrast, dry weight intake rates are based on the weight of the food consumed after the moisture content has been removed. In calculating exposures based on ingestion, the unit of weight used to measure intake should be consistent with those used in measuring the contaminant concentration in the produce. Intake data from the individual component of the NFCS and CSFII are based on "as eaten" (i.e., cooked or prepared) forms of the food items/groups. Thus, corrections to account for changes in portion sizes from cooking losses are not required.

Estimating source-specific exposures to toxic chemicals in fruits and vegetables may also require information on the amount of fruits and vegetables that are exposed to or protected from contamination as a result of cultivation practices or the physical nature of the food product itself (i.e., those having protective coverings that are removed before eating would be considered protected), or the amount grown beneath the soil (i.e., most root crops such as potatoes). The percentages of foods grown above and below ground will be useful when the concentrations of contaminants in foods are estimated from concentrations in soil, water, and air. For example, vegetables grown below ground may be more likely to be contaminated by soil pollutants, but leafy above ground vegetables may be more likely to be contaminated by deposition of air pollutants on plant surfaces.

The purpose of this section is to provide: (1) intake data for individual fruits and vegetables, and total fruits and total vegetables; (2) guidance for converting between as consumed and dry weight intake rates; and (3) intake data for exposed and protected fruits and vegetables and those grown below ground. Recommendations are based on average and upper-percentile intake among the general population of the U.S. Available data have been classified as being either a key or a relevant study based on the considerations discussed in Volume I, Section 1.3.1 of the Introduction. Recommendations are based on data from the CSFII 1989-1991 survey, which was considered the only key intake study for fruits and vegetables. Although Pao et al. (1982) was not considered a key study for intake of fruits and vegetables because it is based on data from NFCS 1977-1978, it was included as a key study for serving size. Other relevant studies are also presented to provide the reader with added perspective on this topic. It should be noted that many of the relevant studies are based on data from USDA's NFCS and CSFII. The USDA NFCS and CSFII are described below.

9.2. INTAKE STUDIES

9.2.1. U.S. Department of Agriculture Nationwide Food Consumption Survey and Continuing Survey of Food Intake by Individuals

USDA conducts the NFCS approximately every 10 years. The three most recent NFCSs were conducted in 1965-66, 1977-78, and 1987-88. The purpose of these surveys was to "analyze the food consumption behavior and dietary status of Americans" (USDA, 1992a). The survey uses a statistical sampling technique designed to ensure that all seasons, geographic regions of the U.S., and demographic and socioeconomic groups are represented. There are two components of the NFCS. The household component collects information on the socioeconomic and demographic characteristics of households, and the types, value, and sources of foods consumed over a 7-day period. The individual component collects information on food intakes of individuals within each household over a 3-day period (USDA, 1992b).

The same basic survey design was used for the three most recent NFCSs, but the sample sizes and statistical classifications used were somewhat different (USDA, 1992a). In 1965-66, 10,000 households were surveyed (USDA, 1972). The sample size increased to 15,000 households (over 36,000 individuals) in 1977-78, but decreased to 4,500 households in 1987-88 because of budgetary constraints and a low response rate (37 percent). Data from the 1977-78 NFCS are presented in this Handbook because the data have been published by USDA in various publications and reanalyzed by various EPA offices according to the food items/groups commonly used to assess exposure. Published one-day data from the 1987-88 NFCS data are also presented.

USDA also conducted the Continuing Survey of Food Intake by Individuals during 1989 through 1991 (USDA, 1993a). The purpose of the survey was to "assess food consumption behavior and nutritional content of diets for policy implications relating to food production and marketing, food safety, food assistance, and nutrition education" (USDA, 1993a). Using a stratified sampling technique, individuals of all ages living in selected households in the 48 conterminous states and Washington, D.C. were surveyed. Individuals provided 3 consecutive days of data, including a personal interview on the first day followed by 2-day dietary records. Over 15,000 individuals participated in the 1989-91 CSFII. The three-day response rate for the 1989/91 CSFII was approximately 45 percent.

Individual average daily intake rates calculated from NFCS data are based on averages of reported individual intakes over one day or three consecutive days. Such short term data are suitable for estimating mean average daily intake rates representative of both short-term and long-term consumption. However, the *distribution* of average daily intake rates generated using short term data (e.g., 3 day) do not necessarily reflect the long-term *distribution* of average daily intake rates. The distributions generated from short term and long term data will differ to the extent that each individual's intake varies from day to day; the distributions will be similar to the extent that individuals' intakes are constant from day to day.

Day to day variation in intake among individuals will be great for food item/groups that are highly seasonal and for items/groups that are eaten year around but that are not typically eaten every day. For these foods, the intake distribution generated from short term data will not be a good reflection of the long term distribution. On the other hand, for broad categories of foods (e.g., vegetables) which are eaten on a daily basis throughout the year with minimal seasonality, the short term distribution may be a reasonable approximation of the true long term distribution, although it will show somewhat more variability. In this and the following section, distributions are shown only for the following broad categories of foods: fruits, vegetables, meats and dairy. Because of the increased variability of the short-term distribution, the short-term upper percentiles shown here will overestimate somewhat the corresponding percentiles of the long-term distribution.

9.2.2. Key Fruits and Vegetables Intake Study Based on the USDA CSFII

U.S. EPA Analysis of USDA 1989-1991 CSFII Data - EPA analyzed three years of data from USDA's CSFII to generate distributions of intake rates for various fruit and vegetable items/groups. Data from the 1989, 1990, and 1991 CFSII were combined into a single data set to increase the number of observations available for analysis. Approximately 15,000 individuals provided intake data over the three survey years. The fruit and vegetable items/groups selected for this analysis included total fruits and total vegetables; individual fruits such as: apples, peaches, pears, strawberries, and other berries; individual vegetables such as: asparagus, beets, broccoli, cabbage, carrots, corn, cucumbers, lettuce, lima beans, okra, onions, peas, peppers, pumpkin, snap beans, tomatoes, and white potatoes; fruits and vegetables categorized as exposed, protected and roots; and various USDA categories (i.e., citrus and other fruits, and dark green, deep yellow, and other vegetables). These fruit and vegetable categories were selected to be consistent with those evaluated in the homegrown food analysis presented in Chapter 12. Intake rates of total vegetables, tomatoes, and white potatoes were adjusted to account for the amount of these food items eaten as meat and grain mixtures as described in Appendix 9A. Food items/groups were identified in the CSFII data base according to USDA-defined food codes. Appendix 9B presents the codes used to determine the various food groups. Intake rates for these food items/groups represent intake of all forms of the product (i.e., home produced and commercially produced).

Individual identifiers in the database were used throughout the analysis to categorize populations according to demographics. These identifiers included identification number, region, urbanization, age, sex, race, body weight, weighting factor, season, and number of days that data were reported. Distributions of intake were determined for individuals who provided data for all three days of the survey. Individuals who did not provide information on body weight, or for which identifying information was unavailable, were excluded from the analysis. Three-day average intake rates were calculated for all individuals in the database for each of the food items/groups. These average daily intake rates were divided by each individual's body weight to generate intake rates in units of g/kg-day. The data were also weighted according to the three-day weights provided in the 1991 CSFII. USDA sample weights are calculated to account for inherent biases in the sample selection process, and to adjust the sample population to reflect the national population. Summary statistics for individual intake rates were generated on a per capita basis. That is, both users and non-users of the food item were included in the analysis. Mean consumer only intake rates may be calculated by dividing the mean per capita intake rate by the percent of the population consuming the food item of interest. Summary statistics included are: number of weighted and unweighted observations, percentage of the population using the food item/group being analyzed, mean intake rate, standard error, and percentiles of the intake rate distribution (i.e., 0, 1, 5, 10, 25, 50, 75, 90, 95, 99, and 100th percentile). Data were provided for the total population using the food item being evaluated and for several demographic groups including: various age groups (i.e., <1, 1-2, 3-5, 6-11, 12-19, 20-39, 40-69, and 70+ years); regions (i.e., Midwest, Northeast, South, and West); urbanizations (i.e., Central City, Nonmetropolitan, and Suburban; seasons (i.e., winter, spring, summer, and fall); and races (i.e., White, Black, Asian, Native American, and other). Table 9-1 provides the codes, definitions, and a description of the data in these categories. The total numbers of individuals in the data set, by demographic group are presented in Table 9-2. The food analysis was accomplished using the SAS statistical programming system (SAS, 1990).

The results of this analysis are presented in Tables 9-3 and 9-4 for total fruits and vegetables, Table 9-5 for individual fruits and vegetables, and Tables 9-6 and 9-7 the various USDA categories and exposed/protected and root food items, respectively. These tables are presented at the end of this Chapter. The results are presented in units of g/kg-day. Thus, use of these data in calculating potential dose does not require the body weight factor to be included in the denominator of the average daily dose (ADD) equation. It should be noted that converting these intake rates into units of g/day by multiplying by a single average body weight is inappropriate, because individual intake rates were indexed to the actual body weights of the survey respondents. However, if there is a need to compare the total intake data presented here to other intake data in units of g/day, a body weight less than 70 kg (i.e., approximately 60 kg; calculated based on the number of respondents in each age category and the average body weights for these age groups, as presented in Chapter 7 of Volume I) should be used because the total survey population included children as well as adults.

The advantages of using the CSFII data set are that the data are expected to be generally representative of the U.S. population and that it includes data on a wide variety of food types. However, it should be noted that the survey covers only the 48 coterminous U.S. States; Hawaii, Alaska, and U.S. Territories are not included. The data set is the most recent of a series of publicly available data sets (i.e., NFCS 1977/78; NFCS 1987/88; CSFII 1989-91) from USDA, and should reflect current eating patterns in the United States. The data set includes three years of intake data combined. However, the CSFII data are based on a three day survey period. Short-term dietary data may not accurately reflect long-term eating patterns. This is particularly true for the tails (extremes) of the distribution of food intake. In addition, the adjustment for including mixtures adds uncertainty to the intake rate distributions. The calculation for including mixtures assumes that intake of any mixture includes all of the foods identified in Appendix Table A9-1 in the proportions specified in that

Table 9-1. Sub-category Codes and Definitions Used in the CSFII 1989-91 Analysis

Code	Definition	Description
		Region[a]
1	Northeast	Includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont
2	Midwest	Includes Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin
3	South	Includes Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia
4	West	Includes Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming
		Urbanization
1	Central City	Cities with populations of 50,000 or more that is the main city within the metropolitan statistical area (MSA).
2	Suburban	An area that is generally within the boundaries of an MSA, but is not within the legal limit of the central city.
3	Nonmetropolitan	An area that is not within an MSA.
		Season
Spring	-	April, May, June
Summer	-	July, August, September
Fall	-	October, November, December
Winter	-	January, February, March
		Race
1	--	White (Caucasian)
2	--	Black
3	--	Asian and Pacific Islander
4	--	Native American, Aleuts, and Eskimos
5, 8, 9	Other/NA	Don't know, no answer, some other race

[a] Alaska and Hawaii were not included.
Source: CSFII 1989-1991.

Table 9-2. Weighted and Unweighted Number of Observations for CSFII Data Used in Analysis of Food Intake

Demographic Factor	Weighted	Unweighted
Total	242,707,000	11,912
Age		
<01	7,394,000	424
01-02	7,827,000	450
03-05	11795,000	603
06-11	21,830,000	1,147
12-19	26,046,000	1,250
20-39	78,680,000	3,555
40-69	71,899,000	3,380
70+	17,236,000	1,103
Season		
Fall	60,633,000	3,117
Spring	60,689,000	3,077
Summer	60,683,000	2,856
Winter	60,702,000	2,862
Urbanization		
Central City	73,410,000	3,607
Nonmetropolitan	53,993,000	3,119
Suburban	115,304,000	5,186
Race		
Asian	2,871,000	149
Black	29,721,000	1,632
Native American	2,102,000	171
Other/NA	7,556,000	350
White	200,457,000	9,610
Region		
Northeast	59,285,000	3,007
Midwest	50,099,000	2,180
South	83,741,000	4,203
West	49,582,000	2,522

table. This may under- or over-estimate intake of certain foods among some individuals.

9.2.3. Key Fruits and Vegetables Serving Size Study Based on the USDA NFCS

Pao et al. (1982) - Foods Commonly Eaten by Individuals - Using data gathered in the 1977-78 USDA NFCS, Pao et al. (1982) calculated distributions for the quantities of individual fruit and vegetables consumed per eating occasion by members of the U.S. population (i.e., serving sizes), over a 3-day period. The data were collected during NFCS home interviews of 37,874 respondents, who were asked to recall food intake for the day preceding the interview, and record food intake the day of the interview and the day after the interview.

Serving size data are presented on an as consumed (g/day) basis. The data presented in Table 9-8 are for all ages of the population, combined. If age-specific intake data are needed, refer to Pao et al. (1982). Although serving size data only are presented in this Handbook, percentiles for the average quantities of individual fruits and vegetables consumed by member of the U.S. population who had consumed these fruits and vegetables over a 3-day period can be found in Pao et al. (1982).

The advantages of using these data are that they were derived from the USDA NFCS and are representative of the U.S. population. This data set provides serving size distributions for a number of commonly eaten fruits and vegetables, but the list of foods is limited and does not account for fruits and vegetables included in complex food dishes. Also, these data represent the quantity of fruits and vegetables consumed per eating occasion. Although these estimates are based on USDA NFCS 1977-78 data, more recent data on serving size were not available. These estimates may be useful for assessing acute exposures to contaminants in specific foods, or other assessments where the amount consumed per eating occasion is necessary.

9.2.4. Relevant Fruits and Vegetables Intake Studies

The U.S. EPA's Dietary Risk Evaluation System (DRES) - USEPA, Office of Pesticide Programs - The U.S. EPA, Office of Pesticide Programs (OPP) uses the Dietary Risk Evaluation System (formerly the Tolerance Assessment System) to assess the dietary risk of pesticide use as part of the pesticide registration process. OPP sets tolerances for specific pesticides on raw agricultural commodities based on estimates of dietary risk. These estimates are calculated using pesticide residue data for the food item of concern and relevant consumption data. Intake rates are based primarily on the USDA 1977-1978 NFCS although intake rates for some food items are based on estimations from production volumes or other data (i.e., some items were assigned an arbitrary value of 0.000001 g/kg-day) (Kariya, 1992). OPP has calculated per capita intake rates of individual fruits and vegetables for 22 subgroups (age, regional, and seasonal) of the population by determining the composition of NFCS food items and disaggregating complex food dishes into their component raw agricultural commodities (RACs) (White et al. 1983).

The DRES per capita, as consumed intake rates for all age/sex/demographic groups combined are presented in Table 9-9. These data are based on both consumers and non consumers of these food items. Data for specific subgroups of the population are not presented here, but are available through OPP via direct request. The data in Table 9-9 may be useful for estimating the risks of exposure associated with the consumption of individual fruits and vegetables. It should be noted that these data are indexed to the actual body weights of the survey respondents and are expressed in units of grams of food consumed per kg bodyweight per day. Consequently, use of these data in calculating potential dose does not require the body weight factor in the denominator of the ADD equation. It should also be noted that conversion of these intake rates into units of g/day by multiplying by a single average body weight is not appropriate because the DRES data base did not rely on a single body weight for all individuals. Instead, DRES used the body weights reported by each individual surveyed to estimate consumption in units of g/kg-day.

The advantages of using these data are that complex food dishes have been disaggregated to provide intake rates for a very large number of fruits and vegetables. These data are also based on the individual body weights of the respondents. Therefore, the use of these data in calculating exposure to toxic chemicals may provide more representative estimates of potential dose per unit body weight. However, because the data are based on NFCS short-term dietary recall the same limitations discussed previously for other NFCS data sets also apply here. In addition, consumption patterns may have changed since the data were collected in 1977-78. OPP is in the process of translating consumption information from the USDA CSFII 1989-91 survey to be used in DRES.

Food and Nutrient Intakes of Individuals in One Day in the U.S., USDA (1980, 1992b) - USDA calculated mean intake rates for total fruits and total vegetables using NFCS data from 1977-78 and 1987-88 (USDA, 1980; USDA, 1992b). The mean total intake rates are presented in Tables 9-10 and 9-11 for fruits and Tables 9-12 and 9-13 for vegetables. These values are based on intake data for one day from the 1977-78 and 1987-88 USDA Nationwide Food Consumption Surveys, respectively. Data from both surveys are presented here to demonstrate that although the 1987-88 survey had fewer respondents, the mean per capita intake rates for all individuals are in good agreement with the earlier survey. Also, slightly different age classifications were used in the two surveys providing a wider range of age categories from which exposure assessors may select appropriate intake rates. Tables 9-10 through 9-13 include both per capita intake rates and intake rates for consumers-only for various ages of individuals. Intake rates for consumers-only were calculated by dividing the per capita consumption rate by the fraction of the population using vegetables or fruits in a day. The average per capita vegetable intake rate is 201 g/day based on the 1977-78 data (USDA, 1980) and 182 g/day based on the 1987-88 data (USDA, 1992b). For fruits the average per capita intake rate is 142 g/day based on the two most recent USDA NFCSs (USDA, 1980; USDA, 1992b).

The advantages of using these data are that they provide intake estimates for all fruits and all vegetables combined. Again, these estimates are based on one-day dietary data which may not reflect usual consumption patterns.

U.S. EPA - Office of Radiation Programs - The U.S. EPA Office of Radiation Programs (ORP) has also used the USDA 1977-1978 NFCS to estimate daily food intake (U.S. EPA, 1984a; 1984b). ORP uses food consumption data to assess human intake of radio nuclides in foods. The 1977-1978 NFCS data have been reorganized by ORP, and food items have been classified according to the characteristics of radionuclide transport. Data for selected agricultural products are presented in Table 9-14 and Table 9-15. These data represent per capita, as consumed intake rates for total, leafy, exposed, and protected produce as well as total grains, breads, and cereals. Exposed produce refers to products (e.g., apples, pears, berries, etc.) that can intercept atmospherically deposited materials. The term protected refers to products (e.g., citrus fruit, carrots, corn, etc.) that are protected from deposition from the atmosphere. Although the fruit and vegetable classifications used in the study are somewhat limited in number, they provide alternative food categories that may be useful to exposure assessors. Because this study was based on the USDA NFCS, the limitations discussed previously regarding short-term dietary recall data also apply to the intake rates reported here. Also, consumption patterns may have changed since the data were collected in 1977-78.

U.S. EPA - Office of Science and Technology - The U.S. EPA Office of Science and Technology (OST) within the Office of Water (formerly the Office of Water Regulations and Standards) used data from the FDA revision of the Total Diet Study Food Lists and Diets (Pennington, 1983) to calculate food intake rates (U.S. EPA, 1989). OST uses these consumption data in its risk assessment model for land application of municipal sludge. The FDA data used are based on the combined results of the USDA 1977-1978, NFCS and the second National Health and Nutrition Examination Survey (NHANES II), 1976-1980 (U.S. EPA, 1989). Because food items are listed as prepared complex foods in the FDA Total Diet Study, each item was broken down into its component parts so that the amount of raw commodities consumed could be determined. Table 9-16 presents intake rates of various fruit and vegetable categories for various age groups and estimated lifetime ingestion rates that have been derived by U.S. EPA. Note that these are per capita intake rates tabulated as grams dry weight/day. Therefore, these rates differ from those in the previous tables because U.S. EPA (1984a, 1984b) report intake rates on an as consumed basis.

The EPA-OST analysis provides intake rates for additional food categories and estimates of lifetime average daily intake on a per capita basis. In contrast to the other analyses of USDA NFCS data, this study reports the data in terms of dry weight intake rates. Thus, conversion is not required when contaminants are to be estimated on a dry weight basis. These data, however, may not reflect current consumption patterns.

Canadian Department of National Health and Welfare Nutrition Canada Survey - The Nutrition Canada Survey was conducted between 1970 and 1972 to "(a) examine the mean consumption of selected food groups and their contribution to nutrient intakes of Canadians, (b) examine patterns of food consumption and nutrient intake at various times of the day, and provide information on the changes in eating habits during pregnancy." (Canadian Department of National Health and Welfare, n.d.). The method used for collecting dietary intake data was 24-hour recall. The recall method relied on interview techniques in which the interviewee was asked to recall all foods and beverages consumed during the day preceding the interview. Intake rates were reported for various age/sex groups of the population and for pregnant women (Table 9-17). The report does not specify whether the values represent per capita or consumer-only intake rates.

However, they appear to be consistent with the as consumed intake rates for consumers-only reported by USDA (1980, 1992b). It should be noted that these data are also based on short-term dietary recall and are based on the Canadian population.

USDA, 1993b - Food Consumption, Prices, and Expenditures, 1970-92 - The USDA's Economic Research Service (ERS) has calculated the amount of food available for human consumption in the United States on an annual basis (USDA, 1993b). Supply and utilization balance sheets have been generated, based on the flow of food items from production to end uses for the years 1970 to 1992. Total available supply was estimated as the sum of production and imports (USDA, 1993b). The availability of food for human use commonly termed as "food disappearance" was determined by subtracting exported foods (USDA, 1993b). USDA (1993b) calculated the per capita food consumption by dividing the total food disappearance by the total U.S. population. USDA (1993b) estimated per capita consumption data for various fruit and vegetable products from 1970-1992 (1992 data are preliminary). In this section, the 1991 values, which are the most recent final data, are presented. Retail weight per capita data are presented in Table 9-18. These data have been derived from the annual per capita values in units of pounds per year, presented by USDA (1993b), by converting to units of g/day.

One of the limitations of this study is that disappearance data do not account for losses from the food supply from waste or spoilage. As a result, intake rates based on these data may overestimate daily consumption because they are based on the total quantity of marketable commodity utilized. Thus, these data represent bounding estimates of intake rates only. It should also be noted that per capita estimates based on food disappearance is not a direct measure of actual consumption or quantity ingested, instead the data are used as indicators of changes in usage over time (USDA, 1993b). An advantage of this study is that it provides per capita consumption rates for fruits and vegetables that are representative of long-term intake because disappearance data are generated annually.

AIHC, 1994 - Exposure Factors Sourcebook - The AIHC Sourcebook (AIHC, 1944) uses the data presented in the 1989 version of the Exposure Factors Handbook which reported data from the USDA 1977-78 NFCS. Distributions are provided in the @Risk format and the @Risk formula is also provided. In this Handbook, new analyses of more recent data from the USDA 1989/91 CSFII are presented. Numbers, however, cannot be directly compared with previous values since the results from the new analysis are presented on a body weight basis.

The Sourcebook was classified as a relevant study because it was not the primary source for the data to make recommendations in this document. However, it can be used as an alternative source of information.

The advantage of using the CSFII and USDA NFCS data sets are that they are the largest publicly available data source on food intake patterns in the United States. Data are available for a wide variety of fruit and vegetable products and are intended to be representative of the U.S. population.

9.2.5. Conversion Between As Consumed and Dry Weight Intake Rates

As noted previously, intake rates may be reported in terms of units as consumed or units of dry weight. It is essential that exposure assessors be aware of this difference so that they may ensure consistency between the units used for intake rates and those used for concentration data (i.e., if the unit of food consumption is grams dry weight/day, then the unit for the amount of pollutant in the food should be grams dry weight).

If necessary, as consumed intake rates may be converted to dry weight intake rates using the moisture content percentages presented in Table 9-19 and the following equation:

$$IR_{dw} = IR_{ac} * [(100-W)/100] \qquad \text{(Eqn. 9-1)}$$

"Dry weight" intake rates may be converted to "as consumed" rates by using:

$$IR_{ac} = IR_{dw}/[(100-W)/100] \qquad \text{(Eqn. 9-2)}$$

where:

IR_{dw} = dry weight intake rate;
IR_{ac} = as consumed intake rate; and
W = percent water content.

9.3. RECOMMENDATIONS

The CSFII data described in this section was used in selecting recommended fruit and vegetable intake rates for the general population and various subgroups of the United

States population. The general design of both key and relevant studies are summarized in Table 9-20. Table 9-21 presents a summary of the recommended values for fruit and vegetable intake and Table 9-22 presents the confidence ratings for the fruit and vegetable intake recommendations. Based on the CSFII 1989-91, the recommended per capita fruit intake rate for the general population is 3.4 g/kg-day and the recommended per capita vegetable intake rate for the general population is 4.3 g/kg-day. Per capita intake rates for specific food items, on a g/kg-day basis, may be obtained from Table 9-5. Percentiles of the per capita intake rate distribution in the general population for total fruits and total vegetables are presented in Tables 9-3 and 9-4. From these tables, the 95th percentile intake rates for fruits and vegetables are 12 g/kg-day and 10 g/kg-day, respectively. It is important to note that the distributions presented in Tables 9-3 through 9-4 are based on data collected over a 3-day period and may not necessarily reflect the long-term distribution of average daily intake rates. However, for these broad categories of food (i.e., total fruits and total vegetables), because they are eaten on a daily basis throughout the year with minimal seasonality, the short term distribution may be a reasonable approximation of the long-term distribution, although it will display somewhat increased variability. This implies that the upper percentiles shown here will tend to overestimate the corresponding percentiles of the true long-term distribution. Intake rates for the home-produced form of these fruit and vegetable products are presented in Volume II, Chapter 4.

This section also presents recommendations for serving size for various fruits and vegetables. These recommendations are based on the USDA NFCS 1977-78 data. Table 9-23 presents the confidence ratings for the serving size recommendations. Percentiles of the serving size, as well as mean values can be obtained from Table 9-8.

9.4. REFERENCES FOR CHAPTER 9

American Industrial Health Council (AIHC). (1994) Exposure factors sourcebook. AIHC, Washington, DC.

Canadian Department of National Health and Welfare, Bureau of National Sciences, Health Protection Branch (n.d.). Food Consumption, Patterns Report: A report from Nutrition Canada.

Kariya, J. (1992) Written communication to L. Phillips, Versar, Inc., March 4, 1992.

Pao, E.M.; Fleming, K.H.; Guenther, P.M.; Mickle, S.J. (1982) Foods commonly eaten by individuals: amount per day and per eating occasion. U.S. Department of Agriculture. Home Economics Report No. 44.

Pennington, J.A.T. (1983) Revision of the total diet study food list and diets. J. Am. Diet. Assoc. 82:166-173.

SAS Institute, Inc. (1990) SAS Procedures Guide, Version 6, Third Edition, Cary, NC: SAS Institute, Inc., 1990, 705 pp.

USDA. (1972) Food consumption: households in the United States, Seasons and year 1965-1966. U.S. Department of Agriculture.

USDA. (1980) Food and nutrient intakes of individuals in one day in the United States, Spring 1977. Nationwide Food Consumption Survey 1977-1978. U.S. Department of Agriculture. Preliminary Report No. 2.

USDA. (1992a) Changes in food consumption and expenditures in American households during the 1980s. U.S. Department of Agriculture. Washington, D.C. Statistical Bulletin No. 849.

USDA. (1992b) Food and nutrient intakes by individuals in the United States, 1 day, 1987-88: U.S. Department of Agriculture, Human Nutrition Information Service. Nationwide Food Consumption Survey 1987-88, NFCS Rpt. No. 87-I-1.

USDA. (1993a) Food and nutrient intakes by individuals in the United States, 1 day, 1989-91. U.S. Department of Agriculture, Agricultural Research Service. NFS Report No. 91-2.

USDA. (1993b) Food consumption prices and expenditures (1970-1992) U.S. Department of Agriculture, Economic Research Service. Statistical Bulletin, No. 867.

U.S. EPA. (1984a) An estimation of the daily average food intake by age and sex for use in assessing the radionuclide intake of individuals in the general population. EPA-520/1-84-021.

U.S. EPA. (1984b) An estimation of the daily food intake based on data from the 1977-1978 USDA Nationwide Food Consumption Survey. Washington, DC: Office of Radiation Programs. EPA-520/1-84-015.

U.S. EPA. (1989) Development of risk assessment methodologies for land application and distribution and marketing of municipal sludge. Washington, DC: Office of Science and Technology. EPA 600/-89/001.

White, S.B.; Peterson, B.; Clayton, C.A.; Duncan, D.P. (1983) Interim Report Number 1: The construction of a raw agricultural commodity consumption data base. Prepared by Research Triangle Institute for EPA Office of Pesticide Programs.

Table 9-3. Intake of Total Fruits (g/kg-day)

Population Group	Percent Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	69.0%	3.381	0.068	0	0	0	0	1.68	4.16	7.98	12.44	26.54	210.72
Age													
< 01	67.9%	14.898	1.285	0	0	0	0	8.80	21.90	35.98	42.77	88.42	210.72
01-02	76.7%	11.836	0.582	0	0	0	2.80	9.76	17.99	25.70	30.69	52.27	80.19
03-05	80.8%	8.422	0.364	0	0	0	2.22	6.37	12.53	19.29	22.78	32.83	52.87
06-11	79.2%	5.047	0.160	0	0	0	1.30	3.86	7.17	11.79	14.49	21.53	30.37
12-19	62.6%	2.183	0.095	0	0	0	0	1.36	3.38	5.66	7.24	11.80	16.86
20-39	58.8%	1.875	0.056	0	0	0	0	1.06	2.82	5.08	6.43	10.26	41.58
40-69	71.0%	2.119	0.051	0	0	0	0	1.36	3.24	5.20	6.73	10.52	23.07
70 +	83.3%	2.982	0.087	0	0	0	0.89	2.42	4.28	6.77	8.31	11.89	15.00
Season													
Fall	68.9%	3.579	0.169	0	0	0	0	1.66	3.94	8.20	13.41	32.62	204.28
Spring	68.3%	3.249	0.116	0	0	0	0	1.73	4.14	7.43	12.22	23.71	88.42
Summer	70.4%	3.381	0.131	0	0	0	0	1.80	4.29	7.87	12.26	23.11	210.72
Winter	68.4%	3.314	0.119	0	0	0	0	1.52	4.27	8.33	12.17	26.54	75.52
Urbanization													
Central City	68.8%	3.288	0.114	0	0	0	0	1.66	4.00	7.82	11.94	23.73	210.72
Nonmetropolitan	67.4%	3.107	0.113	0	0	0	0	1.51	3.94	7.52	12.25	26.04	84.34
Suburban	70.1%	3.567	0.113	0	0	0	0	1.80	4.40	8.43	13.19	28.13	204.28
Race													
Asian	77.2%	5.839	0.632	0	0	0	1.24	4.20	6.76	17.30	20.65	29.61	38.95
Black	63.7%	3.279	0.188	0	0	0	0	1.51	4.25	7.70	12.34	26.54	210.72
Native American	61.4%	3.319	0.490	0	0	0	0	1.58	4.31	7.57	16.02	22.66	29.24
Other/NA	64.9%	4.027	0.465	0	0	0	0	1.77	5.10	10.92	14.96	47.78	53.89
White	70.1%	3.337	0.075	0	0	0	0	1.66	4.06	7.87	12.21	26.48	204.28
Region													
Midwest	69.9%	3.236	0.120	0	0	0	0	1.58	4.07	7.87	11.30	28.64	84.34
Northeast	73.9%	3.665	0.143	0	0	0	0.07	1.84	4.70	8.37	12.75	31.67	88.42
South	62.0%	3.017	0.105	0	0	0	0	1.42	3.80	7.39	11.67	24.67	210.72
West	75.4%	3.880	0.187	0	0	0	0.17	2.08	4.45	9.18	14.61	25.49	204.28

Table 9-4. Intake of Total Vegetables (g/kg-day)

Population Group	Percent Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	97.2%	4.259	0.029	0	0.75	1.29	2.26	3.60	5.37	7.93	10.00	15.65	44.99
Age													
< 01	74.8%	6.802	0.375	0	0	0	0	5.52	10.41	15.27	19.29	29.61	44.99
01-02	95.6%	7.952	0.228	0	1.33	2.32	4.65	7.28	10.26	14.77	16.32	21.24	32.10
03-05	97.2%	7.125	0.200	0	1.11	2.15	3.79	5.83	9.64	13.87	15.43	25.09	35.56
06-11	97.6%	5.549	0.109	0	1.03	1.72	3.09	4.82	7.31	10.06	11.74	18.39	31.30
12-19	98.1%	3.807	0.070	0	0.85	1.30	2.16	3.49	4.71	6.80	8.52	12.26	27.84
20-39	98.2%	3.529	0.037	0	0.75	1.22	2.06	3.16	4.54	6.36	7.63	10.69	17.07
40-69	98.3%	3.741	0.039	0	0.85	1.34	2.19	3.43	4.94	6.56	7.78	10.91	24.51
70 +	98.3%	4.068	0.071	0	0.96	1.47	2.47	3.67	5.35	6.89	8.17	11.96	18.92
Season													
Fall	97.8%	4.366	0.063	0	0.86	1.31	2.28	3.56	5.28	8.33	10.52	17.95	35.56
Spring	96.9%	4.095	0.055	0	0.72	1.20	2.19	3.45	5.19	7.67	9.85	15.33	44.99
Summer	97.0%	4.181	0.059	0	0.58	1.16	2.21	3.54	5.34	7.73	9.54	15.14	41.68
Winter	97.0%	4.394	0.056	0	0.86	1.40	2.36	3.78	5.67	8.03	9.69	15.23	29.69
Urbanization													
Central City	97.4%	4.059	0.053	0	0.67	1.22	2.08	3.34	5.17	7.74	9.51	16.04	44.99
Nonmetropolitan	96.3%	4.450	0.060	0	0.86	1.41	2.44	3.72	5.66	8.28	10.08	16.27	35.56
Suburban	97.6%	4.296	0.044	0	0.82	1.31	2.30	3.64	5.38	7.86	10.17	15.39	41.68
Race													
Asian	93.3%	4.913	0.330	0	0	1.53	2.06	3.66	7.52	10.32	14.84	15.43	16.76
Black	96.1%	4.228	0.093	0	0.36	0.85	1.99	3.19	5.46	8.80	11.35	18.39	32.10
Native American	87.1%	4.880	0.277	0	0	0.58	2.40	4.22	6.85	8.87	11.37	13.89	21.77
Other/NA	96.6%	4.762	0.183	0	0	1.11	2.46	4.24	6.20	9.33	11.93	15.02	22.14
White	97.6%	4.229	0.031	0	0.86	1.37	2.30	3.60	5.32	7.74	9.75	15.31	44.99
Region													
Midwest	97.0%	4.123	0.061	0	0.75	1.20	2.09	3.35	5.16	8.03	9.87	16.90	35.56
Northeast	97.2%	4.494	0.073	0	0.69	1.29	2.37	3.77	5.70	8.42	11.00	15.86	41.68
South	97.4%	4.268	0.047	0	0.86	1.39	2.31	3.66	5.32	7.76	9.80	15.31	44.99
West	96.9%	4.168	0.060	0	0.60	1.22	2.25	3.57	5.38	7.78	9.53	15.28	35.56

NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analyses of the 1989/91 CSFII

Table 9-5. Intake of Individual Fruits and Vegetables (g/kg-day)

	Apple			Asparagus			Beets			Broccoli		
Populatio n Group	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE
Total	28.4%	0.854	0.052	1.5%	0.012	0.008	1.8%	0.009	0.010	10.9%	0.107	0.012
Age												
< 01	41.7%	5.042	0.823	0.0%	0	0	1.2%	0.045	0.296	4.2%	0.142	0.224
01-02	42.9%	4.085	0.508	0.2%	0.003	0.041	0.7%	0.006	0.055	7.6%	0.234	0.134
03-05	44.1%	3.004	0.312	0.2%	0.001	0.038	0.5%	0.006	0.056	10.1%	0.307	0.118
06-11	41.6%	1.501	0.123	0.3%	0.001	0.019	0.9%	0.008	0.040	6.8%	0.098	0.052
12-19	23.0%	0.394	0.062	0.3%	0.003	0.033	0.6%	0.001	0.010	8.2%	0.065	0.028
20-39	21.3%	0.337	0.033	1.1%	0.008	0.012	1.3%	0.004	0.007	11.4%	0.081	0.015
40-69	26.0%	0.356	0.027	2.5%	0.025	0.016	2.4%	0.009	0.009	13.8%	0.102	0.016
70 +	30.8%	0.435	0.052	3.5%	0.026	0.028	5.2%	0.029	0.022	11.8%	0.115	0.028
Season												
Fall	33.7%	1.094	0.116	0.8%	0.005	0.013	1.2%	0.009	0.040	10.8%	0.089	0.024
Spring	25.9%	0.667	0.078	2.7%	0.023	0.017	2.0%	0.009	0.012	11.7%	0.122	0.022
Summer	23.2%	0.751	0.122	1.1%	0.006	0.014	1.7%	0.005	0.008	8.8%	0.120	0.032
Winter	30.4%	0.905	0.095	1.3%	0.015	0.018	2.3%	0.011	0.013	12.3%	0.098	0.020
Urbanization												
Central City	27.4%	0.749	0.081	1.1%	0.013	0.018	1.3%	0.008	0.031	10.6%	0.119	0.024
Nonmetropolitan	26.8%	0.759	0.104	1.3%	0.011	0.015	1.8%	0.010	0.013	9.0%	0.067	0.017
Suburban	29.9%	0.965	0.083	1.8%	0.013	0.012	2.0%	0.008	0.009	12.2%	0.119	0.019
Race												
Asian	38.3%	0.871	0.327	2.7%	0.067	0.123	0.7%	0.040	0.320	15.4%	0.209	0.166
Black	22.7%	0.688	0.159	0.3%	0.003	0.019	1.1%	0.007	0.024	8.3%	0.154	0.047
Native American	20.5%	0.407	0.273	0.0%	0	0	1.2%	0.003	0.028	5.3%	0.021	0.045
Other/NA	24.9%	0.964	0.256	0.6%	0.001	0.009	0.9%	0.015	0.101	10.3%	0.180	0.100
White	29.4%	0.879	0.057	1.7%	0.013	0.009	1.9%	0.008	0.010	11.4%	0.097	0.012
Region												
Midwest	29.1%	0.782	0.082	1.8%	0.015	0.016	0.8%	0.010	0.049	8.4%	0.077	0.025
Northeast	31.5%	0.953	0.116	1.6%	0.015	0.022	2.3%	0.008	0.012	13.5%	0.113	0.026
South	23.6%	0.828	0.099	1.0%	0.010	0.014	1.8%	0.009	0.011	9.8%	0.109	0.022
West	32.7%	0.885	0.121	1.8%	0.012	0.015	2.4%	0.008	0.009	13.4%	0.135	0.025

Table 9-5. Intake of Individual Fruits and Vegetables (g/kg-day) (continued)

Population Group	Cabbage Percent Consuming	Cabbage Mean	Cabbage SE	Carrots Percent Consuming	Carrots Mean	Carrots SE	Corn Percent Consuming	Corn Mean	Corn SE	Cucumbers Percent Consuming	Cucumbers Mean	Cucumbers SE
Total	12.2%	0.088	0.009	16.9%	0.115	0.010	24.1%	0.206	0.010	15.8%	0.063	0.006
Age												
< 01	2.4%	0.023	0.078	13.4%	0.379	0.165	17.5%	0.356	0.128	2.4%	0.021	0.107
01-02	5.1%	0.086	0.089	13.3%	0.214	0.085	32.9%	0.587	0.091	7.3%	0.062	0.069
03-05	7.5%	0.107	0.081	15.1%	0.148	0.052	31.5%	0.490	0.070	12.1%	0.083	0.046
06-11	7.5%	0.049	0.027	17.1%	0.154	0.037	35.8%	0.367	0.032	14.9%	0.086	0.032
12-19	8.5%	0.065	0.028	11.8%	0.056	0.018	24.0%	0.173	0.024	12.6%	0.050	0.017
20-39	10.6%	0.070	0.015	15.2%	0.076	0.013	23.8%	0.154	0.013	17.0%	0.057	0.009
40-69	17.1%	0.115	0.015	20.1%	0.120	0.016	20.4%	0.138	0.013	19.8%	0.070	0.008
70 +	21.1%	0.151	0.025	21.3%	0.132	0.022	19.0%	0.140	0.027	14.8%	0.055	0.016
Season												
Fall	12.3%	0.092	0.019	17.7%	0.100	0.017	23.6%	0.171	0.018	14.3%	0.056	0.014
Spring	12.4%	0.086	0.018	16.5%	0.117	0.022	24.7%	0.204	0.019	15.8%	0.060	0.009
Summer	12.3%	0.097	0.018	13.9%	0.083	0.017	24.8%	0.244	0.022	19.0%	0.092	0.014
Winter	11.9%	0.076	0.014	19.2%	0.160	0.022	23.2%	0.205	0.020	14.3%	0.044	0.010
Urbanization												
Central City	10.8%	0.073	0.015	15.5%	0.111	0.019	22.4%	0.182	0.017	15.1%	0.061	0.011
Nonmetropolitan	13.7%	0.102	0.016	14.4%	0.095	0.017	27.6%	0.255	0.020	15.1%	0.071	0.013
Suburban	12.4%	0.091	0.014	19.2%	0.127	0.015	23.1%	0.198	0.015	16.7%	0.060	0.008
Race												
Asian	27.5%	0.400	0.100	28.2%	0.177	0.101	14.1%	0.134	0.080	16.1%	0.065	0.036
Black	13.9%	0.129	0.029	7.0%	0.066	0.036	24.6%	0.226	0.028	7.8%	0.040	0.021
Native American	4.7%	0.037	0.068	11.1%	0.097	0.075	30.4%	0.373	0.099	6.4%	0.037	0.042
Other/NA	6.0%	0.041	0.044	12.9%	0.104	0.063	16.9%	0.160	0.065	10.9%	0.038	0.029
White	12.1%	0.080	0.009	18.6%	0.122	0.011	24.3%	0.204	0.011	17.5%	0.067	0.007
Region												
Midwest	10.1%	0.065	0.016	16.2%	0.100	0.018	26.8%	0.242	0.020	15.1%	0.074	0.014
Northeast	11.6%	0.083	0.022	19.0%	0.151	0.027	23.3%	0.208	0.026	18.9%	0.097	0.018
South	14.4%	0.106	0.015	12.4%	0.074	0.015	24.9%	0.219	0.016	13.8%	0.042	0.007
West	11.8%	0.088	0.016	23.3%	0.166	0.021	20.1%	0.138	0.018	17.2%	0.050	0.011

Table 9-5. Intake of Individual Fruits and Vegetables (g/kg-day) (continued)

Population Group	Lettuce Percent Consuming	Lettuce Mean	Lettuce SE	Lima Beans Percent Consuming	Lima Beans Mean	Lima Beans SE	Okra Percent Consuming	Okra Mean	Okra SE	Onions Percent Consuming	Onions Mean	Onions SE
Total	41.3%	0.224	0.006	0.9%	0.006	0.007	1.3%	0.009	0.007	17.4%	0.040	0.003
Age												
< 01	6.8%	0.025	0.026	0.5%	0.005	0.055	0.5%	0.003	0.040	1.9%	0.004	0.022
01-02	18.2%	0.116	0.039	0.4%	0.006	0.069	0.2%	0.004	0.068	6.4%	0.012	0.017
03-05	29.4%	0.191	0.031	0.0%	0	0	0.7%	0.013	0.046	8.0%	0.023	0.016
06-11	36.3%	0.247	0.027	0.3%	0.002	0.017	0.3%	0.005	0.028	9.7%	0.033	0.015
12-19	40.4%	0.187	0.014	0.5%	0.003	0.019	1.4%	0.011	0.027	12.2%	0.030	0.010
20-39	44.4%	0.231	0.010	0.7%	0.005	0.012	1.0%	0.008	0.016	20.5%	0.040	0.005
40-69	51.0%	0.264	0.010	1.5%	0.010	0.013	1.8%	0.008	0.010	24.0%	0.054	0.005
70 +	37.4%	0.203	0.017	1.9%	0.008	0.019	2.7%	0.015	0.021	16.5%	0.043	0.012
Season												
Fall	38.1%	0.175	0.010	0.8%	0.004	0.010	0.9%	0.004	0.009	16.3%	0.045	0.007
Spring	43.5%	0.259	0.011	1.0%	0.008	0.015	0.8%	0.009	0.020	19.7%	0.040	0.005
Summer	42.3%	0.218	0.012	0.9%	0.006	0.014	2.2%	0.016	0.015	18.7%	0.040	0.005
Winter	41.5%	0.243	0.013	1.0%	0.007	0.013	1.3%	0.006	0.012	14.8%	0.033	0.006
Urbanization												
Central City	37.9%	0.196	0.009	0.5%	0.004	0.011	1.0%	0.004	0.008	16.4%	0.043	0.006
Nonmetropolitan	39.9%	0.221	0.012	1.5%	0.015	0.018	1.8%	0.013	0.015	15.7%	0.033	0.005
Suburban	44.6%	0.242	0.009	0.9%	0.004	0.007	1.2%	0.010	0.012	19.1%	0.041	0.004
Race												
Asian	40.3%	0.231	0.050	0.0%	0	0	4.7%	0.084	0.074	20.8%	0.090	0.042
Black	27.1%	0.134	0.014	0.9%	0.006	0.021	2.1%	0.024	0.029	9.6%	0.034	0.014
Native American	42.7%	0.146	0.034	0.0%	0	0	0.0%	0	0	5.3%	0.018	0.022
Other/NA	41.1%	0.186	0.027	0.0%	0	0	1.7%	0.004	0.023	15.1%	0.057	0.022
White	43.7%	0.239	0.007	1.0%	0.006	0.007	1.1%	0.006	0.007	19.0%	0.039	0.003
Region												
Midwest	36.1%	0.191	0.012	0.4%	0.005	0.019	0.2%	0	0.004	13.8%	0.033	0.006
Northeast	43.9%	0.246	0.014	0.5%	0.003	0.013	0.6%	0.009	0.031	20.6%	0.057	0.009
South	39.3%	0.210	0.009	1.8%	0.011	0.011	3.2%	0.016	0.010	17.2%	0.034	0.004
West	48.7%	0.263	0.013	0.5%	0.002	0.009	0.2%	0.005	0.022	19.2%	0.039	0.006

Table 9-5. Intake of Fruits and Vegetables (g/kg-day) (continued)

Population Group	n	Other Berries Percent Consuming	Other Berries Mean	Other Berries SE	Peaches Percent Consuming	Peaches Mean	Peaches SE	Pears Percent Consuming	Pears Mean	Pears SE	Peas Percent Consuming	Peas Mean	Peas SE
Total		2.5%	0.029	0.017	8.6%	0.131	0.019	4.8%	0.098	0.036	12.8%	0.095	0.009
Age													
< 01		0.9%	0.092	0.369	14.2%	0.855	0.268	12.3%	1.286	0.598	13.7%	0.294	0.142
01-02		1.3%	0.053	0.248	8.9%	0.286	0.158	2.7%	0.105	0.243	13.6%	0.174	0.083
03-05		2.2%	0.039	0.073	10.0%	0.283	0.121	4.5%	0.144	0.141	12.9%	0.199	0.077
06-11		1.4%	0.014	0.056	13.8%	0.250	0.063	7.8%	0.147	0.057	13.2%	0.120	0.029
12-19		0.8%	0.011	0.029	6.9%	0.084	0.037	3.4%	0.025	0.027	8.4%	0.053	0.021
20-39		2.3%	0.024	0.030	4.2%	0.037	0.019	2.4%	0.026	0.019	10.9%	0.067	0.013
40-69		3.2%	0.031	0.023	8.7%	0.090	0.021	5.2%	0.062	0.022	14.8%	0.084	0.011
70 +		5.1%	0.049	0.040	16.1%	0.161	0.033	7.8%	0.087	0.037	16.4%	0.117	0.024
Season													
Fall		2.6%	0.024	0.023	6.4%	0.113	0.043	5.5%	0.159	0.107	13.2%	0.120	0.023
Spring		1.9%	0.019	0.024	8.4%	0.107	0.037	4.3%	0.071	0.041	12.6%	0.077	0.015
Summer		3.4%	0.032	0.027	12.5%	0.166	0.033	4.2%	0.076	0.066	11.2%	0.074	0.019
Winter		2.0%	0.042	0.058	7.4%	0.136	0.041	5.1%	0.088	0.039	14.1%	0.111	0.017
Urbanization													
Central City		2.9%	0.033	0.030	7.3%	0.121	0.035	4.5%	0.120	0.091	11.7%	0.085	0.018
Nonmetropolitan		1.6%	0.016	0.019	9.8%	0.156	0.034	5.4%	0.083	0.033	14.5%	0.113	0.020
Suburban		2.7%	0.033	0.028	8.8%	0.125	0.029	4.6%	0.092	0.050	12.5%	0.094	0.014
Race													
Asian		2.7%	0.014	0.057	6.7%	0.202	0.235	2.7%	0.053	0.151	8.1%	0.047	0.071
Black		0.9%	0.008	0.034	5.6%	0.111	0.053	2.9%	0.066	0.056	17.0%	0.143	0.032
Native American		2.3%	0.072	0.165	9.9%	0.192	0.158	1.2%	0.003	0.053	2.9%	0.007	0.035
Other/NA		0.9%	0.015	0.069	4.3%	0.118	0.145	5.1%	0.063	0.089	6.9%	0.037	0.058
White		2.8%	0.033	0.019	9.3%	0.132	0.021	5.2%	0.106	0.042	12.5%	0.092	0.010
Region													
Midwest		2.3%	0.022	0.020	9.6%	0.155	0.040	6.0%	0.121	0.054	10.9%	0.071	0.014
Northeast		3.2%	0.023	0.024	9.0%	0.132	0.048	5.7%	0.108	0.064	12.5%	0.101	0.026
South		1.7%	0.030	0.037	7.9%	0.113	0.027	3.6%	0.051	0.023	16.2%	0.126	0.017
West		3.3%	0.043	0.045	8.3%	0.131	0.042	4.5%	0.142	0.142	9.5%	0.067	0.018

Table 9-5. Intake of Individual Fruits and Vegetables (g/kg-day) (continued)

	Peppers			Pumpkins			Snap Beans			Strawberris		
Population Group	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE
Total	6.5%	0.022	0.005	1.0%	0.026	0.032	21.5%	0.146	0.008	3.4%	0.039	0.019
Age												
< 01	0.7%	0.003	0.025	5.2%	0.497	0.363	16.7%	0.439	0.154	0.7%	0.018	0.154
01-02	2.4%	0.011	0.031	0.4%	0.030	0.253	24.9%	0.383	0.070	1.6%	0.155	0.598
03-05	3.0%	0.014	0.032	0.7%	0.018	0.148	25.0%	0.274	0.048	3.2%	0.045	0.080
06-11	4.7%	0.019	0.016	0.4%	0.012	0.118	25.6%	0.183	0.024	3.3%	0.052	0.058
12-19	5.3%	0.017	0.014	0.2%	0	0.007	18.3%	0.112	0.018	2.3%	0.016	0.028
20-39	7.9%	0.026	0.009	0.6%	0.007	0.026	19.0%	0.096	0.010	2.7%	0.028	0.020
40-69	8.6%	0.027	0.008	1.2%	0.011	0.018	22.3%	0.124	0.011	4.5%	0.042	0.020
70 +	4.7%	0.010	0.008	1.7%	0.034	0.053	25.5%	0.149	0.019	5.8%	0.050	0.040
Season												
Fall	6.0%	0.023	0.009	1.9%	0.043	0.056	21.5%	0.164	0.018	1.3%	0.008	0.017
Spring	7.3%	0.021	0.009	0.6%	0.034	0.105	18.9%	0.109	0.013	7.7%	0.105	0.045
Summer	7.9%	0.023	0.009	0.4%	0.012	0.064	22.3%	0.147	0.016	2.2%	0.030	0.032
Winter	4.7%	0.019	0.010	1.0%	0.015	0.037	23.7%	0.163	0.017	2.5%	0.013	0.015
Urbanization												
Central City	6.5%	0.023	0.009	1.1%	0.035	0.068	20.2%	0.133	0.015	2.8%	0.028	0.020
Nonmetropolitan	6.0%	0.017	0.006	0.5%	0.015	0.068	22.3%	0.141	0.013	3.8%	0.052	0.029
Suburban	6.8%	0.023	0.007	1.3%	0.025	0.041	22.0%	0.156	0.013	3.6%	0.040	0.035
Race												
Asian	8.1%	0.102	0.112	0.7%	0.005	0.057	13.4%	0.059	0.050	3.4%	0.395	1.152
Black	3.6%	0.005	0.007	0.3%	0.037	0.238	24.1%	0.188	0.022	1.5%	0.031	0.056
Native American	5.3%	0.015	0.031	0.0%	0	0	21.1%	0.119	0.048	1.8%	0.023	0.120
Other/NA	11.1%	0.037	0.024	0.9%	0.024	0.208	15.1%	0.168	0.073	1.4%	0.007	0.042
White	6.8%	0.022	0.005	1.2%	0.025	0.030	21.5%	0.140	0.009	3.9%	0.037	0.013
Region												
Midwest	4.7%	0.016	0.011	1.2%	0.027	0.050	22.4%	0.146	0.014	4.8%	0.051	0.025
Northeast	9.0%	0.036	0.012	1.4%	0.061	0.106	19.7%	0.131	0.020	3.3%	0.059	0.079
South	5.8%	0.015	0.006	0.5%	0.002	0.026	24.3%	0.177	0.014	2.6%	0.025	0.019
West	7.6%	0.025	0.010	1.3%	0.030	0.060	17.5%	0.107	0.019	3.3%	0.028	0.025

Table 9-5. Intake of Individual Fruits and Vegetables (g/kg-day) (continued)

Population Group	Tomatoes			White Potatoes		
	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE
Total	91.8%	0.876	0.010	87.6%	1.093	0.013
Age						
< 01	64.2%	1.116	0.094	59.9%	1.102	0.128
01-02	93.8%	1.838	0.103	84.2%	2.228	0.113
03-05	94.9%	1.700	0.072	88.1%	1.817	0.086
06-11	95.2%	1.160	0.032	90.5%	1.702	0.058
12-19	95.5%	0.852	0.022	90.1%	1.238	0.042
20-39	94.7%	0.791	0.013	88.6%	0.897	0.018
40-69	90.6%	0.673	0.013	88.1%	0.882	0.018
70 +	87.2%	0.689	0.027	88.9%	0.865	0.031
Season						
Fall	92.5%	0.907	0.021	88.9%	1.169	0.027
Spring	90.6%	0.808	0.018	86.3%	1.036	0.024
Summer	92.4%	0.946	0.019	86.5%	1.001	0.029
Winter	91.9%	0.844	0.018	88.7%	1.167	0.024
Urbanization						
Central City	91.5%	0.827	0.017	84.7%	1.017	0.025
Nonmetropolitan	90.7%	0.827	0.018	89.4%	1.211	0.027
Suburban	92.8%	0.931	0.015	88.5%	1.087	0.019
Race						
Asian	90.6%	1.147	0.110	77.2%	0.446	0.062
Black	87.4%	0.713	0.027	83.3%	1.202	0.047
Native American	84.2%	0.890	0.073	85.4%	1.735	0.134
Other/NA	91.4%	1.004	0.049	77.1%	1.036	0.080
White	92.8%	0.892	0.011	88.9%	1.082	0.014
Region						
Midwest	92.2%	0.814	0.019	89.2%	1.246	0.029
Northeast	93.0%	0.988	0.024	86.6%	1.090	0.030
South	90.7%	0.831	0.016	88.5%	1.074	0.021
West	92.3%	0.914	0.021	85.1%	0.946	0.026

NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analyses of the 1989/91 CSFII

Table 9-6. Intake of USDA Categories of Fruits and Vegetables (g/kg-day)

	Dark Green Vegetables			Deep Yellow Vegetables			Citrus Fruits			Other Fruits			Other Vegetables		
Population Group	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE
Total	19.1%	0.180	0.012	20.0%	0.147	0.010	38.0%	1.236	0.039	57.7%	2.141	0.063	83.1%	1.316	0.016
Age															
< 01	7.5%	0.180	0.177	10.1%	0.178	0.157	24.8%	1.929	0.586	61.6%	12.855	1.284	41.7%	1.346	0.200
01-02	12.4%	0.364	0.137	14.4%	0.281	0.109	43.6%	4.237	0.459	66.4%	7.599	0.498	73.6%	2.077	0.136
03-05	14.8%	0.390	0.119	16.3%	0.177	0.063	41.0%	2.596	0.267	70.0%	5.826	0.348	78.9%	1.979	0.102
06-11	13.3%	0.150	0.044	19.1%	0.185	0.043	40.5%	1.805	0.138	70.1%	3.242	0.126	83.2%	1.534	0.062
12-19	14.3%	0.112	0.030	14.0%	0.080	0.020	37.0%	1.130	0.085	47.3%	1.053	0.070	81.0%	0.950	0.035
20-39	18.8%	0.137	0.016	17.5%	0.100	0.015	33.4%	0.903	0.049	44.9%	0.972	0.042	84.1%	1.081	0.022
40-69	24.4%	0.187	0.016	24.8%	0.164	0.017	39.9%	0.864	0.045	60.9%	1.255	0.038	88.3%	1.374	0.026
70 +	24.6%	0.255	0.034	29.4%	0.245	0.028	46.8%	1.155	0.069	76.1%	1.827	0.067	87.7%	1.615	0.046
Season															
Fall	19.6%	0.169	0.023	22.7%	0.156	0.020	38.3%	1.211	0.074	57.6%	2.354	0.171	82.5%	1.276	0.032
Spring	21.0%	0.187	0.020	19.7%	0.144	0.023	38.4%	1.225	0.072	56.4%	2.024	0.102	83.3%	1.297	0.030
Summer	15.4%	0.182	0.029	15.6%	0.094	0.017	33.8%	1.136	0.093	60.8%	2.245	0.112	83.1%	1.332	0.032
Winter	20.0%	0.180	0.024	21.9%	0.192	0.023	41.3%	1.371	0.073	56.0%	1.943	0.106	83.4%	1.361	0.031
Urbanization															
Central City	20.5%	0.197	0.021	18.6%	0.133	0.019	39.8%	1.187	0.072	55.3%	2.090	0.100	81.4%	1.245	0.027
Nonmetropolitan	16.0%	0.133	0.020	18.4%	0.138	0.021	34.2%	1.153	0.074	57.8%	1.954	0.100	83.2%	1.407	0.033
Suburban	19.9%	0.190	0.019	22.0%	0.160	0.016	39.1%	1.306	0.058	59.2%	2.262	0.110	84.1%	1.319	0.023
Race															
Asian	30.9%	0.327	0.127	29.5%	0.221	0.118	51.0%	2.479	0.453	69.8%	3.360	0.547	85.2%	2.228	0.205
Black	25.9%	0.318	0.039	12.5%	0.104	0.029	40.1%	1.474	0.135	46.2%	1.806	0.156	78.1%	1.232	0.044
Native American	9.4%	0.126	0.092	10.5%	0.081	0.060	33.3%	0.945	0.219	50.9%	2.375	0.431	75.4%	1.077	0.107
Other/NA	15.1%	0.224	0.087	13.4%	0.106	0.071	40.3%	1.439	0.229	52.0%	2.589	0.452	76.3%	1.116	0.104
White	18.1%	0.156	0.012	21.6%	0.154	0.011	37.4%	1.178	0.041	59.8%	2.154	0.071	84.2%	1.326	0.017
Region															
Midwest	12.6%	0.125	0.026	18.7%	0.128	0.020	35.5%	1.099	0.077	59.8%	2.137	0.108	81.2%	1.186	0.029
Northeast	21.1%	0.185	0.026	22.1%	0.175	0.026	45.6%	1.430	0.079	60.5%	2.235	0.132	84.5%	1.445	0.040
South	20.5%	0.206	0.021	16.8%	0.119	0.018	33.5%	1.090	0.067	50.3%	1.927	0.095	83.2%	1.346	0.026
West	22.6%	0.195	0.022	25.2%	0.187	0.021	41.8%	1.449	0.092	65.0%	2.414	0.182	83.8%	1.293	0.033

NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analyses of the 1989/91 CSFII

Table 9-7. Intake of Exposed, Protected, and Rott Fruits and Vegetables (g/kg-day)

	Exposed Fruits			Protected Fruits			Exposed Vegetables			Protected Vegetables			Root Vegetables		
Population Group	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE
Total	44.1%	1.435	0.062	52.9%	1.692	0.037	84.9%	1.490	0.016	34.0%	0.332	0.012	80.7%	1.245	0.015
Age															
< 01	54.7%	9.224	1.247	38.9%	3.097	0.528	42.7%	1.208	0.170	30.9%	1.144	0.192	52.4%	1.857	0.204
01-02	55.3%	5.682	0.486	56.7%	5.518	0.455	78.0%	2.268	0.145	41.6%	0.794	0.104	76.2%	2.398	0.129
03-05	56.9%	4.324	0.344	57.0%	3.443	0.235	83.6%	2.245	0.119	39.8%	0.703	0.081	77.9%	1.914	0.096
06-11	58.8%	2.316	0.120	56.2%	2.339	0.125	84.7%	1.606	0.059	44.3%	0.500	0.035	84.4%	1.850	0.065
12-19	36.4%	0.682	0.065	47.7%	1.401	0.081	83.6%	1.181	0.040	30.1%	0.229	0.025	81.4%	1.290	0.045
20-39	32.7%	0.596	0.038	45.4%	1.188	0.047	86.3%	1.300	0.025	31.6%	0.233	0.015	81.6%	0.988	0.020
40-69	44.3%	0.716	0.031	57.3%	1.284	0.043	89.9%	1.568	0.026	32.4%	0.239	0.014	82.8%	1.059	0.021
70 +	57.7%	1.032	0.058	67.5%	1.780	0.072	86.4%	1.603	0.044	34.6%	0.303	0.028	80.6%	1.109	0.040
Season															
Fall	45.5%	1.753	0.179	50.2%	1.539	0.071	82.8%	1.383	0.033	34.1%	0.336	0.025	80.6%	1.324	0.032
Spring	42.6%	1.184	0.078	53.9%	1.750	0.072	85.0%	1.475	0.031	34.8%	0.320	0.024	80.5%	1.204	0.029
Summer	45.3%	1.440	0.113	54.1%	1.754	0.082	87.1%	1.634	0.033	32.5%	0.334	0.024	80.3%	1.102	0.031
Winter	43.0%	1.362	0.097	53.7%	1.727	0.071	84.9%	1.468	0.033	34.4%	0.337	0.022	81.5%	1.348	0.029
Urbanization															
Central City	42.4%	1.322	0.088	53.3%	1.632	0.069	83.6%	1.413	0.029	31.7%	0.303	0.022	77.6%	1.167	0.029
Nonmetropolitan	44.0%	1.335	0.097	49.4%	1.550	0.069	85.8%	1.550	0.031	37.9%	0.396	0.024	82.3%	1.330	0.030
Suburban	45.3%	1.553	0.112	54.7%	1.797	0.056	85.2%	1.511	0.025	33.1%	0.320	0.018	81.9%	1.254	0.023
Race															
Asian	52.3%	2.118	0.541	69.8%	3.279	0.429	83.2%	2.133	0.195	16.1%	0.166	0.081	55.0%	0.743	0.146
Black	34.6%	1.132	0.149	49.6%	1.861	0.126	81.8%	1.472	0.051	37.3%	0.411	0.038	73.8%	1.309	0.052
Native American	35.7%	0.939	0.316	46.8%	2.019	0.330	75.4%	1.501	0.141	32.7%	0.380	0.095	78.9%	1.791	0.137
Other/NA	34.0%	1.614	0.408	51.7%	2.014	0.263	85.4%	1.682	0.092	22.9%	0.221	0.074	65.4%	1.239	0.110
White	46.1%	1.468	0.070	53.4%	1.629	0.039	85.6%	1.476	0.017	34.1%	0.326	0.013	82.9%	1.237	0.016
Region															
Midwest	47.3%	1.422	0.091	49.5%	1.501	0.072	80.9%	1.215	0.029	35.8%	0.344	0.022	82.2%	1.361	0.033
Northeast	47.3%	1.518	0.118	59.4%	1.887	0.080	84.7%	1.561	0.041	32.4%	0.369	0.036	80.2%	1.304	0.037
South	36.9%	1.271	0.092	47.6%	1.560	0.064	86.7%	1.609	0.027	36.8%	0.358	0.019	81.2%	1.183	0.024
West	49.4%	1.643	0.198	60.1%	1.947	0.084	86.6%	1.546	0.035	28.4%	0.236	0.022	78.5%	1.150	0.032

NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analyses of the 1989/91 CSFII

Table 9-8. Quantity (as consumed) of Fruits and Vegetables Consumed Per Eating Occasion and the Percentage of Individuals Using These Foods in 3 Days

Food category	% Indiv. using food in 3 days	Quantity consumed per eating occasion (g)		Consumers-only Quantity consumed per eating occasion at specified percentiles (g)[a]						
		Average	Standard Deviation	5	25	50	75	90	95	99
Raw vegetables										
White potatoes	74.4	125	90	29	63	105	170	235	280	426
Cabbage and coleslaw	9.7	68	45	15	40	60	90	120	120	240
Carrots	5	43	40	4	13	31	55	100	122	183
Cucumbers	5.6	80	76	8	24	70	110	158	220	316
Lettuce and tossed salad	50.7	65	59	10	20	55	93	140	186	270
Mature onions	8.5	31	33	3	17	18	36	57	72	180
Tomatoes	27.8	81	55	30	45	62	113	123	182	246
Cooked vegetables									190	350
Broccoli	6.2	112	68	30	78	90	155	185	300	450
Cabbage	4.7	128	83	28	75	145	150	225	155	276
Carrots	9.8	70	59	19	46	75	92	150	170	330
Corn, whole kernel	23.9	95	56	21	65	83	123	170	219	350
Lima beans	2.8	110	75	21	67	88	170	175	187	374
Mixed vegetables	3.4	117	69	28	91	94	182	187	350	350
Cowpeas, field peas, black-	2.9	131	88	22	88	88	175	196	170	330
eyed peas	18.3	90	57	20	43	85	85	170	205	380
Green peas	4.5	121	70	24	78	103	185	205	140	280
Spinach	27.3	86	54	18	67	70	135	140	352	430
String beans	2.8	145	98	27	105	108	215	215	238	450
Summer squash	4.1	136	87	38	86	114	185	225	363	486
Sweet potatoes	3.9	91	122	91	122	182	243	243	130	222
Tomato juice	9.2	45	45	7	16	30	65	90		
Cucumber pickles										
Fruits										
Grapefruit	4.7	159	58	106	134	134	165	268	268	330
Grapefruit juice	3.6	202	99	95	125	186	247	250	375	500
Oranges	9	146	57	73	145	145	145	180	228	360
Orange juice	35.5	190	84	95	125	187	249	249	311	498
Apples	18.2	141	49	69	138	138	138	212	212	276
Applesauce, cooked apples	9.8	134	86	28	64	128	130	255	155	488
Apple juice	3.8	191	101	63	124	186	248	248	372	496
Cantaloupe	3.3	171	91	61	136	136	272	272	272	529
Raw peaches	4.5	160	75	76	152	152	152	304	304	456
Raw pears	3.1	163	69	82	164	164	164	164	328	328
Raw strawberries	2.1	100	58	37	75	75	149	149	180	298

[a] Percentiles are cumulative; for example, 50 percent of people eat 105 g white potatoes per day or less.
Source: Pao et al., 1982.

Table 9-9. Mean Per Capita Intake Rates (as consumed) for Fruits and Vegetables Based on All Sex/Age/Demographic Subgroups

Raw Agricultural Commodity[a]	Average Consumption (Grams/Kg Body Weight-Day)	Standard Error
Alfalfa Sprouts	0.0001393	0.0000319
Apples-Dried	0.0002064	0.0000566
Apples-Fresh	0.4567290	0.0142203
Apples-Juice	0.2216490	0.0142069
Apricots-Dried	0.0004040	0.0001457
Apricots-Fresh	0.0336893	0.0022029
Artichokes-Globe	0.0032120	0.0007696
Artichokes-Jerusalem	0.0000010	*
Asparagus	0.0131098	0.0010290
Avocados	0.0125370	0.0020182
Bamboo Shoots	0.0001464	0.0000505
Bananas-Dried	0.0004489	0.0001232
Bananas-Fresh	0.2240382	0.0088206
Bananas-Unspecified	0.0032970	0.0004938
Beans-Dry-Blackeye Peas (cowpeas)	0.0024735	0.0005469
Beans-Dry-Broad Beans (Mature Seed)	0.0000000	*
Beans-Dry-Garbanzo (Chick Pea)	0.0005258	0.0001590
Beans-Dry-Great Northern	0.0000010	*
Beans-Dry-Hyacinth (Mature Seeds)	0.0000000	*
Beans-Dry-Kidney	0.0136313	0.0045628
Beans-Dry-Lima	0.0079892	0.0016493
Beans-Dry-Navy (Pea)	0.0374073	0.0023595
Beans-Dry-Other	0.0398251	0.0023773
Beans-Dry-Pigeon Beans	0.0000357	0.0000357
Beans-Dry-Pinto	0.0363498	0.0048479
Beans-Succulent-Broad Beans (Immature Seed)	0.0000000	*
Beans-Succulent-Green	0.2000500	0.0062554
Beans-Succulent-Hyacinth (Young Pods)	0.0000000	*
Beans-Succulent-Lima	0.0256648	0.0021327
Beans-Succulent-Other	0.0263838	0.0042782
Beans-Succulent-Yellow, Wax	0.0054634	0.0009518
Beans-Unspecified	0.0052345	0.0012082

Table 9-9. Mean Per Capita Intake Rates (as consumed) for Fruits and Vegetables Based on All Sex/Age/Demographic Subgroups

Raw Agricultural Commodity[a]	Average Consumption (Grams/Kg Body Weight-Day)	Standard Error
Beets-Roots	0.0216142	0.0014187
Beets-Tops (Greens)	0.0008287	0.0003755
Bitter Melon	0.0000232	0.0000233
Blackberries	0.0064268	0.0007316
Blueberries	0.0090474	0.0008951
Boysenberries	0.0007313	0.0006284
Bread Nuts	0.0000010	*
Bread Fruit	0.0000737	0.0000590
Broccoli	0.0491295	0.0032966
Brussel Sprouts	0.0068480	0.0009061
Cabbage-Chinese/Celery, Inc. Bok Choy	0.0045632	0.0020966
Cabbage-Green and Red	0.0936402	0.0039046
Cactus Pads	0.0000010	*
Cantaloupes	0.0444220	0.0029515
Carambola	0.0000010	*
Carob	0.0000913	0.0000474
Carrots	0.1734794	0.0041640
Casabas	0.0007703	0.0003057
Cassava (Yuca Blanca)	0.0002095	0.00001574
Cauliflower	0.0158368	0.0011522
Celery	0.0609611	0.0014495
Cherimoya	0.0000010	*
Cherries-Dried	0.0000010	*
Cherries-Fresh	0.0321754	0.0024966
Cherries-Juice	0.0034080	0.0009078
Chicory (French or Belgian Endive)	0.0006707	0.0001465
Chili Peppers	0.0000000	*
Chives	0.0000193	0.0000070
Citrus Citron	0.0001573	0.0000324
Coconut-Copra	0.0012860	0.0000927
Coconut-Fresh	0.0001927	0.0000684
Coconut-Water	0.0000005	0.0000005

Table 9-9. Mean Per Capita Intake Rates (as consumed) for Fruits and Vegetables Based on All Sex/Age/Demographic Subgroups

Raw Agricultural Commodity[a]	Average Consumption (Grams/Kg Body Weight-Day)	Standard Error
Collards	0.0188966	0.0032628
Corn, Pop	0.0067714	0.0003348
Corn, Sweet	0.2367071	0.0062226
Crabapples	0.0003740	*
Cranberries	0.0150137	0.0006153
Cranberries-Juice	0.0170794	0.0022223
Crenshaws	0.0000010	*
Cress, Upland	0.0000010	*
Cress, Garden, Field	0.0000000	*
Cucumbers	0.0720821	0.0034389
Currants	0.0005462	0.0000892
Dandelion	0.0005039	0.0002225
Dates	0.0006662	0.0001498
Dewberries	0.0023430	*
Eggplant	0.0061858	0.0007645
Elderberries	0.0001364	0.0001365
Endive, Curley and Escarole	0.0011851	0.0001929
Fennel	0.0000000	*
Figs	0.0027847	0.0005254
Garlic	0.0007621	0.0000230
Genip (Spanish Lime)	0.0000010	*
Ginkgo Nuts	0.0000010	*
Gooseberries	0.0003953	0.0001341
Grapefruit-Juice	0.0773585	0.0053846
Grapefruit-Pulp	0.0684644	0.0032321
Grapes-Fresh	0.0437931	0.0023071
Grapes-Juice	0.0900960	0.0058627
Grapes-Leaves	0.0000119	0.0000887
Grapes-Raisins	0.0169730	0.0009221
Groundcherries (Poha or Cape-Gooseberries)	0.0000000	*
Guava	0.0000945	0.0000558
Honeydew Melons	0.0183628	0.0042879

Table 9-9. Mean Per Capita Intake Rates (as consumed) for Fruits and Vegetables Based on All Sex/Age/Demographic Subgroups

Raw Agricultural Commodity[a]	Average Consumption (Grams/Kg Body Weight-Day)	Standard Error
Huckleberries (Gaylussacia)	0.0000010	*
Juneberry	0.0000010	*
Kale	0.0015036	0.0006070
Kiwi	0.0000191	0.0000191
Kohlrabi	0.0002357	0.0001028
Kumquats	0.0000798	0.0000574
Lambsquarter	0.0000481	0.0000481
Leafy Oriental Vegetables	0.0000010	*
Leeks	0.0000388	0.0000221
Lemons-Juice	0.0189564	0.0009004
Lemons-Peel	0.0002570	0.0001082
Lemons-Pulp	0.0002149	0.0000378
Lemons-Unspecified	0.0020695	0.0003048
Lentiles-Split	0.0000079	0.0000064
Lentiles-Whole	0.0012022	0.0002351
Lettuce-Head Varieties	0.2122803	0.0059226
Lettuce-Leafy Varieties	0.0044328	0.0003840
Lettuce-Unspecified	0.0092008	0.0004328
Limes-Juice	0.0032895	0.0005473
Limes-Pulp	0.0000941	0.0000344
Limes-Unspecified	0.0000010	*
Loganberries	0.0002040	*
Logan Fruit	0.0000010	*
Loquats	0.0000000	*
Lychee-Dried	0.0000010	*
Lychees (Litchi)	0.0000010	*
Maney (Mammee Apple)	0.0000010	*
Mangoes	0.0005539	0.0002121
Mulberries	0.0000010	*
Mung Beans (Sprouts)	0.0066521	0.0006462
Mushrooms	0.0213881	0.0009651
Mustard Greens	0.0145284	0.0024053

Table 9-9. Mean Per Capita Intake Rates (as consumed) for Fruits and Vegetables Based on All Sex/Age/Demographic Subgroups

Raw Agricultural Commodity[a]	Average Consumption (Grams/Kg Body Weight-Day)	Standard Error
Nectarines	0.0129663	0.0013460
Okra	0.0146352	0.0017782
Olives	0.0031757	0.0002457
Onions-Dehydrated or Dried	0.0001192	0.0000456
Onions-Dry-Bulb (Cipollini)	0.1060612	0.0021564
Onions-Green	0.0019556	0.0001848
Oranges-Juice	1.0947265	0.0283937
Oranges-Peel	0.0001358	0.0000085
Oranges-Pulp	0.1503524	0.0092049
Papayas-Dried	0.0009598	0.0000520
Papayas-Fresh	0.0013389	0.0005055
Papayas-Juice	0.0030536	0.0012795
Parsley Roots	0.0000010	*
Parsley	0.0036679	0.0001459
Parsnips	0.0006974	0.0001746
Passion Fruit (Granadilla)	0.0000010	*
Pawpaws	0.0000010	*
Peaches-Dried	0.0000496	0.0000152
Peaches-Fresh	0.2153916	0.0078691
Pears-Dried	0.0000475	0.0000279
Pears-Fresh	0.1224735	0.0050442
Peas (Garden)-Green Immature	0.1719997	0.0067868
Peas (Garden)-Mature Seeds, Dry	0.0017502	0.0002004
Peppers, Sweet, Garden	0.0215525	0.0010091
Peppers-Other	0.0043594	0.0004748
Persimmons	0.0004008	0.0002236
Persian Melons	0.0000010	*
Pimentos	0.0019485	0.0001482
Pineapple-Dried	0.0000248	0.0000195
Pineapple-Fresh, Pulp	0.0308283	0.0017136
Pineapple-Fresh, Juice	0.0371824	0.0026438
Pitanga (Surinam Cherry)	0.0000010	*

Table 9-9. Mean Per Capita Intake Rates (as consumed) for Fruits and Vegetables Based on All Sex/Age/Demographic Subgroups

Raw Agricultural Commodity[a]	Average Consumption (Grams/Kg Body Weight-Day)	Standard Error
Plantains	0.0016370	0.0007074
Plums, Prune-Juice	0.0137548	0.0017904
Plums (Damsons)-Fresh	0.0248626	0.0020953
Plums-Prunes (Dried)	0.0058071	0.0005890
Poke Greens	0.0002957	0.0001475
Pomegranates	0.0000820	0.0000478
Potatoes (White)-Whole	0.3400582	0.0102200
Potatoes (White)-Unspecified	0.0000822	0.0000093
Potatoes (White)-Peeled	0.7842573	0.0184579
Potatoes (White)-Dry	0.0012994	0.0001896
Potatoes (White)-Peel Only	0.0000217	0.0000133
Pumpkin	0.0044182	0.0004354
Quinces	0.0001870	*
Radishes-Roots	0.0015558	0.0001505
Radishes-Tops	0.0000000	*
Raspberries	0.0028661	0.0005845
Rhubarb	0.0037685	0.0006588
Rutabagas-Roots	0.0027949	0.0009720
Rutabagas-Tops	0.0000000	*
Salsify (Oyster Plant)	0.0000028	0.0000028
Shallots	0.0000000	*
Soursop (Annona Muricata)	0.0000010	*
Soybeans-Sprouted Seeds	0.0000000	*
Spinach	0.0435310	0.0030656
Squash-Summer	0.0316479	0.0022956
Squash-Winter	0.0324417	0.0026580
Strawberries	0.0347089	0.0020514
Sugar Apples (Sweetsop)	0.0000010	*
Sweetpotatoes (including Yams)	0.0388326	0.0035926
Swiss Chard	0.0016915	0.0004642
Tangelos	0.0025555	0.0006668
Tangerine-Juice	0.0000839	0.0000567

Table 9-9. Mean Per Capita Intake Rates (as consumed) for Fruits and Vegetables Based on All Sex/Age/Demographic Subgroups

Raw Agricultural Commodity[a]	Average Consumption (Grams/Kg Body Weight-Day)	Standard Error
Tangerines	0.0088441	0.0010948
Tapioca	0.0012199	0.0000951
Taro-Greens	0.0000010	*
Taro-Root	0.0000010	*
Tomatoes-Catsup	0.0420320	0.0015878
Tomatoes-Juice	0.0551351	0.0029515
Tomatoes-Paste	0.0394767	0.0012512
Tomatoes-Puree	0.17012311	0.0054679
Tomatoes-Whole	0.4920164	0.0080927
Towelgourd	0.0000010	*
Turnips-Roots	0.0082392	0.0014045
Turnips-Tops	0.0147111	0.0025845
Water Chestnuts	0.0004060	0.0000682
Watercress	0.0003553	0.0001564
Watermelon	0.0765054	0.0068930
Yambean, Tuber	0.0000422	0.0000402
Yautia, Tannier	0.0000856	0.0000571
Youngberries	0.0003570	*

* Not reported
[a] Consumed in any raw or prepared form
Source: DRES data base.

Table 9-10. Mean Total Fruit Intake (as consumed) in a Day by Sex and Age (1977-1978)[a]

Age (yr)	Per Capita Intake (g/day)	Percent of Population Using Fruit in a Day	Intake (g/day) for Users Only[b]
Males and Females	169	86.8	196
1 and under	146	62.9	231
1-2	134	56.1	239
3-5	152	60.1	253
6-8			
Males	133	50.5	263
9-11	120	51.2	236
12-14	147	47.0	313
15-18	107	39.4	271
19-22	141	46.4	305
23-34	115	44.0	262
35-50	171	62.4	275
51-64	174	62.2	281
65-74	186	62.6	197
75 and over			
Females	148	59.7	247
9-11	120	48.7	247
12-14	126	49.9	251
15-18	133	48.0	278
19-22	122	47.7	255
23-34	133	52.8	252
35-50	171	66.7	256
51-64	179	69.3	259
65-74	189	64.7	292
75 and over			
Males and Females	142	54.2	263
All ages			

[a] Based on USDA Nationwide Food Consumption Survey (1977-1978) data for one day.
[b] Intake for users only was calculated by dividing the per capita intake rate by the fraction of the population using fruit in a day.
Source: USDA, 1980.

Table 9-11. Mean Total Fruit Intake (as consumed) in a Day by Sex and Age (1987-1988)[a]

Age (yr)	Per Capita Intake (g/day)	Percent of Population Using Fruit in 1 Day	Intake (g/day) for Users Only[b]
Males and Females			
5 and under	157	59.2	265
Males			
6-11	182	63.8	285
12-19	158	49.4	320
20 and over	133	46.5	286
Females			
6-11	154	58.3	264
12-19	131	47.1	278
20 and over	140	52.7	266
Males and Females			
All Ages	142	51.4	276

[a] Based on USDA Nationwide Food Consumption Survey (1987-1988) data for one day.
[b] Intake for users only was calculated by dividing the per capita intake rate by the fraction of the population using fruits in a day.
Source: USDA, 1992b.

Table 9-12. Mean Total Vegetable Intake (as consumed) in a Day by Sex and Age (1977-1978)[a]

Age (yr)	Per Capita Intake (g/day)	Percent of Population Using Vegetables in a Day	Intake (g/day) for Users Only[b]
Males and Females			
1 and under	76	62.7	121
1-2	91	78.0	116
3-5	100	79.3	126
6-8	136	84.3	161
Males			
9-11	138	83.5	165
12-14	184	84.5	217
15-18	216	85.9	251
19-22	226	84.7	267
23-34	248	88.5	280
35-50	261	86.8	300
51-64	285	90.3	316
65-74	265	88.5	300
75 and over	264	93.6	281
Females			
9-11	139	83.7	166
12-14	154	84.6	183
15-18	178	83.8	212
19-22	184	81.1	227
23-34	187	84.7	221
35-50	187	84.6	221
51-64	229	89.8	255
65-74	221	87.2	253
75 & over	198	88.1	226
Males and Females			
All Ages	201	85.6	235

[a] Based on USDA Nationwide Food Consumption Survey (1977-1978) data for one day.
[b] Intake for users only was calculated by dividing the per capita intake rate by the fraction of the population using vegetables in a day.
Source: USDA, 1980.

Table 9-13. Mean Total Vegetable Intake (as consumed) in a Day by Sex and Age (1987-1988)[a]

Age (yr)	Per Capita Intake (g/day)	Percent of Population Using Vegetables in 1 Day	Intake (g/day) for Users Only[b]
Males and Females			
5 and under	81	74.0	109
Males			
6-11	129	86.8	149
12-19	173	85.2	203
20 and over	232	85.0	273
Females			
6-11	129	80.6	160
12-19	129	75.8	170
20 and over	183	82.9	221
Males and Females			
All Ages	182	82.6	220

[a] Based on USDA Nationwide Food Consumption Survey (1987-1988) data for one day.
[b] Intake for users only was calculated by dividing the per capita intake rate by the fraction of the population using vegetables in a day.
Source: USDA, 1992b.

Table 9-14. Mean and Standard Error for the Per Capita Daily Intake of Food Class and Subclass by Region (g/day as consumed)

	US population	Northeast	North Central	South	West
Total Produce	282.6 ± 3.5	270.6 ± 6.9	282.4 ± 6.7	280.7 ± 5.6	303.1 ± 8.2
Leafy[a]	39.2 ± 0.8	38.1 ± 1.5	37.1 ± 1.5	38.4 ± 1.2	45.3 ± 1.8
Exposed[b]	86.0 ± 1.5	88.5 ± 3.0	87.8 ± 2.9	76.9 ± 2.4	95.5 ± 3.6
Protected[c]	150.4 ± 2.3	137.2 ± 4.5	150.1 ± 4.3	160.1 ± 3.6	152.5 ± 5.3
Other	7.0 ± 0.3	6.9 ± 0.6	7.3 ± 0.5	5.4 ± 0.4	9.8 ± 0.7
Total Grain	200.0 ± 3.0	203.5 ± 5.8	192.8 ± 5.6	202.2 ± 4.7	202.6 ± 6.9
Breads	147.3 ± 1.4	153.1 ± 2.8	150.9 ± 2.7	143.9 ± 2.3	139.5 ± 3.3
Cereals	29.9 ± 1.3	24.6 ± 2.5	28.7 ± 2.4	34.6 ± 2.0	30.9 ± 3.0
Other	22.9 ± 1.7	25.9 ± 3.3	13.3 ± 3.2	23.7 ± 2.7	32.1 ± 4.0

[a] Produce belonging to this category include: cabbage, cauliflower, broccoli, celery, lettuce, and spinach.

[b] Produce belonging to this category include: apples, pears, berries, cucumber, squash, grapes, peaches, apricots, plums, prunes, string beans, pea pods, and tomatoes.

[c] Produce belonging to this category include: carrots, beets, turnips, parsnips, citrus fruits, sweet corn, legumes (peas, beans, etc.), melons, onion, and potatoes.

NOTE: Northeast = Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania.

North Central = Ohio, Illinois, Indiana, Wisconsin, Michigan, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas.

South = Maryland, Delaware, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Texas, and Oklahoma.

West = Montana, Idaho, Wyoming, Utah, Colorado, New Mexico, Arizona, Nevada, Washington, Oregon, and California.

Source: U.S. EPA, 1984b.

Table 9-15. Mean and Standard Error for the Daily Intake of Food Subclasses Per Capita by Age (g/day as consumed)

Age (years)	Leafy produce[a]	Exposed produce[b]	Protected produce[c]	Other produce	Breads	Cereal	Other Grains
All Ages	39.2 ± 0.8	86.0 ± 1.5	150.4 ± 2.3	7.0 ± 0.3	147.3 ± 1.4	29.9 ± 1.3	22.9 ± 1.7
< 1	3.2 ± 4.9	75.5 ± 9.8	50.8 ± 14.7	25.5 ± 1.8	16.2 ± 9.2	37.9 ± 8.2	1.8 ± 10.9
1-4	9.1 ± 2.4	55.6 ± 4.8	94.5 ± 7.2	5.1 ± 0.9	104.6 ± 4.5	38.4 ± 4.0	14.8 ± 5.4
5-9	20.1 ± 2.0	69.2 ± 4.8	128.9 ± 6.1	4.3 ± 0.8	154.3 ± 3.8	39.5 ± 3.4	22.7 ± 4.5
10-14	26.1 ± 1.9	76.8 ± 3.8	151.7 ± 5.7	8.1 ± 0.7	186.2 ± 3.6	36.4 ± 3.2	25.6 ± 4.2
15-19	31.4 ± 2.0	71.9 ± 4.0	156.6 ± 6.0	6.2 ± 0.7	188.5 ± 3.7	28.8 ± 3.3	27.8 ± 4.4
20-24	35.3 ± 2.6	65.6 ± 5.2	144.5 ± 7.8	5.0 ± 1.0	166.5 ± 4.9	20.2 ± 4.3	25.0 ± 5.8
25-29	41.4 ± 2.7	73.4 ± 5.3	149.8 ± 8.0	7.0 ± 1.0	170.0 ± 5.0	18.2 ± 4.4	26.6 ± 5.9
30-39	44.4 ± 2.1	77.1 ± 4.2	150.5 ± 6.3	6.1 ± 0.8	156.8 ± 3.9	24.7 ± 2.7	23.3 ± 3.6
40-59	51.3 ± 1.6	94.7 ± 3.3	162.9 ± 4.9	6.9 ± 0.6	144.4 ± 3.1	24.7 ± 2.7	23.3 ± 3.6
≥ 60	45.4 ± 1.8	114.2 ± 3.6	163.9 ± 5.5	7.6 ± 0.7	122.1 ± 3.4	42.5 ± 3.0	19.3 ± 4.0

[a] Produce belonging to this category include: cabbage, cauliflower, broccoli, celery, lettuce, and spinach.
[b] Produce belonging to this category include: apples, pears, berries, cucumber, squash, grapes, peaches, apricots, plums, prunes, string beans, pea pods, and tomatoes.
[c] Produce belonging to this category include: carrots, beets, turnips, parsnips, citrus fruits, sweet corn, legumes (peas, beans, etc.), melons, onion, and potatoes.
Source: U.S. EPA, 1984a.

Table 9-16. Consumption of Foods (g dry weight/day) for Different Age Groups and Estimated Lifetime Average Daily Food Intakes for a US Citizen (averaged across sex) Calculated from the FDA Diet Data

	Age (in years)						Estimated[a] lifetime
	(0-1)	(1-5)	(6-13)	(14-19)	(20-44)	(45-70)	
Potatoes	5.67	10.03	14.72	19.40	17.28	14.79	15.60
Leafy Veg.	0.84	0.49	0.85	1.22	2.16	2.65	1.97
Legume Veg.	3.81	4.56	6.51	8.45	9.81	9.50	8.75
Root Veg.	3.04	0.67	1.20	1.73	1.77	1.64	1.60
Garden fruits	0.66	1.67	2.57	3.47	4.75	4.86	4.15
Peanuts	0.34	2.21	2.56	2.91	2.43	1.91	2.25
Mushrooms	0.00	0.01	0.03	0.04	0.14	0.06	0.08
Veg. Oils	27.62	17.69	27.54	37.04	37.20	27.84	31.24

[a] The estimated lifetime dietary intakes were estimated by:

$$\text{Estimated lifetime} = \frac{IR(0\text{-}1) + 5yrs * IR(1\text{-}5) + 8\,yrs * IR(6\text{-}13) + 6\,yrs * IR(14\text{-}19) + 25\,yrs * IR(20\text{-}44) + 25\,yrs * IR(45\text{-}70)}{70\ years}$$

where IR = the intake rate for a specific age group.
Source: U.S. EPA, 1989.

Table 9-17. Mean Daily Intake of Foods (Grams) Based on the Nutrition Canada Dietary Survey[a]

Age (yrs)	Sample Size	Fruit and Fruit Products	Vegetables Not Including Potatoes	Potatoes	Nuts and Legumes
Males and Females					
1-4	1031	258	56	75	6
5-11	1995	312	83	110	13
Males					
12-19	1070	237	94	185	20
20-39	999	244	155	189	15
40-64	1222	194	134	131	15
65+	881	165	118	124	8
Females					
12-19	1162	237	97	115	15
20-39	1347	204	134	99	8
40-64	1500	239	136	79	10
65+	818	208	103	80	5
Pregnant Females					
---	769	301	156	114	15

[a] Report does not specify whether means were calculated per capita or for consumers only. The reported values are consistent with the as consumed intake rates for consumers only reported by USDA (1980).
Source: Canadian Department of National Health and Welfare, n.d.

Table 9-18. Per Capita consumption of Fresh Fruits and Vegetables in 1991[a]

Fresh Fruits		Fresh Vegetables	
Food Item	Per Capita Consumption (g/day)[b]	Food Item	Per Capita Consumption (g/day)[b]
<u>Citrus</u>		Artichokes	0.62
Oranges (includes Temple oranges)	10.2	Asparagus	0.75
Tangerines and Tangelos	1.6	Snap Beans	1.4
Lemons	3.1	Broccoli	3.5
Limes	0.9	Brussel Sprouts	0.4
Grapefruit	7.1	Cabbage	9.5
Total Fresh Citrus	22.9	Carrots	9.0
		Cauliflower	2.2
<u>Noncitrus</u>	21.8	Celery	7.8
Apples	0.1	Sweet Corn	6.6
Apricots	1.7	Cucumber	5.2
Avocados	31.2	Eggplant	0.5
Bananas	0.5	Escarole/Endive	0.3
Cherries	0.4	Garlic	1.6
Cranberries	8.2	Head Lettuce	30.2
Grapes	0.5	Onions	18.4
Kiwi Fruit	1.0	Bell Peppers	5.8
Mangoes	7.6	Radishes	0.6
Peaches & Nectarines	3.7	Spinach	0.9
Pears	2.2	Tomatoes	16.3
Pineapple	0.3	Total Fresh Vegetables	126.1
Papayas	1.7		
Plums and Prunes	4.1		
Strawberries	85.0		
Total Fresh Noncitrus	107.7		
Total Fresh Fruits			

[a] Based on retail-weight equivalent. Includes imports; excludes exports and foods grown in home gardens. Data for 1991 used.
[b] Original data were presented in lbs/yr; data were converted to g/day by multiplying by a factor of 454 g/lb and dividing by 365 days/yr.
Source: USDA, 1993b.

Table 9-19. Mean Moisture Content of Selected Fruits, Vegetables, and Grains Expressed As Percentages of Edible Portions

Food	Moisture Content (Percent) Raw	Cooked	Comments
Fruit			
Apples - dried	31.76	84.13*	sulfured; *without added sugar
Apples -	83.93*	84.46**	*with skin; **without skin
Apples - juice		87.93	canned or bottled
Applesauce		88.35*	*unsweetened
Apricots	86.35	86.62*	*canned juice pack with skin
Apricots - dried	31.09	85.56*	sulfured; *without added sugar
Bananas	74.26		
Blackberries	85.64		
Blueberries	84.61	86.59*	*frozen unsweetened
Boysenberries	85.90		frozen unsweetened
Cantaloupes - unspecified	89.78		
Casabas	91.00		
Cherries - sweet	80.76	84.95*	*canned, juice pack
Crabapples	78.94		
Cranberries	86.54		
Cranberries - juice cocktail	85.00		bottled
Currants (red and white)	83.95		
Elderberries	79.80		
Grapefruit	90.89		
Grapefruit - juice	90.00	90.10*	*canned unsweetened
Grapefruit - unspecified	90.89		pink, red, white
Grapes - fresh	81.30		American type (slip skin)
Grapes - juice	84.12		canned or bottled
Grapes - raisins	15.42		seedless
Honeydew melons	89.66		
Kiwi fruit	83.05		
Kumquats	81.70		
Lemons - juice	90.73	92.46*	*canned or bottled
Lemons - peel	81.60		
Lemons - pulp	88.98		
Limes - juice	90.21	92.52*	*canned or bottled
Limes - unspecified	88.26		
Loganberries	84.61		
Mulberries	87.68		
Nectarines	86.28		
Oranges - unspecified	86.75		all varieties
Peaches	87.66	87.49*	*canned juice pack
Pears - dried	26.69	64.44*	sulfured; *without added sugar
Pears - fresh	83.81	86.47*	*canned juice pack
Pineapple	86.50	83.51*	*canned juice pack
Pineapple - juice		85.53	canned
Plums		85.20	
Quinces	83.80		
Raspberries	86.57		
Strawberries	91.57	89.97*	*frozen unsweetened
Tangerine - juice	88.90	87.00*	*canned sweetened
Tangerines	87.60	89.51*	*canned juice pack
Watermelon	91.51		
Vegetables			
Alfalfa sprouts	91.14		
Artichokes - globe & French	84.38	86.50	boiled, drained
Artichokes - Jerusalem	78.01		

Table 9-19. Mean Moisture Content of Selected Fruits, Vegetables, and Grains Expressed As Percentages of Edible Portions

Food	Moisture Content (Percent) Raw	Cooked	Comments
Asparagus	92.25	92.04	boiled, drained
Bamboo shoots	91.00	95.92	boiled, drained
Beans - dry			
Beans - dry - blackeye peas (cowpeas)	66.80	71.80	boiled, drained
Beans - dry - hyacinth (mature seeds)	87.87	86.90	boiled, drained
Beans - dry - navy (pea)	79.15	76.02	boiled, drained
Beans - dry - pinto	81.30	93.39	boiled, drained
Beans - lima	70.24	67.17	boiled, drained
Beans - snap - Italian - green - yellow	90.27	89.22	boiled, drained
Beets	87.32	90.90	boiled, drained
Beets - tops (greens)	92.15	89.13	boiled, drained
Broccoli	90.69	90.20	boiled, drained
Brussel sprouts	86.00	87.32	boiled, drained
Cabbage - Chinese/celery, including bok choy	95.32	95.55	boiled, drained
Cabbage - red	91.55	93.60	boiled, drained
Cabbage - savoy	91.00	92.00	boiled, drained
Carrots	87.79	87.38	boiled, drained
Cassava (yucca blanca)	68.51		
Cauliflower	92.26	92.50	boiled, drained
Celeriac	88.00	92.30	boiled, drained
Celery	94.70	95.00	boiled, drained
Chili peppers	87.74	92.50*	*canned solids & liquid
Chives	92.00		
Cole slaw	81.50		
Collards	93.90	95.72	boiled, drained
Corn - sweet	75.96	69.57	boiled, drained
Cress - garden - field	89.40	92.50	boiled, drained
Cress - garden	89.40	92.50	boiled, drained
Cucumbers	96.05		
Dandelion - greens	85.60	89.80	boiled, drained
Eggplant	91.93	91.77	boiled, drained
Endive	93.79		
Garlic	58.58		
Kale	84.46	91.20	boiled, drained
Kohlrabi	91.00	90.30	boiled, drained
Lambsquarter	84.30	88.90	boiled, drained
Leeks	83.00	90.80	boiled, drained
Lentils - whole	67.34	68.70	stir-fried
Lettuce - iceberg	95.89		
Lettuce - romaine	94.91		
Mung beans (sprouts)	90.40	93.39	boiled, drained
Mushrooms	91.81	91.08	boiled, drained
Mustard greens	90.80	94.46	boiled, drained
Okra	89.58	89.91	boiled, drained
Onions	90.82	92.24	boiled, drained
Onions - dehydrated or dried	3.93		
Parsley	88.31		
Parsley roots	88.31		
Parsnips	79.53	77.72	boiled, drained
Peas (garden) - mature seeds - dry	88.89	88.91	boiled, drained
Peppers - sweet - garden	92.77	94.70	boiled, drained
Potatoes (white) - peeled	78.96	75.42	baked

Table 9-19. Mean Moisture Content of Selected Fruits, Vegetables, and Grains Expressed As Percentages of Edible Portions

Food	Moisture Content (Percent) Raw	Cooked	Comments
Potatoes (white) - whole	83.29	71.20	baked
Pumpkin	91.60	93.69	boiled, drained
Radishes - roots	94.84		
Rhubarb	93.61	67.79	frozen, cooked with added sugar
Rutabagas - unspecified	89.66	90.10	boiled, drained
Salsify (oyster plant)	77.00	81.00	boiled, drained
Shallots	79.80		
Soybeans - sprouted seeds	69.05	79.45	steamed
Spinach	91.58	91.21	boiled, drained
Squash - summer	93.68	93.70	all varieties; boiled, drained
Squash - winter	88.71	89.01	all varieties; baked
Sweetpotatoes (including yams)	72.84	71.85	baked in skin
Swiss chard	92.66	92.65	boiled, drained
Tapioca - pearl	10.99		dry
Taro - greens	85.66	92.15	steamed
Taro - root	70.64	63.80	
Tomatoes - juice		93.90	canned
Tomatoes - paste		74.06	canned
Tomatoes - puree		87.26	canned
Tomatoes - raw	93.95		
Tomatoes - whole	93.95	92.40	boiled, drained
Towelgourd	93.85	84.29	boiled, drained
Turnips - roots	91.87	93.60	boiled, drained
Turnips - tops	91.07	93.20	boiled, drained
Water chestnuts	73.46		
Yambean - tuber	89.15	87.93	boiled, drained
<u>Grains</u>			
Barley - pearled	10.09	68.80	
Corn - grain - endosperm	10.37		
Corn - grain - bran	3.71		crude
Millet	8.67	71.41	
Oats	8.22		
Rice - rough - white	11.62	68.72	
Rye - rough	10.95		
Rye - flour - medium	9.85		
Sorghum (including milo)	9.20		
Wheat - rough - hard white	9.57		
Wheat - germ	11.12		crude
Wheat - bran	9.89		crude
Wheat - flour - whole grain	10.27		

Source: USDA, 1979-1986.

Table 9-20. Summary of Fruit and Vegetable Intake Studies

Study	Survey Population Used in Calculating Intake	Types of Data Used	Units	Food Items
KEY STUDIES				
EPA Analysis of 1989/91 USDA CSFII data	Per capita data; consumer only data can be calculated	1989/91 CSFII data; Based on 3-day average individual intake rate	g/kg-day; as consumed	Major food groups; individual food items; exposed and protected fruits and vegetables; USDA food categories
Pao et al., 1982	Consumers only serving size data provided	1977/78 NFCS 3-day individual intake data	g; as consumed	Serving sizes for only a limited number of products
RELEVANT STUDIES				
AIHC, 1994	Per Capita	Based on the 1977/78 USDA NFCS data provided in the 1989 version of the Exposure Factors Handbook.	g/day	Distributions for vegetables using @Risk software.
Canadian Department of National Health and Welfare, n.d.	Consumers only?	1970-72 survey based on 24-hour dietary recall	g/day; as consumed?	Fruit and fruit products, vegetables not including potatoes and nuts and legumes
EPA's DRES	Per capita (i.e., consumers and nonconsumers)	1977/78 NFCS 3-day individual intake data	g/kg-day; as consumed	Intake for a wide variety of fruits and vegetables presented; complex food groups were disaggregated
USDA, 1980; 1992b	Per capita and consumer only	1977/78 and 1987/88 NFCS 1-day individual intake data	g/day; as consumed	Total fruits and total vegetables
USDA, 1993	Per capita consumption based on "food disappearance"	Based on food supply and utilization data provided by the National Agricultural Statistics Service (NASS), Customs Service Reports, and trade associations	g/day; as consumed	Various food groups
U.S. EPA/ORP, 1984a; 1984b	Per capita	1977/78 NFCS Individual intake data	g/day; as consumed	Exposed, protected, and leafy produce
U.S. EPA/OST, 1989	Estimated lifetime dietary intake	Based on FDA Total Diet Study Food List which used 1977/78 NFCS data, and NHANES II data	g/day; dry weight	Various food groups; complex foods disaggregated

Table 9-21. Summary of Recommended Values for Per Capita Intake of Fruits and Vegetables and Serving Size

Mean	95th Percentile	Multiple Percentiles	Study
Total Fruit Intake 3.4 g/kg-day	12 g/kg-day	see Table 9-3	EPA Analysis of CSFII 1989-91 Data
Total Vegetable Intake 4.3 g/kg-day	10 g/kg-day	see Table 9-4	EPA Analysis of CSFII 1989-91 Data
Individual Fruit and Vegetables Intake see Table 9-5	see Table 9-5	see Table 9-5	EPA Analysis of CSFII 1989-91 Data
Serving Size see Table 9-8	see Table 9-8	see Table 9-8	Pao et al., 1982

Table 9-22. Confidence in Fruit and Vegetable Intake Recommendations

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	USDA CSFII survey receives high level of peer review. EPA analysis of these data has not been peer reviewed outside the Agency. (Peer review will be conducted as part of the peer review of this Handbook)	Medium (This will become a "high" once the Handbook's peer review is completed)
• Accessibility	CSFII data is publicly available	High
• Reproducibility	Enough information is included to reproduce results	High
• Focus on factor of interest	Analysis is specifically designed to address food intake	High
• Data pertinent to U.S.	Data focuses on the U.S. population	High
• Primary data	This is new analysis of primary data	High
• Currency	Is the most current data publicly available	High
• Adequacy of data collection period	Survey is designed to collect short-term data.	Medium confidence for average values; Low confidence for long term percentile distribution
• Validity of approach	Survey methodology was adequate	High
• Study size	Study size was very large and therefore adequate	High
• Representativeness of the population	The population studied was the U.S. population.	High
• Characterization of variability	Survey was not designed to capture long term day-to-day variability. Short term distributions are provided	Medium
• Lack of bias in study design (high rating is desirable)	Response rate was adequate?	Medium
• Measurement error	No measurements were taken. The study relied on survey data.	N/A
Other Elements		
• Number of studies	1; CSFII is the most recent data publicly available. Therefore, it was the only study classified as key study.	Low
• Agreement between researchers	Although the CSFII was the only study classified as key study, the results are in good agreement with earlier data.	High
Overall Rating	The survey is representative of U.S. population; Although there was only one study considered key, these data are the most recent and are in agreement with earlier data; the approach used to analyzed the data was adequate. However, due to the limitations of the survey design estimation of long-term percentile values (especially the upper percentiles) is uncertain.	High confidence in the average; Low confidence in the long-term upper percentiles

Table 9-23. Confidence in Fruits and Vegetable Serving Size Recommendations

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	USDA NFCS survey receives high level of peer review.	High
• Accessibility	The NFCS data are publicly available	High
• Reproducibility	Methodology is clearly explained	High
• Focus on factor of interest	Analysis is specifically designed to address food intake	High
• Data pertinent to U.S.	Data focuses on the U.S. population	High
• Primary data	The study analyzed primary data	High
• Currency	The data are old (i.e., 1977-78)	Low
• Adequacy of data collection period	Survey is designed to collect short-term data.	Medium
• Validity of approach	Survey methodology was adequate	High
• Study size	Study size was very large and therefore adequate	High
• Representativeness of the population	The population studied was the U.S. population.	High
• Characterization of variability	Survey was not designed to capture long term day-to-day variability. Short term distributions are provided	Medium
• Lack of bias in study design (high rating is desirable)	Response rate was adequate	Medium
• Measurement error	No measurements were taken. The study relied on survey data.	N/A
Other Elements		
• Number of studies	1	Low
• Agreement between researchers	Although serving size data may have been collected in other surveys, they have not been reported in any other study.	Low
Overall Rating	The survey is representative of U.S. population; the approach used to analyzed the data was adequate. However, due to the limitations of the survey design estimation of long-term percentile values (especially the upper percentiles) is uncertain.	Medium

APPENDIX 9A

Calculations Used in the 1989/91 CSFII Analysis to Correct for Mixtures

APPENDIX 9A
Calculations Used in the 1989/91 CSFII Analysis to Correct for Mixtures

Distributions of intake for various food groups were generated for the food/items groups using the USDA 1989/91 CSFII data set as described in Sections 9.2.2. and 11.1.2. However, several of the food categories used did not include meats, dairy products, and vegetables that were eaten as mixtures with other foods. Thus, adjusted intake rates were calculated for food items that were identified by USDA (1995) as comprising a significant portion of grain and meat mixtures. To account for the amount of these foods consumed as mixtures, the mean fractions of total meat or grain mixtures represented by these food items were calculated (Table 9A-1) using Appendix C of USDA (1995). Mean values for all individuals were used to calculate these fractions. These fractions were multiplied by each individual's intake rate for total meat mixtures or grain mixtures to calculate the amount of the individual's food mixture intake that can be categorized into one of the selected food groups. These amounts were then added to the total intakes rates for meats, grains, total vegetables, tomatoes, and white potatoes to calculate an individual's total intake of these food groups, as shown in the example for meats below.

$$IR_{meat-adjusted} = (IR_{gr\ mixtures} * FR_{meat/gr}) + (IR_{mt\ mixtures} * FR_{meat/mt}) + (IR_{meat})$$

where:

$IR_{meat\text{-}adjusted}$	=	adjusted individual intake rate for total meat;
$IR_{gr\ mixtures}$	=	individual intake rate for grain mixtures;
$IR_{mt\ mixtures}$	=	individual intake rate for meat mixtures;
IR_{meat}	=	individual intake rate for meats;
$Fr_{meat/gr}$	=	fraction of grain mixture that is meat; and
$Fr_{meat/mt}$	=	fraction of meat mixture that is meat.

Population distributions for mixture-adjusted intakes were based on adjusted intake rates for the population of interest.

Table 9A-1. Fraction of Grain and Meat Mixture Intake Represented by Various Food Items/Groups

Grain Mixtures	
total vegetables	0.2360
tomatoes	0.1685
white potatoes	0.0000
total meats	0.0787
beef	0.0449
pork	0.0112
poultry	0.0112
dairy	0.1348
total grains	0.3146
Meat Mixtures	
total vegetables	0.2778
tomatoes	0.1111
white potatoes	0.0333
total meats	0.3556
beef	0.2000
pork	0.0222
poultry	0.0778
dairy	0.0556
total grains	0.1333

APPENDIX 9B

Food Codes and Definitions Used in Analysis of the 1989/91 USDA CSFII Data

Appendix 9B. Food Codes and Definitions Used in Analysis of the 1989/91 USDA CSFII Data

Food Product	Food Codes	
MAJOR FOOD GROUPS		
Total Fruits	6- Fruits citrus fruits and juices dried fruits other fruits fruits/juices & nectar fruit/juices baby food	(includes baby foods)
Total Vegetables	7- Vegetables (all forms) white potatoes & PR starchy dark green vegetables deep yellow vegetables tomatoes and tom. mixtures other vegetables veg. and mixtures/baby food veg. with meat mixtures	411- Beans/legumes 412- Beans/legumes 413- Beans/legumes (includes baby foods; mixtures, mostly vegetables; does not include nuts and seeds)
Total Meats	20- Meat, type not specified 21- Beef 22- Pork 23- Lamb, veal, game, carcass meat 24- Poultry 25- Organ meats, sausages, lunchmeats, meat spreads	(excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks; includes baby foods)
Total Dairy	1- Milk and Milk Products milk and milk drinks cream and cream substitutes milk desserts, sauces, and gravies cheeses	(includes regular fluid milk, human milk, imitation milk products, yogurt, milk-based meal replacements, and infant formulas)
INDIVIDUAL FOODS		
White Potatoes	71- White Potatoes and PR Starchy Veg. baked, boiled, chips, sticks, creamed, scalloped, au gratin, fried, mashed, stuffed, puffs, salad, recipes, soups, Puerto Rican starchy vegetables	(does not include vegetables soups; vegetable mixtures; or vegetable with meat mixtures)
Peppers	7512100 Pepper, hot chili, raw 7512200 Pepper, raw 7512210 Pepper, sweet green, raw 7512220 Pepper, sweet red, raw 7522600 Pepper, green, cooked, NS as to fat added 7522601 Pepper, green, cooked, fat not added 7522602 Pepper, green, cooked, fat added 7522604 Pepper, red, cooked, NS as to fat added 7522605 Pepper, red, cooked, fat not added	7522606 Pepper, red, cooked, fat added 7522609 Pepper, hot, cooked, NS as to fat added 7522610 Pepper, hot, cooked, fat not added 7522611 Pepper, hot, cooked, fat added 7551101 Peppers, hot, sauce 7551102 Peppers, pickled 7551105 Peppers, hot pickled (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Onions	7510950 Chives, raw 7511150 Garlic, raw 7511250 Leek, raw 7511701 Onions, young green, raw 7511702 Onions, mature 7521550 Chives, dried 7521740 Garlic, cooked 7521840 Leek, cooked 7522100 Onions, mature cooked, NS as to fat added 7522101 Onions, mature cooked, fat not added	7522102 Onions, mature cooked, fat added 7522103 Onions, pearl cooked 7522104 Onions, young green cooked, NS as to fat 7522105 Onions, young green cooked, fat not added 7522106 Onions, young green cooked, fat added 7522110 Onion, dehydrated 7541501 Onions, creamed 7541502 Onion rings (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)

Food Product	Food Codes			
Corn	7510960	Corn, raw	7521621	Corn, cooked, white/fat not added
	7521600	Corn, cooked, NS as to color/fat added	7521622	Corn, cooked, white/fat added
	7521601	Corn, cooked, NS as to color/fat not added	7521625	Corn, white, cream style
	7521602	Corn, cooked, NS as to color/fat added	7521630	Corn, yellow, canned, low sodium, NS fat
	7521605	Corn, cooked, NS as to color/cream style	7521631	Corn, yell., canned, low sod., fat not add
	7521607	Corn, cooked, dried	7521632	Corn, yell., canned, low sod., fat added
	7521610	Corn, cooked, yellow/NS as to fat added	7521749	Hominy, cooked
	7521611	Corn, cooked, yellow/fat not added	752175-	Hominy, cooked
	7521612	Corn, cooked, yellow/fat added	7541101	Corn scalloped or pudding
	7521615	Corn, yellow, cream style	7541102	Corn fritter
	7521616	Corn, cooked, yell. & wh./NS as to fat	7541103	Corn with cream sauce
	7521617	Corn, cooked, yell. & wh./fat not added	7550101	Corn relish
	7521618	Corn, cooked, yell. & wh./fat added	76405-	Corn, baby
	7521619	Corn, yellow, cream style, fat added	(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby food)	
	7521620	Corn, cooked, white/NS as to fat added		
Apples	6210110	Apples, dried, uncooked	6310141	Apple rings, fried
	6210115	Apples, dried, uncooked, low sodium	6310142	Apple, pickled
	6210120	Apples, dried, cooked, NS as to sweetener	6310150	Apple, fried
	6210122	Apples, dried, cooked, unsweetened	6340101	Apple, salad
	6210123	Apples, dried, cooked, with sugar	6340106	Apple, candied
	6210130	Apple chips	6410101	Apple cider
	6310100	Apples, raw	6410401	Apple juice
	6310111	Applesauce, NS as to sweetener	6410405	Apple juice with vitamin C
	6310112	Applesauce, unsweetened	6410409	Apple juice with calcium
	6310113	Applesauce with sugar	6710200	Applesauce baby fd., NS as to str. or jr.
	6310114	Applesauce with low calorie sweetener	6710201	Applesauce baby food, strained
	6310121	Apples, cooked or canned with syrup	6710202	Applesauce baby food, junior
	6310131	Apple, baked NS as to sweetener	6720200	Apple juice, baby food
	6310132	Apple, baked, unsweetened	(includes baby food; except mixtures)	
	6310133	Apple, baked with sugar		
Tomatoes	74-	Tomatoes and Tomato Mixtures raw, cooked, juices, sauces, mixtures, soups, sandwiches		
Snap Beans	7510180	Beans, string, green, raw	7520602	Beans, string, cooked, yellow/fat
	7520498	Beans, string, cooked, NS color/fat added	7540301	Beans, string, green, creamed
	7520499	Beans, string, cooked, NS color/no fat	7540302	Beans, string, green, w/mushroom sauce
	7520500	Beans, string, cooked, NS color & fat	7540401	Beans, string, yellow, creamed
	7520501	Beans, string, cooked, green/NS fat	7550011	Beans, string, green, pickled
	7520502	Beans, string, cooked, green/no fat	7640100	Beans, green, string, baby
	7520503	Beans, string, cooked, green/fat	7640101	Beans, green, string, baby, str.
	7520511	Beans, str., canned, low sod.,green/NS fat	7640102	Beans, green, string, baby, junior
	7520512	Beans, str., canned, low sod.,green/no fat	7640103	Beans, green, string, baby, creamed
	7520513	Beans, str., canned, low sod.,green/fat	(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby foods)	
	7520600	Beans, string, cooked, yellow/NS fat		
	7520601	Beans, string, cooked, yellow/no fat		
Beef	21-	Beef beef, nfs beef steak beef oxtails, neckbones, ribs roasts, stew meat, corned, brisket, sandwich steaks ground beef, patties, meatballs other beef items beef baby food	(excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks; includes baby food)	

Food Product	Food Codes	
Pork	22- Pork pork, nfs; ground dehydrated chops steaks, cutlets ham roasts Canadian bacon bacon, salt pork other pork items pork baby food	(excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks; includes baby food)
Game	233- Game	(excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks)
Poultry	24- Poultry chicken turkey duck other poultry poultry baby food	(excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks; includes baby food)
Eggs	3- Eggs eggs egg mixtures egg substitutes eggs baby food froz. meals with egg as main ingred.	(includes baby foods)
Broccoli	722- Broccoli (all forms)	(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Carrots	7310- Carrots (all forms) 7311140 Carrots in Sauce 7311200 Carrot Chips 76201- Carrots, baby	(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby foods except mixtures)
Pumpkin	732- Pumpkin (all forms) 733- Winter squash (all forms) 76205- Squash, baby	(does not include vegetable soups; vegetables mixtures; or vegetable with meat mixtures; includes baby foods)
Asparagus	7510080 Asparagus, raw 75202- Asparagus, cooked 7540101 Asparagus, creamed or with cheese	(does not include vegetable soups; vegetables mixtures, or vegetable with meat mixtures)
Lima Beans	7510200 Lima Beans, raw 752040- Lima Beans, cooked 752041- Lima Beans, canned 75402- Lima Beans with sauce	(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; does not include succotash)
Cabbage	7510300 Cabbage, raw 7510400 Cabbage, Chinese, raw 7510500 Cabbage, red, raw 7514100 Cabbage salad or coleslaw 7514130 Cabbage, Chinese, salad 75210- Chinese Cabbage, cooked 75211- Green Cabbage, cooked	75212- Red Cabbage, cooked 752130- Savoy Cabbage, cooked 75230- Sauerkraut, cooked 7540701 Cabbage, creamed 755025- Cabbage, pickled or in relish (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Lettuce	75113- Lettuce, raw 75143- Lettuce salad with other veg. 7514410 Lettuce, wilted, with bacon dressing 7522005 Lettuce, cooked	(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)

Food Product	Food Codes	
Okra	7522000 Okra, cooked, NS as to fat 7522001 Okra, cooked, fat not added 7522002 Okra, cooked, fat added 7522010 Lufta, cooked (Chinese Okra)	7541450 Okra, fried 7550700 Okra, pickled (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Peas	7512000 Peas, green, raw 7512775 Snowpeas, raw 75223- Peas, cowpeas, field or blackeye, cooked 75224- Peas, green, cooked 75225- Peas, pigeon, cooked 75231- Snowpeas, cooked 7541650 Pea salad	7541660 Pea salad with cheese 75417- Peas, with sauce or creamed 76409- Peas, baby 76411- Peas, creamed, baby (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby foods except mixtures)
Cucumbers	7511100 Cucumbers, raw 75142- Cucumber salads 752167- Cucumbers, cooked 7550301 Cucumber pickles, dill 7550302 Cucumber pickles, relish 7550303 Cucumber pickles, sour 7550304 Cucumber pickles, sweet	7550305 Cucumber pickles, fresh 7550307 Cucumber, Kim Chee 7550311 Cucumber pickles, dill, reduced salt 7550314 Cucumber pickles, sweet, reduced salt (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Beets	7510250 Beets, raw 752080- Beets, cooked 752081- Beets, canned 7540501 Beets, harvard	7550021 Beets, pickled 76403- Beets, baby (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby foods except mixtures)
Strawberries	6322- Strawberries 6413250 Strawberry Juice	(includes baby food; except mixtures)
Other Berries	6320- Other Berries 6321- Other Berries 6341101 Cranberry salad	6410460 Blackberry Juice 64105- Cranberry Juice (includes baby food; except mixtures)
Peaches	62116- Dried Peaches 63135- Peaches 6412203 Peach Juice 6420501 Peach Nectar	67108- Peaches ,baby 6711450 Peaches, dry, baby (includes baby food; except mixtures)
Pears	62119- Dried Pears 63137- Pears 6341201 Pear salad 6421501 Pear Nectar	67109- Pears, baby 6711455 Pears, dry, baby 6721200 Pear juice, baby (includes baby food; except mixtures)

Food Product	Food Codes			
EXPOSED/PROTECTED FRUITS/VEGETABLES, ROOT VEGETABLES				
Exposed Fruits	621011-	Apple, dried	63143-	Plum
	621012-	Apple, dried	63146-	Quince
	6210130	Apple chips	63147-	Rhubarb/Sapodillo
	62104-	Apricot, dried	632-	Berries
	62108-	Currants, dried	64101-	Apple Cider
	62110-	Date, dried	64104-	Apple Juice
	62116-	Peaches, dried	6410409	Apple juice with calcium
	62119-	Pears, dried	64105-	Cranberry Juice
	62121-	Plum, dried	64116-	Grape Juice
	62122-	Prune, dried	64122-	Peach Juice
	62125-	Raisins	64132-	Prune/Strawberry Juice
	63101-	Apples/applesauce	6420101	Apricot Nectar
	63102-	Wi-apple	64205-	Peach Nectar
	63103-	Apricots	64215-	Pear Nectar
	63111-	Cherries, maraschino	67102-	Applesauce, baby
	63112-	Acerola	67108-	Peaches, baby
	63113-	Cherries, sour	67109-	Pears, baby
	63115-	Cherries, sweet	6711450	Peaches, baby, dry
	63117-	Currants, raw	6711455	Pears, baby, dry
	63123-	Grapes	67202-	Apple Juice, baby
	6312601	Juneberry	6720380	White Grape Juice, baby
	63131-	Nectarine	67212-	Pear Juice, baby
	63135-	Peach	(includes baby foods/juices except mixtures; excludes fruit mixtures)	
	63137-	Pear		
	63139-	Persimmons		
Protected Fruits	61-	Citrus Fr., Juices (incl. cit. juice mixtures)	63145-	Pomegranate
	62107-	Bananas, dried	63148-	Sweetsop, Soursop, Tamarind
	62113-	Figs, dried	63149-	Watermelon
	62114-	Lychees/Papayas, dried	64120-	Papaya Juice
	62120-	Pineapple, dried	64121-	Passion Fruit Juice
	62126-	Tamarind, dried	64124-	Pineapple Juice
	63105-	Avocado, raw	64125-	Pineapple juice
	63107-	Bananas	64133-	Watermelon Juice
	63109-	Cantaloupe, Carambola	6420150	Banana Nectar
	63110-	Cassaba Melon	64202-	Cantaloupe Nectar
	63119-	Figs	64203-	Guava Nectar
	63121-	Genip	64204-	Mango Nectar
	63125-	Guava/Jackfruit, raw	64210-	Papaya Nectar
	6312650	Kiwi	64213-	Passion Fruit Nectar
	6312651	Lychee, raw	64221-	Soursop Nectar
	6312660	Lychee, cooked	6710503	Bananas, baby
	63127-	Honeydew	6711500	Bananas, baby, dry
	63129-	Mango	6720500	Orange Juice, baby
	63133-	Papaya	6721300	Pineapple Juice, baby
	63134-	Passion Fruit	(includes baby foods/juices except mixtures; excludes fruit mixtures)	
	63141-	Pineapple		

Food Product	Food Codes			
Exposed Veg.	721-	Dark Green Leafy Veg.	752167-	Cucumber, cooked
	722-	Dark Green Nonleafy Veg.	752170-	Eggplant, cooked
	74-	Tomatoes and Tomato Mixtures	752171-	Fern shoots
	7510050	Alfalfa Sprouts	752172-	Fern shoots
	7510075	Artichoke, Jerusalem, raw	752173-	Flowers of sesbania, squash or lily
	7510080	Asparagus, raw	7521801	Kohlrabi, cooked
	75101-	Beans, sprouts and green, raw	75219-	Mushrooms, cooked
	7510260	Broccoflower, raw	75220-	Okra/lettuce, cooked
	7510275	Brussel Sprouts, raw	7522116	Palm Hearts, cooked
	7510280	Buckwheat Sprouts, raw	7522121	Parsley, cooked
	7510300	Cabbage, raw	75226-	Peppers, pimento, cooked
	7510400	Cabbage, Chinese, raw	75230-	Sauerkraut, cooked/canned
	7510500	Cabbage, Red, raw	75231-	Snowpeas, cooked
	7510700	Cauliflower, raw	75232-	Seaweed
	7510900	Celery, raw	75233-	Summer Squash
	7510950	Chives, raw	7540050	Artichokes, stuffed
	7511100	Cucumber, raw	7540101	Asparagus, creamed or with cheese
	7511120	Eggplant, raw	75403-	Beans, green with sauce
	7511200	Kohlrabi, raw	75404-	Beans, yellow with sauce
	75113-	Lettuce, raw	7540601	Brussel Sprouts, creamed
	7511500	Mushrooms, raw	7540701	Cabbage, creamed
	7511900	Parsley	75409-	Cauliflower, creamed
	7512100	Pepper, hot chili	75410-	Celery/Chiles, creamed
	75122-	Peppers, raw	75412-	Eggplant, fried, with sauce, etc.
	7512750	Seaweed, raw	75413-	Kohlrabi, creamed
	7512775	Snowpeas, raw	75414-	Mushrooms, Okra, fried, stuffed, creamed
	75128-	Summer Squash, raw	754180-	Squash, baked, fried, creamed, etc.
	7513210	Celery Juice	7541822	Christophine, creamed
	7514100	Cabbage or cole slaw	7550011	Beans, pickled
	7514130	Chinese Cabbage Salad	7550051	Celery, pickled
	7514150	Celery with cheese	7550201	Cauliflower, pickled
	75142-	Cucumber salads	755025-	Cabbage, pickled
	75143-	Lettuce salads	7550301	Cucumber pickles, dill
	7514410	Lettuce, wilted with bacon dressing	7550302	Cucumber pickles, relish
	7514600	Greek salad	7550303	Cucumber pickles, sour
	7514700	Spinach salad	7550304	Cucumber pickles, sweet
	7520060	Algae, dried	7550305	Cucumber pickles, fresh
	75201-	Artichoke, cooked	7550307	Cucumber, Kim Chee
	75202-	Asparagus, cooked	7550308	Eggplant, pickled
	75203-	Bamboo shoots, cooked	7550311	Cucumber pickles, dill, reduced salt
	752049-	Beans, string, cooked	7550314	Cucumber pickles, sweet, reduced salt
	75205-	Beans, green, cooked/canned	7550500	Mushrooms, pickled
	75206-	Beans, yellow, cooked/canned	7550700	Okra, pickled
	75207-	Bean Sprouts, cooked	75510-	Olives
	752085-	Breadfruit	7551101	Peppers, hot
	752090-	Brussel Sprouts, cooked	7551102	Peppers,pickled
	75210-	Cabbage, Chinese, cooked	7551104	Peppers, hot pickled
	75211-	Cabbage, green, cooked	7551301	Seaweed, pickled
	75212-	Cabbage, red, cooked	7553500	Zucchini, pickled
	752130-	Cabbage, savoy, cooked	76102-	Dark Green Veg., baby
	75214-	Cauliflower	76401-	Beans, baby (excl. most soups & mixtures)
	75215-	Celery, Chives, Christophine (chayote)		

Food Product	Food Codes			
Protected Veg.	732-	Pumpkin	752175-	Hominy
	733-	Winter Squash	75223-	Peas, cowpeas, field or blackeye, cooked
	7510200	Lima Beans, raw	75224-	Peas, green, cooked
	7510550	Cactus, raw	75225-	Peas, pigeon, cooked
	7510960	Corn, raw	75301-	Succotash
	7512000	Peas, raw	75402-	Lima Beans with sauce
	7520070	Aloe vera juice	75411-	Corn, scalloped, fritter, with cream
	752040-	Lima Beans, cooked	7541650	Pea salad
	752041-	Lima Beans, canned	7541660	Pea salad with cheese
	7520829	Bitter Melon	75417-	Peas, with sauce or creamed
	752083-	Bitter Melon, cooked	7550101	Corn relish
	7520950	Burdock	76205-	Squash, yellow, baby
	752131-	Cactus	76405-	Corn, baby
	752160-	Corn, cooked	76409-	Peas, baby
	752161-	Corn, yellow, cooked	76411-	Peas, creamed, baby
	752162-	Corn, white, cooked		(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
	752163-	Corn, canned		
	7521749	Hominy		
Root Vegetables	71-	White Potatoes and Puerto Rican St. Veg.	7522110	Onions, dehydrated
	7310-	Carrots	752220-	Parsnips, cooked
	7311140	Carrots in sauce	75227-	Radishes, cooked
	7311200	Carrot chips	75228-	Rutabaga, cooked
	734-	Sweetpotatoes	75229-	Salsify, cooked
	7510250	Beets, raw	75234-	Turnip, cooked
	7511150	Garlic, raw	75235-	Water Chestnut
	7511180	Jicama (yambean), raw	7540501	Beets, harvard
	7511250	Leeks, raw	75415-	Onions, creamed, fried
	75117-	Onions, raw	7541601	Parsnips, creamed
	7512500	Radish, raw	7541810	Turnips, creamed
	7512700	Rutabaga, raw	7550021	Beets, pickled
	7512900	Turnip, raw	7550309	Horseradish
	752080-	Beets, cooked	7551201	Radishes, pickled
	752081-	Beets, canned	7553403	Turnip, pickled
	7521362	Cassava	76201-	Carrots, baby
	7521740	Garlic, cooked	76209-	Sweetpotatoes, baby
	7521771	Horseradish	76403-	Beets, baby
	7521840	Leek, cooked		(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
	7521850	Lotus root		
	752210-	Onions, cooked		
USDA SUBCATEGORIES				
Dark Green Vegetables	72-	Dark Green Vegetables all forms leafy, nonleafy, dk. gr. veg. soups		
Deep Yellow Vegetables	73-	Deep Yellow Vegetables all forms carrots, pumpkin, squash, sweetpotatoes, dp. yell. veg. soups		
Other Vegetables	75-	Other Vegetables all forms		
Citrus Fruits	61-	Citrus Fruits and Juices	6720700	Orange-Pineapple Juice, baby food
	6720500	Orange Juice, baby food	6721100	Orange-Apple-Banana Juice, baby food
	6720600	Orange-Apricot Juice, baby food		(excludes dried fruits)

Food Product	Food Codes	
Other Fruits	62- Dried Fruits 63- Other Fruits 64- Fruit Juices and Nectars Excluding Citrus 671- Fruits, baby 67202- Apple Juice, baby 67203- Baby Juices	67204- Baby Juices 67212- Baby Juices 67213- Baby Juices 6725- Baby Juice 673- Baby Fruits 674- Baby Fruits
MIXTURES		
Meat Mixtures	27- Meat Mixtures 28-	(includes frozen plate meals and soups)
Grain Mixtures	58- Grain Mixtures	(includes frozen plate meals and soups)

TABLE OF CONTENTS

Page No.

10. INTAKE OF FISH AND SHELLFISH

10.1. BACKGROUND

Contaminated finfish and shellfish are potential sources of human exposure to toxic chemicals. Pollutants are carried in the surface waters, but also may be stored and accumulated in the sediments as a result of complex physical and chemical processes. Consequently, finfish and shellfish are exposed to these pollutants and may become sources of contaminated food.

Accurately estimating exposure to a toxic chemical among a population that consumes fish from a polluted water body requires an estimation of intake rates of the caught fish by both fishermen and their families. Commercially caught fish are marketed widely, making the prediction of an individual's consumption from a particular commercial source difficult. Since the catch of recreational and subsistence fishermen is not "diluted" in this way, these individuals and their families represent the population that is most vulnerable to exposure by intake of contaminated fish from a specific location.

This section focuses on intake rates of fish. Note that in this section the term fish refers to both finfish and shellfish. The following subsections address intake rates for the general population, and recreational and subsistence fishermen. Data are presented for intake rates for both marine and freshwater fish, when available. The available studies have been classified as either key or relevant based on the guidelines given in Volume I, Section 1.3. Recommended intake rates are based on the results of key studies, but other relevant studies are also presented to provide the reader with added perspective on the current state-of-knowledge pertaining to fish intake.

Survey data on fish consumption have been collected using a number of different approaches which need to be considered in interpreting the survey results. Generally, surveys are either "creel" studies in which fishermen are interviewed while fishing, or broader population surveys using either mailed questionnaires or phone interviews. Both types of data can be useful for exposure assessment purposes, but somewhat different applications and interpretations are needed. In fact, results from creel studies have often been misinterpreted, due to inadequate knowledge of survey principles. Below, some basic facts about survey design are presented, followed by an analysis of the differences between creel and population based studies.

The typical survey seeks to draw inferences about a larger population from a smaller sample of that population. This larger population, from which the survey sample is to be taken and to which the results of the survey are to be generalized, is denoted the target population of the survey. In order to generalize from the sample to the target population, the probability of being sampled must be known for each member of the target population. This probability is reflected in weights assigned to each survey respondent, with weights being inversely proportional to sampling probability. When all members of the target population have the same probability of being sampled, all weights can be set to one and essentially ignored.

In a mail or phone study of licensed anglers, the target population is generally all licensed anglers in a particular area, and in the studies presented, the sampling probability is essentially equal for all target population members. In a creel study, the target population is anyone who fishes at the locations being studied; generally, in a creel study, the probability of being sampled is not the same for all members of the target population. For instance, if the survey is conducted for one day at a site, then it will include all persons who fish there daily but only about 1/7 of the people who fish there weekly, 1/30th of the people who fish there monthly, etc. In this example, the probability of being sampled (or inverse weight) is seen to be proportional to the frequency of fishing. However, if the survey involves interviewers revisiting the same site on multiple days, and persons are only interviewed once for the survey, then the probability of being in the survey is not proportional to frequency; in fact, it increases less than proportionally with frequency. At the extreme of surveying the same site every day over the survey period with no re-interviewing, all members of the target population would have the same probability of being sampled regardless of fishing frequency, implying that the survey weights should all equal one.

On the other hand, if the survey protocol calls for individuals to be interviewed each time an interviewer encounters them (i.e., without regard to whether they were previously interviewed), then the inverse weights will again be proportional to fishing frequency, no matter how many times interviewers revisit the same site. Note that when individuals can be interviewed multiple times, the results of each interview are included as separate records in the data base and the survey weights should be inversely proportional to the expected number of times that an individual's interviews are included in the data base.

In the published analyses of most creel studies, there is no mention of sampling weights; by default all weights are set to 1, implying equal probability of sampling. However, since the sampling probabilities in a creel study, even with repeated interviewing at a site, are highly dependent on fishing frequency, the fish intake distributions reported for these surveys are not reflective of the corresponding target populations. Instead, those individuals with high fishing frequencies are given too big a weight and the distribution is skewed to the right, i.e., it overestimates the target population distribution.

Price et. al. (1994) explained this problem and set out to rectify it by adding weights to creel survey data; he used data from two creel studies (Puffer et al., 1981 and Pierce et al., 1981) as examples. Price et al. (1994) used inverse fishing frequency as survey weights and produced revised estimates of median and 95th percentile intake for the above two studies. These revised estimates were dramatically lower than the original estimates. The approach of Price et al. (1994) is discussed in more detail in Section 10.5 where the Puffer et. al. (1981) and Pierce et al. (1981) studies are summarized.

When the correct weights are applied to survey data the resulting percentiles reflect, on average, the distribution in the target population; thus, for example, an estimated 90 percent of the target population will have intake levels below the 90th percentile of the survey fish intake distribution. There is another way, however, of characterizing distributions in addition to the standard percentile approach; this approach is reflected in statements of the form "50 percent of the income is received by, for example, the top 10 percent of the population, which consists of individuals making more than $100,000", for example. Note that the 50th percentile (median) of the income distribution is well below $100,000. Here the $100,000 level can be thought of as, not the 50th percentile of the population income distribution, but as the 50th percentile of the "resource utilization distribution" (see Appendix 10A for technical discussion of this distribution). Other percentiles of the resource utilization distribution have similar interpretations; e.g., the 90th percentile of the resource utilization distribution (for income) would be that level of income such that 90 percent of total income is received by individuals with incomes below this level and 10 percent by individuals with income above this level. This alternative approach to characterizing distributions is of particular interest when a relatively small fraction of individuals consumes a relatively large fraction of a resource, which is the case with regards to recreational fish consumption. In the studies of recreational anglers, this alternative approach based on resource utilization will be presented, where possible, in addition to the primary approach of presenting the standard percentiles of the fish intake distribution.

It has been determined that the resource utilization approach to characterizing distributions has relevance to the interpretation of creel survey data. As mentioned above, most published analyses of creel surveys do not employ weights reflective of sampling probability, but instead give each respondent equal weight. For mathematical reasons that are explained in Appendix 10A, when creel analyses are performed in this (equal weighting) manner, the calculated percentiles of the fish intake distribution do not reflect the percentiles of the target population fish intake distribution but instead reflect (approximately) the percentiles of the "resource utilization distribution". Thus, one would not expect 50 percent of the target population to be consuming above the median intake level as reported from such a creel survey, but instead would expect that 50 percent of the total recreational fish consumption would be individuals consuming above this level. As with the example above, and in accordance with the statement above that creel surveys analyzed in this manner overestimate intake distributions, the actual median level of intake in the target population will be less (probably considerably so) than this level and, accordingly, (considerably) less than 50 percent of the target population will be consuming at or above this level. These considerations are discussed when the results of individual creel surveys are presented in later sections and should be kept in mind whenever estimates based on creel survey data are utilized.

The U.S. EPA has prepared a review of and an evaluation of five different survey methods used for obtaining fish consumption data. They are:

- Recall-Telephone Survey;
- Recall-Mail Survey;
- Recall-Personal Interview;
- Diary; and
- Creel Census.

The reader is referred to *U.S. EPA 1992-Consumption Surveys for Fish and Shellfish* for more detail on these survey methods and their advantages and limitations.

10.2. KEY GENERAL POPULATION STUDIES

Tuna Research Institute Survey - The Tuna Research Institute (TRI) funded a study of fish consumption which was performed by the National Purchase Diary (NPD) during the period of September, 1973 to August, 1974. The data tapes from this survey were obtained by the National Marine Fisheries Service (NMFS), which later, along with the FDA, USDA and TRI, conducted an intensive effort to identify and correct errors in the data base. Javitz (1980) summarized the TRI survey methodology and used the corrected tape to generate fish intake distributions for various sub-populations.

The TRI survey sample included 6,980 families who were currently participating in a syndicated national purchase diary panel, 2,400 additional families where the head of household was female and under 35 years old; and 210 additional black families (Javitz, 1980). Of the 9,590 families in the total sample, 7,662 families (25,162 individuals) completed the questionnaire, a response rate of 80 percent. The survey was weighted to represent the U.S. population based on a number of census-defined controls (i.e., census region, household size, income, presence of children, race and age). The calculations of means, percentiles, etc. were performed on a weighted basis with each person contributing in proportion to his/her assigned survey weight.

The survey population was divided into 12 different sample segments and, for each of the 12 survey months, data were collected from a different segment. Each survey household was given a diary in which they recorded, over a one month period, the date of any fish meals consumed and the following accompanying information: the species of fish consumed, whether the fish was commercially or recreationally caught, the way the fish was packaged (canned, frozen fresh, dried, smoked), the amount of fish prepared and consumed, and the number of servings consumed by household members and guests. Both meals eaten at home and away from home were recorded. The amount of fish prepared was determined as follows (Javitz, 1980): "For fresh fish, the weight was recorded in ounces and may have included the weight of the head and tail. For frozen fish, the weight was recorded in packaged ounces, and it was noted whether the fish was breaded or combined with other ingredients (e.g., TV dinners). For canned fish, the weight was recorded in packaged ounces and it was noted whether the fish was canned in water, oil, or with other ingredients (e.g., soups)".

Javitz (1980) reported that the corrected survey tapes contained data on 24,652 individuals who consumed fish in the survey month and that tabulations performed by NPD indicated that these fish consumers represented 94 percent of the U.S. population. For this population of "fish consumers", Javitz (1980) calculated means and percentiles of fish consumption by demographic variables (age, sex, race, census region and community type) and overall (Tables 10-1 through 10-4). The overall mean fish intake rate among fish consumers was calculated at 14.3 g/day and the 95th percentile at 41.7 g/day.

Table 10-1. Total Fish Consumption by Demographic Variables[a]

Demographic Category	Intake (g/person/day) Mean	95th Percentile
Race		
Caucasian	14.2	41.2
Black	16.0	45.2
Oriental	21.0	67.3
Other	13.2	29.4
Sex		
Female	13.2	38.4
Male	15.6	44.8
Age (years)		
0- 9	6.2	16.5
10-19	10.1	26.8
20-29	14.5	38.3
30-39	15.8	42.9
40-49	17.4	48.1
50-59	20.9	53.4
60-69	21.7	55.4
70+	13.3	39.8
Census Region		
New England	16.3	46.5
Middle Atlantic	16.2	47.8
East North Central	12.9	36.9
West North Central	12.0	35.2
South Atlantic	15.2	44.1
East South Central	13.0	38.4
West South Central	14.4	43.6
Mountain	12.1	32.1
Pacific	14.2	39.6
Community Type		
Rural, non-SMSA	13.0	38.3
Central city, 2M or more	19.0	55.6
Outside central city, 2M or more	15.9	47.3
Central city, 1M - 2M	15.4	41.7
Outside central city, 1M - 2M	14.5	41.5
Central city, 500K - 1M	14.2	41.0
Outside central city, 500K - 1M	14.0	39.7
Outside central city, 250K - 500K	12.2	32.1
Central city, 250K - 500K	14.1	40.5
Central city, 50K - 250K	13.8	43.4
Outside central city, 50K - 250K	11.3	31.7
Other urban	13.5	39.2

[a] The calculations in this table are based on respondents who consumed fish during the survey month. These respondents are estimated to represent 94 percent of the U.S. population.

Source: Javitz, 1980.

As seen in Table 10-1, the mean and 95th percentile of fish consumption were higher for Asian-Americans as compared to the other racial groups. Other differences in intake rates are those between gender and age groups. While males (15.6 g/d) eat slightly more fish than females (13.2 g/d), and adults eat more fish than children, the corresponding differences in body weight would probably compensate for the different intake rates in exposure calculations (Javitz, 1980). There appeared to be no large differences in regional intake rates, although higher rates are shown in the New England and Middle Atlantic census regions.

The mean and 95th percentile intake rates by age-gender groups are presented in Table 10-2. Tables 10-3 and 10-4 present the distribution of fish consumption for females and males, respectively, by age; these tables give the percentages of females/males in a given age bracket with intake rates within various ranges. Table 10-5 presents mean total fish consumption by fish species.

Table 10-2. Mean and 95th Percentile of Fish Consumption (g/day) by Sex and Age[a]

		Total Fish	
	Age (years)	Mean	95th Percentile
Female	0 - 9	6.1	17.3
	10 - 19	9.0	25.0
	20 - 19	13.4	34.5
	30 - 39	14.9	41.8
	40 - 49	16.7	49.6
	50 - 59	19.5	50.1
	60 - 69	19.0	46.3
	70+	10.7	31.7
Male	0 - 9	6.3	15.8
	10 - 19	11.2	29.1
	20 - 19	16.1	43.7
	30 - 39	17.0	45.6
	40 - 49	18.2	47.7
	50 - 59	22.8	57.5
	60 - 69	24.4	61.1
	70+	15.8	45.7
Overall		14.3	41.7

[a] The calculations in this table are based upon respondents who consumed fish in the month of the survey. These respondents are estimated to represent 94.0% of the U.S. population.

Source: Javitz, 1980.

The TRI survey data were also utilized by Rupp et al. (1980) to generate fish intake distributions for three age groups (< 11, 12-18, and 19+ years) within each of the 9 census regions and for the entire U.S. Separate distributions were derived for freshwater finfish, saltwater finfish and shellfish; thus a total of 90 (3*3*10) different distributions were derived, each corresponding to intake of a specific category of fish for a given age group within a given region. The analysis of Rupp et al. (1980) included only those respondents with known age. This amounted to 23,213 respondents.

Ruffle et al. (1994) used the percentiles data of Rupp et al. (1980) to estimate the best fitting lognormal parameters for each distribution. Three methods (non-linear optimization, first probability plot and second probability plot) were used to estimate optimal parameters. Ruffle et al. (1994) determined that, of the three methods, the non-linear optimization method (NLO) generally gave the best results. For some of the distributions fitted by the NLO method, however, it was determined that the lognormal model did not adequately fit the empirical fish intake distribution. Ruffle et al. (1994) used a criterion of minimum sum of squares (min SS) less than 30 to identify which distributions provided adequate fits. Of the 90 distributions studied, 77 were seen to have min SS < 30; for these Ruffle et al. (1994) concluded that the NLO modeled lognormal distributions are "well suited for risk assessment". Of the remaining 13 distributions, 12 had min SS > 30; for these Ruffle at al. (1994) concluded that modeled lognormal distributions "may also be appropriate for use when exercised with due care and with sensitivity analyses". One distribution, that of freshwater finfish intake for children < 11 years of age in New England, could not be modeled due to the absence of any reported consumption.

Table 10-6 presents the optimal lognormal parameters, the mean (μ), standard deviation (s), and min SS, for all 89 modeled distributions. These parameters can be used to determine percentiles of the corresponding distribution of average daily fish consumption rates through the relation $DFC(p) = \exp[\mu + z(p)s]$ where DFC(p) is the pth percentile of the distribution of average daily fish consumption rates and z(p) is the z-score associated with the pth percentile (e.g., $z(50) = 0$). The mean average daily fish consumption rate is given by $\exp[\mu + 0.5s^2]$.

The analyses of Javitz (1980) and Ruffle et al. (1994) were based on consumers only, who are estimated to represent 94.0 percent of the U.S. population. U.S. EPA estimated the mean intake in the general population by multiplying the fraction consuming, 0.94, by the mean among consumers reported by Javitz (1980) of 14.3 g/day; the resulting estimate is 13.4 g/day. The 95th percentile estimate of Javitz (1980) of 41.7 g/day among consumers would be essentially unchanged when applied to the general population; 41.7 g/day would represent the 95.3 percentile (i.e., $100*[0.95*0.94+0.06]$) among the general population.

Advantages of the TRI data survey are that it was a large, nationally representative survey with a high response rate (80 percent) and was conducted over an entire year. In addition, consumption was recorded in a

Table 10-3. Percent Distribution of Total Fish Consumption for Females by Age[a]

	Consumption Category (g/day)										
	0.0-5.0	5.1-10.0	10.1-15.0	15.1-20.0	20.1-25.0	25.1-30.0	30.1-37.5	37.6-47.5	47.6-60.0	60.1-122.5	over 122.5
Age (yrs)	Percentage										
0-9	55.5	26.8	11.0	3.7	1.0	1.1	0.7	0.3	0.0	0.0	0.0
10-19	17.8	31.4	15.4	6.9	3.5	2.4	1.2	0.7	0.2	0.4	0.0
20-29	28.1	26.1	20.4	11.8	6.7	3.5	4.4	2.2	0.9	0.9	0.0
30-39	22.4	23.6	18.0	12.7	8.3	4.8	3.8	2.8	1.9	1.7	0.1
40-49	17.5	21.9	20.7	13.2	9.3	4.5	4.6	2.8	3.4	2.1	0.2
50-59	17.0	17.4	16.8	15.5	10.5	8.5	6.8	5.2	4.2	2.0	0.2
60-69	11.5	16.9	20.6	15.9	9.1	9.2	6.0	6.1	2.4	2.1	0.2
70+	41.9	22.1	12.3	9.7	5.2	2.9	2.6	1.2	0.8	1.2	0.1
Overall	28.9	24.0	16.8	10.7	6.4	4.3	3.5	2.4	1.6	1.2	0.1

[a] The percentage of females in an age bracket whose average daily fish consumption is within the specified range.
The calculations in this table are based upon the respondents who consumed fish during the month of the survey. These respondents are estimated to represent 94% of the U.S. population.
Source: Javitz, 1980.

Table 10-4. Percent Distribution of Total Fish Consumption for Males by Age[a]

	Consumption Category (g/day)										
	0.0-5.0	5.1-10.0	10.1-15.0	15.1-20.0	20.1-25.0	25.1-30.0	30.1-37.5	37.6-47.5	47.6-60.0	60.1-122.5	over 122.5
Age (yrs)	Percentage										
0-9	52.1	30.1	11.9	3.1	1.2	0.6	0.7	0.1	0.2	0.1	0.0
10-19	27.8	29.3	19.0	10.4	6.0	3.2	1.7	1.7	0.4	0.5	0.0
20-29	16.7	22.9	19.6	14.5	8.8	6.2	4.4	3.1	1.9	1.9	0.1
30-39	16.6	21.2	19.2	13.2	9.5	7.3	5.2	3.2	1.3	2.2	0.0
40-49	11.9	22.3	18.6	14.7	8.4	8.5	5.3	5.2	3.3	1.7	0.1
50-59	9.9	15.2	15.4	14.4	10.4	9.7	8.7	7.6	4.3	4.1	0.2
60-69	7.4	15.0	15.6	12.8	11.4	8.5	9.9	8.3	5.5	5.5	0.1
70+	24.5	21.7	15.7	9.9	9.8	5.3	5.4	3.1	1.7	2.8	0.1
Overall	22.6	23.1	17.0	11.3	7.7	5.7	4.6	3.6	2.2	2.1	0.1

[a] The percentage of males in an age bracket whose average daily fish consumption is within the specified range.
The calculations in this table are based upon respondents who consumed fish during the month of the survey. These respondents are estimated to represent 94.0% of the U.S. population.
Source: Javitz, 1980.

Table 10-5. Mean Total Fish Consumption by Species[a]

Species	Mean consumption (g/day)	Species	Mean consumption (g/day)
Not reported	1.173	Mullet[b]	0.029
Abalone	0.014	Oysters[b]	0.291
Anchovies	0.010	Perch (Freshwater)[b]	0.062
Bass[b]	0.258	Perch (Marine)	0.773
Bluefish	0.070	Pike (Marine)[b]	0.154
Bluegills[b]	0.089	Pollock	0.266
Bonito[b]	0.035	Pompano	0.004
Buffalofish	0.022	Rockfish	0.027
Butterfish	0.010	Sablefish	0.002
Carp[b]	0.016	Salmon[b]	0.533
Catfish (Freshwater)[b]	0.292	Scallops[b]	0.127
Catfish (Marine)[b]	0.014	Scup[b]	0.014
Clams[b]	0.442	Sharks	0.001
Cod	0.407	Shrimp[b]	1.464
Crab, King	0.030	Smelt[b]	0.057
Crab, other than King[b]	0.254	Snapper	0.146
Crappie[b]	0.076	Snook[b]	0.005
Croaker[b]	0.028	Spot[b]	0.046
Dolphin[b]	0.012	Squid and Octopi	0.016
Drums	0.019	Sunfish	0.020
Flounders[b]	1.179	Swordfish	0.012
Groupers	0.026	Tilefish	0.003
Haddock	0.399	Trout (Freshwater)[b]	0.294
Hake	0.117	Trout (Marine)[b]	0.070
Halibut[b]	0.170	Tuna, light	3.491
Herring	0.224	Tuna, White Albacore	0.008
Kingfish	0.009	Whitefish[b]	0.141
Lobster (Northern)[b]	0.162	Other finfish[b]	0.403
Lobster (Spiny)	0.074	Other shellfish[b]	0.013
Mackerel, Jack	0.002		
Mackerel, other than Jack	0.172		

[a] The calculations in this table are based upon respondents who consumed fish during the month of the survey. These respondents are estimated to represent 94.0% percent of the U.S. population.
[b] Designated as freshwater or estuarine species by Stephan (1980).
Source: Javitz, 1980.

Table 10-6. Best Fits of Lognormal Distributions Using the NonLinear Optimization (NLO) Method

	Adults	Teenagers	Children
Shellfish			
μ	1.370	-0.183	0.854
σ	0.858	1.092	0.730
(min SS)	27.57	1.19	16.06
Finfish (freshwater)			
μ	0.334	0.578	-0.559
σ	1.183	0.822	1.141
(min SS)	6.45	23.51	2.19
Finfish (saltwater)			
μ	2.311	1.691	0.881
σ	0.72	0.830	0.970
(min SS)	30.13	0.33	4.31

The following equations may be used with the appropriate μ and σ values to obtain an average Daily Consumption Rate (DCR), in grams, and percentiles of the DCR distribution.

$DCR50 = \exp(\mu)$

$DCR90 = \exp[\mu + z(0.90) \cdot \sigma]$

$DCR99 = \exp[\mu + z(0.99) \cdot \sigma]$

$DCR_{avg} = \exp[\mu + 0.5 \cdot \sigma^2]$

Source: Ruffle et al., 1994.

daily diary over a one month period; this format should be more reliable than one based on one-month recall. The upper percentiles presented are derived from one month of data, and are likely to overestimate the corresponding upper percentiles of the long-term (i.e., one year or more) average daily fish intake distribution. Similarly, the standard deviation of the fitted lognormal distribution probably overestimates the standard deviation of the long-term distribution. However, the period of this survey (one month) is considerably longer than those of many other consumption studies, including the USDA National Food Consumption Surveys, which report consumption over a 3 day to one week period.

Another obvious limitation of this data base is that it is now over twenty years out of date. Ruffle et al. (1994) considered this shortcoming and suggested that one may wish to shift the distribution upward to account for the recent increase in fish consumption. Adding $\ln(1+x/100)$ to the log mean μ will shift the distribution upward by x percent (e.g., adding $0.22 = \ln(1.25)$ increases the distribution by 25 percent). Although the TRI survey distinguished between recreationally and commercially caught fish, Javitz (1980), Rupp et al. (1980), and Ruffle et al. (1994) (which was based on Rupp et al., 1980) did not present analyses by this variable.

USDA, 1989-1991 - Continuing Survey of Food Intakes by Individuals (CSFII) — The USDA conducts the CSFII on an ongoing basis. U.S. EPA combined the CSFII data tapes for the years 1989, 1990, and 1991 to create a large data base from which to generate fish intake estimates. Participants in the CSFII provided 3 consecutive days of dietary data. For the first day's data, participants supplied dietary recall information to an in-home interviewer. Second and third day dietary intakes were recorded by participants. Data collection for the CSFII started in April of the given year and was completed in March of the following year.

The CSFII contains 469 fish-related food codes; survey respondents reported consumption across 284 of these codes. Respondents estimated the weight of each food that they consumed. The fish component (by weight) of these foods was calculated using data from the recipe file for release 7 of the USDA's Nutrient Data Base for Individual Food Intake Surveys. The amount of fish consumed by each individual was then calculated by summing, over all fish containing foods, the product of the weight of food consumed and the fish component (i.e., the percentage fish by weight) of the food.

The recipe file also contains cooking loss factors associated with each food. These were utilized to convert, for each fish containing food, the as-eaten fish weight consumed into an uncooked equivalent weight of fish. Analyses of fish intake were performed on both an as-eaten and uncooked basis.

Each (fish-related) food code was assigned by EPA a habitat type of either freshwater/estuarine or marine. Food codes were also designated as finfish or shellfish. Average daily individual consumption (g/day) for a given fish type-by-habitat category (e.g., marine finfish) was calculated by summing the amount of fish consumed by the individual across the three reporting days for all fish-related food codes in the given fish-by-habitat category and then dividing by 3. Individual consumption per day consuming fish (g/day) was calculated similarly except that total fish consumption was divided by the number of survey days the individual reported consuming fish; this was calculated for fish consumers only (i.e., those consuming fish on at least one of the three survey days). The reported body-weight of the individual was used to convert consumption in g/day to consumption in g/kg-day.

There were a total of 11,912 respondents in the combined data set who had three-day dietary intake data. A set of survey weights was assigned to this data set to make it representative of the U.S. population with respect to various demographic characteristics related to food intake.

Analyses of fish intake were performed on an as-eaten as well as on an uncooked equivalent basis and on a g/day as well as g/kg-day basis. Table 10-7 gives mean per-capita fish intake rates (g/day) based on uncooked equivalent weight by habitat and fish type. The per capita intake rate of finfish and shellfish from all habitats was 20.1 g/day. Per-capita consumption estimates by species, as consumed, are shown in Appendix 10C. Table 10-8 displays the mean and various percentiles of the distribution of total fish intake per day consuming fish, by habitat. Also displayed is the percentage of the population consuming fish of the specified habitat during the three day survey period. Tables 10-9 and 10-10 present similar results as above but on a mg/kg-day basis; Tables 10-11 and 10-12 present results in the same format for fish intake (g/day) on an as-eaten (cooked) basis.

Table 10-7. Per Capita Mean Fish Consumption Rates (g/day) By Habitat and Fish Type (Uncooked Fish Weight)

	Finfish Rate (90% C.I.)	Shellfish Rate (90% C.I.)	Total Rate (90% C.I.)
Habitat			
Fresh/Estuarine	3.5 (2.9-4.1)	3.2 (2.7-3.7)	6.6 (5.9-7.4)
Marine	12.6 (11.6-13.6)	0.8 (0.7-1.0)	13.5 (12.4-14.5)
Total	16.1 (15.0-17.2)	4.0 (3.4-4.6)	20.1 (18.8-21.4)

Source: U.S. EPA Analysis of CSFII, 1989-1991

The advantages of this study are its large size, its relative currency and its representativeness. In addition, through use of the USDA recipe files, the analysis identified all fish-related food codes and estimated the percent fish content of each of these codes. By contrast, some analyses of the USDA National Food Consumption Surveys (NFCS's) which reported per capita fish intake rates (e.g., Pao et al., 1982; USDA, 1992a) excluded certain fish containing foods (e.g., fish mixtures, frozen plate meals) in their calculations.

Results from the 1977-1978 NFCS survey (Pao et al., 1982) showed that only a small percentage of consumers ate fish on more than one occasion per day. This implies that the distribution presented for fish intake per day consuming fish can be used as a surrogate for the distribution of fish intake per (fish) eating occasion.

USDA Nationwide Food Consumption Survey 1977-78 - The USDA 1977-78 Nationwide Food Consumption Survey (NFCS) was described in Chapter 9. The survey consisted of a household and individual component. For the individual component, all members of surveyed households were asked to provide 3 consecutive days of dietary data. For the first day's data, participants supplied dietary recall information to an in-home interviewer. Second and third day dietary intakes were recorded by participants. A total of 15,000 households were included in the 77-78 NFCS and about 38,000 individuals completed the 3-day diet records. Fish intake was estimated based on consumption of fish products identified in the NFCS data base according to NFCS-defined food codes. These products included fresh, breaded, floured, canned, raw and dried fish, but not fish mixtures or frozen plate meals.

Pao et al. (1982) used the 1977-78 NCFS to examine the quantity of fish consumed per eating occasion. For each individual consuming fish in the 3 day survey period, the quantity of fish consumed per eating occasion was derived by dividing the total reported fish intake over the 3 day period by the number of occasions the individual reported eating fish. The distributions, by age and sex, for the quantity of fish consumed per eating occasion are displayed in Table 10-13 (Pao et al., 1982). For the general population, the average quantity of fish consumed per fish meal was 117 g, with a 95th percentile of 284 g. Males in the age groups 19-34, 35-64 and 65-74 years had the highest average and 95th percentile quantities among the age-sex groups presented.

Pao et al. (1982) also used the data from this survey set to calculate per capita fish intake rates. However, because these data are now almost 20 years out of date, this analysis is not considered key with respect to

Table 10-8. Distribution of Fish Intake (grams) Per Day Consuming Fish, By Habitat
(Uncooked fish weight)

Habitat	Statistic	Estimate	90 Percent Confidence Interval
Fresh/Estuarine	Mean	95.3	87.2 - 103.5
	50th%	56.4	50.8 - 65.1
	90th%	240.5	223.4 - 266.8
	95th%	325.1	297.0 - 328.7
	99th%	501.7	472.7 - 591.5
	Percent Consuming	18.5	
Marine	Mean	112.8	107.4 - 118.2
	50th%	93.3	92.0 - 98.2
	90th%	222.7	214.6 - 229.5
	95th%	267.7	260.8 - 275.4
	99th%	415.1	346.0 - 428.5
	Percent Consuming	28.9	
All Fish	Mean	129.0	123.7 - 134.3
	50th%	101.9	98.9 - 103.8
	90th%	249.1	241.0 - 264.1
	95th%	326.0	306.0 - 335.6
	99th%	497.5	469.2 - 519.7
	Percent Consuming	37.0	

Note: Percentile confidence intervals estimated using the bootstrap method with 1,000 replications; percent consuming gives the percentage of individuals consuming the specified category of fish during the 3-day survey period.

Source: U.S. EPA Analysis of CSFII, 1989-1991.

Table 10-9. Per Capita Fish Consumption Rates (milligrams/kg-day) By Habitat and Fish Type
(Uncooked Fish Weight)

	Finfish	Shellfish	Total
	Rate (90% C.I.)	Rate (90% C.I.)	Rate (90% C.I.)
Habitat			
Fresh/Estuarine	58 (47-66)	47 (39-54)	103 (92-115)
Marine	217 (197-237)	14 (12-16)	230 (211-251)
Total	274 (252-296)	60 (52-68)	334 (311-357)

Source: U.S. EPA Analysis of CSFII, 1989-1991.

Table 10-10. Distribution of Fish Intake (milligrams/kg) Per Day Consuming Fish, By Habitat (Uncooked Fish Weight)

Habitat	Statistic	Estimate	90 Percent Confidence Interval
Fresh/Estuarine	Mean	1,492	1,363 - 1,622
	50th%	910	834 - 979
	90th%	3,837	3,502 - 3,954
	95th%	4,793	4,646 - 5,200
	99th%	8,332	7,137 - 8,921
	Percent Consuming	18.5	
Marine	Mean	1,937	1,835 - 2,039
	50th%	1,505	1,450 - 1,566
	90th%	3,699	3,585 - 4,022
	95th%	5,055	4,873 - 5,267
	99th%	8,508	7,848 - 9,139
	Percent Consuming	28.9	
All Fish	Mean	2,145	2,056 - 2,235
	50th%	1,663	1,611 - 1,721
	90th%	4,224	4,086 - 4,454
	95th%	5,478	5,163 - 4,686
	99th%	9,172	8,605 - 9,797
	Percent Consuming	37.0	

Note: Percentile confidence intervals estimated using the bootstrap method with 1,000 replications; percent consuming gives the percentage of individuals consuming the specified category of fish during the 3-day survey period.

Source: U.S. EPA Analysis of CSFII, 1989-1991.

Table 10-11. Per Capita Fish Consumption Rates (g/day) By Habitat and Fish Type (Cooked fish weight)

	Finfish Rate (90% C.I.)	Shellfish Rate (90% C.I.)	Total Rate (90% C.I.)
Habitat			
Fresh/Estuarine	2.8 (2.3-3.2)	2.8 (2.3-3.2)	5.6 (4.9-6.2)
Marine	11.4 (10.5-12.2)	0.8 (0.6-0.9)	12.1 (11.2-13.0)
Total	14.1 (13.1-15.1)	3.5 (3.1-4.0)	17.7 (16.6-18.8)

Note: Percentile confidence intervals estimates using the bootstrap method with 1,000 replications; percent consuming gives the percentage of individuals consuming the specified category of fish during the 3-day survey period.

Source: U.S. EPA Analysis of CSFII, 1989-1991.

Table 10-12. Distribution of Fish Intake (grams) Per Day Consuming Fish, By Habitat (Cooked Fish Weight)

Habitat	Statistic	Estimate	90 Percent Confidence Interval
Fresh/Estuarine	Mean	79.8	73.2 - 86.4
	50th%	50.0	43.9 - 54.3
	90th%	203.1	192.6 - 222.8
	95th%	259.2	241.0 - 266.8
	99th%	431.9	379.8 - 518.4
	Percent Consuming	18.5	
Marine	Mean	101.4	96.7 - 106.1
	50th%	83.9	78.4 - 87.4
	90th%	198.2	191.7 - 205.5
	95th%	231.6	226.5 - 242.7
	99th%	337.0	313.8 - 377.1
	Percent Consuming	28.9	
All Fish	Mean	113.1	108.7 - 127.5
	50th%	90.7	88.4 - 93.2
	90th%	222.7	213.3 - 227.9
	95th%	268.5	261.7 - 290.0
	99th%	410.6	399.2 - 463.2
	Percent Consuming	37.0	

Note: Percentile confidence intervals estimated using the bootstrap method with 1,000 replications; percent consuming gives the percentage of individuals consuming the specified category of fish during the 3-day survey period.

Source: U.S. EPA Analysis of CSFII, 1989-1991.

Table 10-13. Distribution of Quantity of Fish Consumed (in grams) Per Eating Occasion, By Age and Sex

			Percentiles						
Age (years)-Sex Group	Mean	SD	5th	25th	50th	75th	90th	95th	99th
1-2 Male-Female	52	38	8	28	43	58	112	125	168
3-5 Male-Female	70	51	12	36	57	85	113	170	240
6-8 Male-Female	81	58	19	40	72	112	160	170	288
9-14 Male	101	78	28	56	84	113	170	255	425
9-14 Female	86	62	19	45	79	112	168	206	288
15-18 Male	117	115	20	57	85	142	200	252	454
15-18 Female	111	102	24	56	85	130	225	270	568
19-34 Male	149	125	28	64	113	196	284	362	643
19-34 Female	104	74	20	57	85	135	184	227	394
35-64 Male	147	116	28	80	113	180	258	360	577
35-64 Female	119	98	20	57	85	152	227	280	480
65-74 Male	145	109	35	75	113	180	270	392	480
65-74 Female	123	87	24	61	103	168	227	304	448
75+ Male	124	68	36	80	106	170	227	227	336
75+ Female	112	69	20	61	112	151	196	225	360
Overall	117	98	20	57	85	152	227	284	456

Source: Pao et. al., 1982.

assessing per capita intake (the average quantity of fish consumed per fish meal should be less subject to change over time than is per capita intake). In addition, fish mixtures and frozen plate meals were not included in the calculation of fish intake. The per capita fish intake rate reported by Pao et al. (1982) was 11.8 g/day. The 1977-1978 NCFS was a large and well designed survey and the data are representative of the U.S. population.

10.3. RELEVANT GENERAL POPULATION STUDIES

National Human Activity Pattern Survey (NHAPS) - Tsang and Klepeis (1996) - The U.S. EPA collected information for the general population on the duration and frequency of time spent in selected activities and time spent in selected microenvironments via 24-hour diaries. Over 9,000 individuals from 48 contiguous states participated in NHAPS. Approximately 4,700 participants also provided information on seafood consumption. The survey was conducted between October 1992 and September 1994. Data were collected on the (1) number of people that ate seafood in the last month, (2) the number of servings of seafood consumed, and (3) whether the seafood consumed was caught or purchased (Tsang and Klepeis, 1996). The participant responses were weighted according to selected demographics such as age, gender, and race to ensure that results were representative of the U.S. population. Of those 4,700 respondents, 2,980 (59.6 percent) ate seafood (including shellfish, eels, or squid) in the last month (Table 10-14). The number of servings per month were categorized in ranges of 1-2, 3-5, 6-10, 11-19, and 20+ servings per month (Table 10-15). The highest percentage (35 percent) of respondent population had an intake of 3-5 servings per month. Most (92 percent) of the respondents purchased the seafood they ate (Table 10-16).

Intake data were not provided in the survey. However, intake of fish can be estimated using the information on the number of servings of fish eaten from this study and serving size data from other studies. The recommended mean value in this Handbook for fish serving size is 123 g/day. Using this mean value for serving size and assuming that the average individual eats 3-5 servings per month, the amount of seafood eaten per month would range from 369 to 615 grams/month or 12.3 to 20.5 g/day for the highest percentage of the population. These values are within the range of mean intake values for total fish (20.1 g/day) calculated in the U.S. EPA analysis of the USDA CSFII data. It should be noted that an all inclusive description for seafood was not presented in Tsang and Klepeis (1996). It is not known if processed or canned seafood and seafood mixtures are included in the seafood category.

The advantages of NHAPS is that the data were collected for a large number of individuals and are representative of the U.S. general population. However, evaluation of seafood intake was not the primary purpose of the study and the data do not reflect the actual amount of seafood that was eaten. However, using the assumption described above, the estimated seafood intake from this study are comparable to those observed in the EPA CSFII analysis.

USDA Nationwide Food Consumption Survey 1987-88 — The USDA 1987-88 Nationwide Food Consumption Survey (NFCS) was described in Chapter 9. Briefly, the survey consisted of a household and individual component. The household component asked about household food consumption over the past one week period. For the individual component, each member of a surveyed household was interviewed (in person) and asked to recall all foods eaten the previous day; the information from this interview made up the "one day data" for the survey. In addition, members were instructed to fill out a detailed dietary record for the day of the interview and the following day. The data for this entire 3-day period made up the "3-day diet records". A statistical sampling design was used to ensure that all seasons, geographic regions of the U.S., demographic, and socioeconomic groups were represented. Sampling weights were used to match the population distribution of 13 demographic characteristics related to food intake (USDA, 1992a).

Total fish intake was estimated based on consumption of fish products identified in the NFCS data base according to NFCS-defined food codes. These products included fresh, breaded, floured, canned, raw and dried fish, but not fish mixtures or frozen plate meals.

A total of 4,500 households participated in the survey; the household response rate was 38 percent. One day data was obtained for 10,172 (81 percent) of the 12,522 individuals in participating households; 8,468 (68 percent) individuals completed 3-day diet records.

USDA (1992b) used the one day data to derive per capita fish intake rate and intake rates for consumers of total fish. These rates, calculated by sex and age group, are shown in Table 10-17. Intake rates for consumers-only were calculated by dividing the per capita intake rate by the fraction of the population consuming fish in one day.

The 1987-1988 NFCS was also utilized to estimate consumption of home produced fish (as well as home

TABLE 10-14. PERCENT OF POPULATION THAT ATE SEAFOOD (INCLUDING SHELLFISH, EELS, OR SQUID)

		DID RES EAT SEAFOOD LAST MONTH					
		0:NO		1:YES		8:DK	
	ALL	RESPOND.		RESPOND.		RESPOND.	
	N	N	%	N	%	N	%
OVERALL	4663	1811	38.8	2780	59.6	72	1.5
----- GENDER ------							
.	2	1	50.0	1	50.0	.	.
1:MALE	2163	821	38.0	1311	60.6	31	1.4
2:FEMALE	2498	989	39.6	1468	58.8	41	1.6
------ AGE --------							
.	84	25	29.8	42	50.0	17	20.2
1:1-4	263	160	60.8	102	38.8	1	0.4
2:5-11	348	177	50.9	166	47.7	5	1.4
3:12-17	326	179	54.9	137	42.0	10	3.1
4:18-64	2972	997	33.5	1946	65.5	29	1.0
5:> 64	670	273	40.7	387	57.8	10	1.5
------ RACE -------							
.	60	20	33.3	22	36.7	18	30.0
1:WHITE	3774	1475	39.1	2249	59.6	50	1.3
2:BLACK	463	156	33.7	304	65.7	3	0.6
3:ASIAN	77	21	27.3	56	72.7	.	.
4:SOME OTHERS	96	39	40.6	56	58.3	1	1.0
5:HISPANIC	193	100	51.8	93	48.2	.	.
---- HISPANIC -----							
.	46	10	21.7	17	37.0	19	41.3
0:NO	4243	1625	38.3	2565	60.5	53	1.2
1:YES	348	165	47.4	183	52.6	.	.
8:DK	26	11	42.3	15	57.7	.	.
--- EMPLOYMENT ----							
.	958	518	54.1	412	43.0	28	2.9
1:FULL TIME	2017	630	31.2	1366	67.7	21	1.0
2:PART TIME	379	134	35.4	236	62.3	9	2.4
3:NOT EMPLOYED	1309	529	40.4	766	58.5	14	1.1
--- EDUCATION -----							
.	1021	550	53.9	434	42.5	37	3.6
1:< HIGH SCHOOL	399	196	49.1	198	49.6	5	1.3
2:HIGH SCHOOL GRAD	1253	501	40.0	739	59.0	13	1.0
3:< COLLEGE	895	304	34.0	584	65.3	7	0.8
4:COLLEGE GRAD.	650	159	24.5	484	74.5	7	1.1
5:POST GRAD.	445	101	22.7	341	76.6	3	0.7
-- CENSUS REGION --							
1:NORTHEAST	1048	370	35.3	655	62.5	23	2.2
2:MIDWEST	1036	449	43.3	575	55.5	12	1.2
3:SOUTH	1601	590	36.9	989	61.8	22	1.4
4:WEST	978	402	41.1	561	57.4	15	1.5
--- DAY 0F WEEK ---							
1:WEEKDAY	3156	1254	39.7	1848	58.6	54	1.7
2:WEEKEND	1507	557	37.0	932	61.8	18	1.2
------ SEASON -----							
1:WINTER	1264	462	36.6	780	61.7	22	1.7
2:SPRING	1181	469	39.7	691	58.5	21	1.8
3:SUMMER	1275	506	39.7	745	58.4	24	1.9
4:FALL	943	374	39.7	564	59.8	5	0.5
------ ASTHMA -----							
0:NO	4287	1674	39.0	2563	59.8	50	1.2
1:YES	341	131	38.4	207	60.7	3	0.9
8:DK	35	6	17.1	10	28.6	19	54.3
------ ANGINA -----							
0:NO	4500	1750	38.9	2698	60.0	52	1.2
1:YES	125	56	44.8	68	54.4	1	0.8
8:DK	38	5	13.2	14	36.8	19	50.0
-- BRONCH/EMPHYS --							
0:NO	4424	1726	39.0	2648	59.9	50	1.1
1:YES	203	80	39.4	121	59.6	2	1.0
8:DK	36	5	13.9	11	30.6	20	55.6

NOTE: . = MISSING DATA; DK = DONT' KNOW; % = ROW PERCENTAGE; N = SAMPLE SIZE

Source: Tsang and Klepeis, 1996.

TABLE 10-15. NUMBER OF SERVINGS OF SEAFOOD CONSUMED

		# OF SERVINGS RES ATE SEAFOOD					
		1:1-2	2:3-5	3:6-10	4:11-19	5:20+	8:DK
	ALL	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.
	N	N	N	N	N	N	N
OVERALL	2780	918	990	519	191	98	64
----- GENDER ------							
1:MALE	1311	405	458	261	101	57	29
2:FEMALE	1468	512	532	258	90	41	35
9:REF	1	1	.	.	.	.	.
------ AGE -------							
.	42	13	16	5	4	1	3
1:1-4	102	55	29	12	2	.	4
2:5-11	166	72	57	21	6	4	6
3:12-17	137	68	54	9	2	1	3
4:18-64	1946	603	679	408	145	79	32
5:> 64	387	107	155	64	32	13	16
------ RACE -------							
1:WHITE	2249	731	818	428	155	76	41
2:BLACK	304	105	103	56	16	10	14
3:ASIAN	56	15	17	11	5	5	3
4:SOME OTHERS	56	22	18	6	5	3	2
5:HISPANIC	93	41	25	14	9	2	2
9:REF	22	4	9	4	1	2	2
----- HISPANIC ----							
0:NO	2566	844	922	480	175	88	57
1:YES	182	68	52	34	15	8	5
8:DK	15	5	8	2	.	.	.
9:REF	17	1	8	3	1	2	2
--- EMPLOYMENT ----							
.	399	190	140	40	11	5	13
1:FULL TIME	1366	407	466	307	107	57	22
2:PART TIME	236	70	95	46	14	8	3
3:NOT EMPLOYED	766	249	285	124	57	26	25
9:REF	13	2	4	2	2	2	1
--- EDUCATION ----							
.	434	205	149	47	12	7	14
1:< HIGH SCHOOL	198	88	62	20	6	10	12
2:HIGH SCHOOL GRAD	739	267	266	119	46	21	20
3:< COLLEGE	584	161	219	122	48	26	8
4:COLLEGE GRAD.	484	115	183	121	43	17	5
5:POST GRAD.	341	82	111	90	36	17	5
-- CENSUS REGION --							
1:NORTHEAST	655	191	241	137	62	12	12
2:MIDWEST	575	199	221	102	17	22	14
3:SOUTH	989	336	339	175	70	41	28
4:WEST	561	192	189	105	42	23	10
--- DAY 0F WEEK ---							
1:WEEKDAY	1848	602	661	346	129	70	40
2:WEEKEND	932	316	329	173	62	28	24
------ SEASON -----							
1:WINTER	780	262	284	131	60	28	15
2:SPRING	691	240	244	123	45	25	14
3:SUMMER	745	220	249	160	59	31	26
4:FALL	564	196	213	105	27	14	9
------ ASTHMA -----							
0:NO	2563	846	917	475	180	88	57
1:YES	207	69	71	42	11	9	5
8:DK	10	3	2	2	.	1	2
------ ANGINA -----							
0:NO	2698	896	960	509	183	95	55
1:YES	68	19	27	8	7	1	6
8:DK	14	3	3	2	1	2	3
-- BRONCH/EMPHYS --							
0:NO	2648	877	940	495	185	91	60
1:YES	121	37	47	23	6	6	2
8:DK	11	4	3	1	.	1	2

NOTE: . = MISSING DATA; DK = DON’T KNOW; % = ROW PERCENTAGE; N = SAMPLE SIZE

Source: Tsang and Klepeis, 1996.

TABLE 10-16. FREQUENCY OF SEAFOOD THAT WAS CONSUMED BEING PURCHASED OR CAUGHT BY SOMEONE THEY KNEW

		WAS SEAFOOD PURCHASED OR CAUGHT			
		.	1:MOSTLY PURCHAS- ED	2:MOSTLY CAUGHT	8:DK
	ALL	RESPOND.	RESPOND.	RESPOND.	RESPOND.
	N	N	N	N	N
OVERALL	2780	3	2584	154	39
----- GENDER ------					
1:MALE	1311	1	1206	85	19
2:FEMALE	1468	2	1377	69	20
9:REF	1	.	1	.	.
------ AGE -------					
.	42	.	39	3	.
1:1-4	102	.	94	8	.
2:5-11	166	.	153	9	4
3:12-17	137	.	129	6	2
4:18-64	1946	3	1810	106	27
5:> 64	387	.	359	22	6
------ RACE -------					
1:WHITE	2249	1	2092	124	32
2:BLACK	304	1	280	19	4
3:ASIAN	56	.	50	4	2
4:SOME OTHERS	56	.	55	.	1
5:HISPANIC	93	.	86	7	.
9:REF	22	1	21	.	.
----- HISPANIC ----					
0:NO	2566	2	2387	140	37
1:YES	182	.	169	13	.
8:DK	15	.	12	1	2
9:REF	17	1	16	.	.
--- EMPLOYMENT ----					
.	399	.	368	25	6
1:FULL TIME	1366	2	1285	64	15
2:PART TIME	236	1	217	15	3
3:NOT EMPLOYED	766	.	701	50	15
9:REF	13	.	13	.	.
--- EDUCATION ----					
.	434	.	401	26	7
1:< HIGH SCHOOL	198	.	174	20	4
2:HIGH SCHOOL GRAD	739	.	680	48	11
3:< COLLEGE	584	2	547	28	7
4:COLLEGE GRAD.	484	.	460	19	5
5:POST GRAD.	341	1	322	13	5
-- CENSUS REGION --					
1:NORTHEAST	655	2	627	21	5
2:MIDWEST	575	.	547	20	8
3:SOUTH	989	1	897	73	18
4:WEST	561	.	513	40	8
--- DAY 0F WEEK ---					
1:WEEKDAY	1848	2	1724	100	22
2:WEEKEND	932	1	860	54	17
------ SEASON -----					
1:WINTER	780	.	741	35	4
2:SPRING	691	.	655	27	9
3:SUMMER	745	2	674	54	15
4:FALL	564	1	514	38	11
------ ASTHMA -----					
0:NO	2563	2	2384	142	35
1:YES	207	1	190	12	4
8:DK	10	.	10	.	.
------ ANGINA -----					
0:NO	2698	3	2507	151	37
1:YES	68	.	63	3	2
8:DK	14	.	14	.	.
-- BRONCH/EMPHYS --					
0:NO	2648	3	2457	149	39
1:YES	121	.	116	5	.
8:DK	11	.	11	.	.

NOTE: . = MISSING DATA; DK = DON'T KNOW; % = ROW PERCENTAGE; N = SAMPLE SIZE

Source: Tsang and Klepeis, 1996.

Table 10-17. Mean Fish Intake in a Day, by Sex and Age[a]

Sex Age (year)	Per capita intake (g/day)	Percent of population consuming fish in 1 day	Mean intake (g/day) for consumers only[b]
Males or Females	4	6.0	67
5 and under			
Males	3	3.7	79
6-11	3	2.2	136
12-19	15	10.9	138
20 and over			
Females	7	7.1	99
6-11	9	9.0	100
12-19	12	10.9	110
20 and over			
All individuals	11	9.4	117

[a] Based on USDA Nationwide Food Consumption Survey 1987-88 data for one day.
[b] Intake for users only was calculated by dividing the per capita consumption rate by the fraction of the population consuming fish in one day.
Source: USDA, 1992b.

produced fruits, vegetables, meats and dairy products) in the general U.S. population. The methodology for estimating home-produced intake rates was rather complex and involved combining the household and individual components of the NFCS; the methodology, as well as the estimated intake rates, are described in detail in Chapter 12. However, since much of the rest of this chapter is concerned with estimating consumption of recreationally caught, i.e., home produced fish, the methods and results of Chapter 12, as they pertain to fish consumption, are summarized briefly here.

A total of 2.1 percent of the survey population reported home produced fish consumption during the survey week. Among consumers, the mean intake rate was 2.07 g/kg-day and the 95th percentile was 7.83 g/kg-day; the per-capita intake rate was 0.04 g/kg-day. Note that intake rates for home-produced foods were indexed to the weight of the survey respondent and reported in g/kg-day.

It is possible to compare the estimates of home-produced fish consumption derived in this analyses with estimates derived from studies of recreational anglers (described in Sections 10.4-10.8); however, the intake rates must be put into a similar context. The home-produced intake rates described refer to average daily intake rates among individuals consuming home-produced fish in a week; results from recreational angler studies, however, usually report average daily rates for those eating home-produced fish (or for those who recreationally fish) at least some time during the year. Since many of these latter individuals eat home-produced fish at a frequency of less than once per week, the average daily intake in this group would be expected to be less than that reported.

The NFCS household component contains the question “Does anyone in your household fish?”. For the population answering yes to this question (21 percent of households), the NFCS data show that 9 percent consumed home-produced fish in the week of the survey; the mean intake rate for these consumers from fishing households was 2.2 g/kg-day. (Note that 91 percent of individuals reporting home grown fish consumption for the week of the survey indicated that a household member fishes; the overall mean intake rate among home-produced fish consumers, regardless of fishing status, was the above reported 2.07 g/kg-day). The per capita intake rate among those living in a fishing household is then calculated as 0.2 g/kg-day (2.2 * 0.09). Using the estimated average weight of survey participants of 59 kg, this translates into 11.8 g/day. Among members of fishing households, home-produced fish consumption accounted for 32.5 percent of total fish consumption.

As discussed in Chapter 12 of this volume, intake rates for home-produced foods, including fish, are based on the results of the household survey, and as such, reflect the weight of fish taken into the household. In most of the recreational fish surveys discussed later in this section, the weight of the fish catch (which generally corresponds to the weight taken into the household) is multiplied by an edible fraction to convert to an uncooked equivalent of the amount consumed. This fraction may be species specific, but some studies used an average value; these average values ranged from 0.3 to 0.5. Using a factor of 0.5 would convert the above 11.8 g/day rate to 5.9 g/day. This estimate, 5.9 g/day, of the per-capita fish intake rate among members of fishing households is within the range of the per-capita intake rates among recreational anglers addressed in sections to follow.

An advantage of analyses based on the 1987-1988 USDA NFCS is that the data set is a large, geographically and seasonally balanced survey of a representative sample of the U.S. population. The survey response rate, however, was low and an expert panel concluded that it was not possible to establish the presence or absence of non-response bias (USDA, 1992b). Limitations of the home-produced analysis are given in Chapter 12 of this volume.

10.4. KEY RECREATIONAL (MARINE FISH STUDIES)

National Marine Fisheries Service (1986a, b, c; 1993) - The National Marine Fisheries Service (NMFS) conducts systematic surveys, on a continuing basis, of marine recreational fishing. These surveys are designed to estimate the size of the recreational marine finfish catch by location, species and fishing mode. In addition, the surveys provide estimates for the total number of participants in marine recreational finfishing and the total number of fishing trips. The surveys are not designed to estimate individual consumption of fish from marine recreational sources, primarily because they do not attempt to estimate the number of individuals consuming the recreational catch. Intake rates for marine recreational anglers can be estimated, however, by employing assumptions derived from other data sources about the number of consumers.

The NMFS surveys involve two components, telephone surveys and direct interviewing of fishermen in the field. The telephone survey randomly samples residents of coastal regions, defined generally as counties within 25 miles of the nearest seacoast, and inquires about participation in marine recreational fishing in the resident's home state in the past year, and more specifically, in the past two months. This component of the survey is used to estimate, for each coastal state, the total number of coastal region residents who participate in marine recreational fishing (for finfish) within the state, as well as the total number of (within state) fishing trips these residents take. To estimate the total number of participants and fishing trips in the state, by coastal residents and others, a ratio approach, based on the field interview data, was used. Thus, if the field survey data found that there was a 4:1 ratio of fishing trips taken by coastal residents as compared to trips taken by non-coastal and out of state residents, then an additional 25 percent would be added to the number of trips taken by coastal residents to generate an estimate of the total number of within state trips.

The field intercept survey is essentially a creel type survey. The survey utilizes a national site register which details marine fishing locations in each state. Sites for field interviews are chosen in proportion to fishing frequency at the site. Anglers fishing on shore, private boat, and charter/party boat modes who had completed their fishing were interviewed. The field survey included questions about frequency of fishing, area of fishing, age, and place of residence. The fish catch was classified by the interviewer as either type A, type B1 or type B2 catch. The type A catch denoted fish that were taken whole from the fishing site and were available for inspection. The type B1 and B2 catch were not available for inspection; the former consisted of fish used as bait, filleted, or discarded dead while the latter was fish released alive. The type A catch was identified by species and weighed, with the weight reflecting total fish weight, including inedible parts. The type B1 catch was not weighed, but weights were estimated using the average weight derived from the type A catch for the given species, state, fishing mode and season of the year. For both the A and B1 catch, the intended disposition of the catch (e.g., plan to eat, plan to throw away, etc.) was ascertained.

EPA obtained the raw data tapes from NMFS in order to generate intake distributions and other specialized analyses. Fish intake distributions were generated using the field survey tapes. Weights proportional to the inverse of the angler's reported fishing frequency were employed to correct for the unequal probabilities of sampling; this was the same approach used by NMFS in deriving their estimates. Note that in the field survey, anglers were interviewed regardless of past interviewing experience; thus, the use of inverse fishing frequency as weights was justified (see Section 10.1).

For each angler interviewed in the field survey, the yearly amount of fish caught that was intended to be eaten by the angler and his/her family or friends was estimated by EPA as follows:

$$Y = [(\text{wt of A catch}) * I_A + (\text{wt of B1 catch}) * I_B] * [\text{Fishing frequency}] \qquad \text{(Eqn. 10-1)}$$

where I_A (I_B) are indicator variables equal to 1 if the type A (B1) catch was intended to be eaten and equal to 0 otherwise. To convert Y to a daily fish intake rate by the angler, it was necessary to convert amount of fish caught to edible amount of fish, divide by the number of intended consumers, and convert from yearly to daily rate. Although theoretically possible, EPA chose not to use species specific edible fractions to convert overall weight to edible fish weight since edible fraction estimates were not readily available for many marine species. Instead, an average value of 0.5 was employed. For the number of intended consumers, EPA used an average value of 2.5 which was an average derived from the results of several studies of recreational fish consumption (Chemrisk, 1991; Puffer et al., 1981; West et al., 1989). Thus, the average daily intake rate (ADI) for each angler was calculated as

$$ADI = Y * (0.5)/[2.5 * 365] \qquad \text{(Eqn. 10-2)}$$

Note that ADI will be 0 for those anglers who either did not intend to eat their catch or who did not catch any fish. The distribution of ADI among anglers was calculated by region and coastal status (i.e., coastal versus non-coastal counties). A mean ADI for the overall population of a given area was calculated as follows: first the estimated number of anglers in the area was multiplied by the average number of intended fish consumers (2.5) to get a total number of recreational marine finfish consumers. This number was then multiplied by the mean ADI among anglers to get the total recreational marine finfish consumption in the area. Finally, the mean ADI in the population was calculated by dividing total fish consumption by the total population in the area.

The results presented below are based on the results of the 1993 survey. Samples sizes were 200,000 for the telephone survey and 120,000 for the field surveys. All coastal states in the continental U.S. were included in the survey except Texas and Washington.

Table 10-18 presents the estimated number of coastal, non-coastal, and out-of-state fishing participants by state and region of fishing. Florida had the greatest number of both Atlantic and Gulf participants. The total number of coastal residents who participated in marine finfishing in their home state was 8 million; an additional 750,000 non-coastal residents participated in marine finfishing in their home state.

Table 10-19 presents the estimated total weight of the A and B1 catch by region and time of year. For each region, the greatest catches were during the six-month period from May through October. This period accounted for about 90 percent of the North and Mid-Atlantic catch, about 80 percent of the N. California and Oregon catch, about 70 percent of the S. Atlantic and S. California catch and 62 percent of the Gulf catch. Note that in the North and Mid-Atlantic regions, field surveys were not done in January and February due to very low fishing activity. For all regions, over half the catch occurred within 3 miles of the shore or in inland waterways.

Table 10-20 presents the mean and 95th percentile of average daily intake of recreationally caught marine finfish among anglers by region. The mean ADI among all anglers was 5.6, 7.2, and 2.0 g/day for the Atlantic, Gulf, and Pacific regions, respectively. Also given is the per-capita ADI in the overall population (anglers and non-anglers) of the region and in the overall coastal population of the region. Table 10-21 gives the distribution of the catch by species for the Atlantic and Gulf regions and Table 10-22 for Pacific regions.

The NMFS surveys provide a large, up-to-date, and geographically representative sample of marine angler activity in the U.S. The major limitation of this data base in terms of estimating fish intake is the lack of information regarding the intended number of consumers of each angler's catch. In this analysis, it was assumed that every angler's catch was consumed by the same number (2.5) of people; this number was derived from averaging the results of other studies. This assumption introduces a relatively low level of uncertainty in the estimated mean intake rates among anglers, but a somewhat higher level of uncertainty in the estimated intake distributions. It should be noted that under the above assumption, the distributions shown here pertain not only to the population of anglers, but also to the entire population of recreational fish consumers, which is 2.5 times the number of anglers. If the number of consumers was changed, to, for instance, 2.0, then the distribution would be increased by a factor of 1.25 (2.5/2.0) but the estimated population of recreational fish consumers to which the distribution would apply would decrease by a factor of 0.8 (2.0/2.5). Note that the mean intake rate of marine finfish in the overall population is independent of the assumption of number of intended fish consumers.

Table 10-18. Estimated Number of Participants in Marine Recreational Fishing by State and Subregion

Subregion	State	Coastal Participants	Non Coastal Participants	Out of State [a]	Total Participants [a]
Pacific	So. California	902	8	159	910
	N. California	534	99	63	633
	Oregon	265	19	78	284
	TOTAL	1,701	126		
North Atlantic	Connecticut	186	*[b]	47	186
	Maine	93	9	100	102
	Massachusetts	377	69	273	446
	New Hampshire	34	10	32	44
	Rhode Island	97	*	157	97
	TOTAL	787	88		
Mid-Atlantic	Delaware	90	*	159	90
	Maryland	540	32	268	572
	New Jersey	583	9	433	592
	New York	539	13	70	552
	Virginia	294	29	131	323
	TOTAL	1,046	83		
South Atlantic	Florida	1,201	*	741	1,201
	Georgia	89	61	29	150
	N. Carolina	398	224	745	622
	S. Carolina	131	77	304	208
	TOTAL	1,819	362		
Gulf of Mexico	Alabama	95	9	101	104
	Florida	1,053	*	1,349	1,053
	Louisiana	394	48	63	442
	Mississippi	157	42	51	200
	TOTAL	1,699	99		
	GRAND TOTAL	8,053	760		

[a] Not additive across states. One person can be counted as "OUT OF STATE" for more than one state.
[b] An asterisk (*) denotes no non-coastal counties in state.
Source: NMFS, 1993.

Table 10-19. Estimated Weight of Fish Caught (Catch type A and B1) by Marine Recreational Fishermen, by Wave and Subregion

	Atlantic and Gulf		Pacific	
	Region	Weight (1000 kg)	Region	Weight (1000 kg)
Jan/Feb	South Atlantic	1,060	So. California	418
	Gulf	3,683	N. California	101
			Oregon	165
	TOTAL	4,743	TOTAL	684
Mar/Apr	North Atlantic	310	So. California	590
	Mid Atlantic	1,030	N. California	346
	South Atlantic	1,913	Oregon	144
	Gulf	3,703		
	TOTAL	6,956	TOTAL	1,080
May/Jun	North Atlantic	3,272	So.California	1,195
	Mid Atlantic	4,815	N. California	563
	South Atlantic	4,234	Oregon	581
	Gulf	5,936		
	TOTAL	18,257	TOTAL	2,339
Jul/Aug	North Atlantic	4,003	So. California	
	Mid Atlantic	9,693	N. California	1,566
	South Atlantic	4,032	Oregon	1,101
	Gulf	5,964		39
	TOTAL	23,692	TOTAL	2,706
Sep/Oct	North Atlantic	2,980	So. California	859
	Mid Atlantic	7,798	N. California	1,032
	South Atlantic	3,296	Oregon	724
	Gulf	7,516		
	TOTAL	21,590	TOTAL	2,615
Nov/Dec	North Atlantic	456	So. California	447
	Mid Atlantic	1,649	N. California	417
	South Atlantic	2,404	Oregon	65
	Gulf	4,278		
	TOTAL	8,787	TOTAL	929
	GRAND TOTAL	84,025	GRAND TOTAL	10,353

Source: NMFS, 1993.

Table 10-20. Average Daily Intake (g/day) of Marine Finfish, by Region and Coastal Status

	Intake Among Anglers				
Region[a]	Mean	95th Percentile	Per-Capita (Coastal)[b]	Per-Capita (Coastal & Non-Coastal)[c]	Proportion of Population Coastal
N. Atlantic	6.2	20.1	1.2	1.1	0.82
Mid-Atlantic	6.3	18.9	1.2	0.9	0.70
S. Atlantic	4.7	15.9	1.5	1.0	0.51
All Atlantic	5.6	18.0	1.3	0.9	0.66
Gulf	7.2	26.1	3.0	1.9	0.60
S. California	2.0	5.5	0.2	0.2	0.96
N. California	2.0	5.7	0.3	0.3	0.70
Oregon	2.2	8.9	0.5	0.5	0.87
All Pacific	2.0	6.8	0.3	0.3	0.86

[a] N. Atlantic - ME, NH, MA, RI, and CT; Mid-Atlantic - NY, NJ, MD, DE, and VA; S. Atlantic - NC, SC, GA, and FL (Atlantic Coast); Gulf - AL, MS, LA, and FL (Gulf Coast).
[b] Mean intake rate among entire coastal population of region.
[c] Mean intake rate among entire population of region.
Source: NMFS, 1993.

Table 10-21. Estimated Weight of Fish Caught (Catch Type A and B1)[a] by Marine Recreational Fishermen by Species Group and Subregion, Atlantic and Gulf

	North Atlantic (1,000 kg)	Mid Atlantic (1,000 kg)	South Atlantic (1,000 kg)	Gulf (1,000 kg)	All Regions (1,000 kg)
Cartilaginous fishes	66	1,673	162	318	2,219
Eels	14	9	*[b]	0[c]	23
Herrings	118	69	1	89	177
Catfishes	0	306	138	535	979
Toadfishes	0	7	0	*	7
Cods and Hakes	2,404	988	4	0	1,396
Searobins	2	68	*	*	70
Sculpins	1	*	0	0	1
Temperate Basses	837	2,166	22	4	2,229
Sea Basses	22	2,166	644	2,477	5,309
Bluefish	4,177	3,962	1,065	158	5,362
Jacks	0	138	760	2,477	3,375
Dolphins	65	809	2,435	1,599	4,908
Snappers	0	*	508	3,219	3,727
Grunts	0	9	239	816	1,064
Porgies	132	417	1,082	2,629	4,160
Drums	3	2,458	2,953	9,866	15,280
Mullets	1	43	382	658	1,084
Barracudas	0	*	356	244	600
Wrasses	783	1,953	46	113	2,895
Mackerels and Tunas	878	3,348	4,738	4,036	13,000
Flounders	512	4,259	532	377	5,680
Triggerfishes/Filefishes	0	48	109	544	701
Puffers	*	16	56	4	76
Other fishes	105	72	709	915	1,801

[a] For Catch Type A and B1, the fish were not thrown back.
[b] An asterisk (*) denotes data not reported.
[c] Zero (0) = < 1000 kg.
Source: NMFS, 1993.

Table 10-22. Estimated Weight of Fish Caught (Catch Type A and B1)[a] by Marine Recreational Fishermen by Species Group and Subregion, Pacific

Species Group	Southern California (1,000 kg)	Northern California (1,000 kg)	Oregon (1,000 kg)	Total
Cartilaginous fish	35	162	1	198
Sturgeons	0[b]	89	13	102
Herrings	10	15	40	65
Anchovies	*[c]	7	0	7
Smelts	0	71	0	71
Cods and Hakes	0	0	0	0
Silversides	58	148	0	206
Striped Bass	0	51	0	51
Sea Basses	1,319	17	0	1,336
Jacks	469	17	1	487
Croakers	141	136	0	277
Sea Chubs	53	1	0	54
Surfperches	74	221	47	342
Pacific Barracuda	866	10	0	876
Wrasses	73	5	0	78
Tunas and Mackerels	1,260	36	1	1,297
Rockfishes	409	1,713	890	3,012
California Scorpionfish	86	0	0	86
Sablefishes	0	0	5	5
Greenlings	22	492	363	877
Sculpins	6	81	44	131
Flatfishes	106	251	5	362
Other fishes	89	36	307	432

[a] For Catch Type A and B1, the fish were not thrown back.
[b] Zero (0) = < 1000 kg.
[c] An asterisk (*) denotes data not reported.
Source: NMFS, 1993.

Another uncertainty involves the use of 0.5 as an (average) edible fraction. This figure is somewhat conservative (i.e., the true average edible fraction is probably lower); thus, the intake rates calculated here may be biased upward somewhat.

It should be noted again that the recreational fish intake distributions given refer only to marine finfish. In addition, the intake rates calculated are based only on the catch of anglers in their home state. Marine fishing performed out-of-state would not be included in these distributions. Therefore, these distributions give an estimate of consumption of locally caught fish.

10.5 RELEVANT RECREATIONAL MARINE STUDIES

Puffer et al. - Intake Rates of Potentially Hazardous Marine Fish Caught in the Metropolitan Los Angeles Area - Puffer et al. (1981) conducted a creel survey with sport fishermen in the Los Angeles area in 1980. The survey was conducted at 12 sites in the harbor and coastal areas to evaluate intake rates of potentially hazardous marine fish and shellfish by local, non-professional fishermen. It was conducted for the full 1980 calendar year, although inclement weather in January, February, and March limited the interview days. Each site was surveyed an average of three times per month, on different days, and at a different time of the day. The survey questionnaire was designed to collect information on demographic characteristics, fishing patterns, species, number of fish caught, and fish consumption patterns. Scales were used to obtain fish weights. Interviews were conducted only with anglers who had caught fish, and the anglers were interviewed only once during the entire survey period.

Puffer et al. (1981) estimated daily consumption rates (grams/day) for each angler using the following equation:

$$(K \times N \times W \times F)/[E \times 365] \qquad \text{(Eqn. 10-3)}$$

where:

K = edible fraction of fish (0.25 to 0.5 depending on species);
F = frequency of fishing/year;
E = number of fish eaters in family/living group;
W = average weight of (grams) fish in catch; and
N = number of fish in catch.

No explicit survey weights were used in analyzing this survey; thus, each respondent's data was given equal weight.

A total of 1,059 anglers were interviewed for the survey. The ethnic and age distribution of respondents is shown in Table 10-23; 88 percent of respondents were male. The median intake rate was higher for Oriental/Samoan anglers (median 70.6 g/day) than for other ethnic groups and higher for those ages over 65 years (median 113.0 g/day) than for other age groups. Puffer et al. (1981) found similar median intake rates for seasons; 36.3 g/day for November through March and 37.7 g/day for April through October. Puffer et al. (1981) also evaluated fish preparation methods; these data are presented in Appendix 10B. The cumulative distribution of recreational fish (finfish and shellfish) consumption by survey respondents is presented in Table 10-24; this distribution was calculated only for those fishermen who indicated they eat the fish they catch. The median fish consumption rate was 37 g/day and the 90th percentile rate was 225 g/day (Puffer et al., 1981). A description of catch patterns for primary fish species kept is presented in Table 10-25.

Table 10-23. Median Intake Rates Based on Demographic Data of Sport Fishermen and Their Family/Living Group

	Percent of total interviewed	Median intake rates (g/person-day)
Ethnic Group		
Caucasian	42	46.0
Black	24	24.2
Mexican-American	16	33.0
Oriental/Samoan	13	70.6
Other	5	--[a]
Age (years)		
< 17	11	27.2
18 - 40	52	32.5
41 - 65	28	39.0
> 65	9	113.0

[a] Not reported.
Source: Puffer et al., 1981.

Table 10-24. Cumulative Distribution of Total Fish/Shellfish Consumption by Surveyed Sport Fishermen in the Metropolitan Los Angeles Area

Percentile	Intake rate (g/person-day)
5	2.3
10	4.0
20	8.3
30	15.5
40	23.9
50	36.9
60	53.2
70	79.8
80	120.8
90	224.8
95	338.8

Source: Puffer et al. (1981).

Table 10-25. Catch Information for Primary Fish Species Kept by Sport Fishermen (n = 1059)

Species	Average Weight (Grams)	Percent of Fishermen who Caught
White Croaker	153	34
Pacific Mackerel	334	25
Pacific Bonito	717	18
Queenfish	143	17
Jacksmelt	223	13
Walleye Perch	115	10
Shiner Perch	54	7
Opaleye	307	6
Black Perch	196	5
Kelp Bass	440	5
California Halibut	1752	4
Shellfish[a]	421	3

[a] Crab, mussels, lobster, abalone.
Source: Modified from Puffer et al., 1981.

As mentioned in the Background to this Chapter, intake distributions derived from analyses of creel surveys which did not employ weights reflective of sampling probabilities will overestimate the target population intake distribution and will, in fact, be more reflective of the "resource utilization distribution". Therefore, the reported median level of 37.3 g/day does not reflect the fact that 50 percent of the target population has intake above this level; instead 50 percent of recreational fish consumption is by individuals consuming at or above 37.3 g/day. In order to generate an intake distribution reflective of that in the target population, weights inversely proportional to sampling probability need to be employed. Price et al. (1994) made this attempt with the Puffer et al. (1981) survey data, using inverse fishing frequencies as the sampling weights. Price et al. (1994) was unable to get the raw data for this survey, but using frequency tables and the average level of fish consumption per fishing trip provided in Puffer et al. (1981), generated an approximate revised intake distribution. This distribution was dramatically lower than that obtained by Puffer et al. (1981); the median was estimated at 2.9 g/day (compared with 37.3 from Puffer et al., 1981) and the 90th percentile at 35 g/day (compared to 225 g/day from Puffer et al., 1981).

There are several limitations to the interpretation of the percentiles presented by both Puffer et al. (1981) and Price et al. (1994). As described in Appendix 10A, the interpretation of percentiles reported from creel surveys in terms of percentiles of the "resource utilization distribution" is approximate and depends on several assumptions. One of these assumptions is that sampling probability is proportional to inverse fishing frequency. In this survey, where interviewers revisited sites numerous times and anglers were not interviewed more than once, this assumption is not valid, though it is likely that the sampling probability is still highly dependant on fishing frequency so that the assumption does hold in an approximate sense. The validity of this assumption also impacts the interpretation of percentiles reported by Price et al. (1994) since inverse frequency was used as sampling weights. It is likely that the value (2.9 g/day) of Price et al. (1994) underestimates somewhat the median intake in the target population, but is much closer to the actual value than the Puffer et al. (1981) estimate of 37.3 g/day. Similar statements would apply about the 90th percentile. Similarly, the 37.3 g/day median value, if interpreted as the 50th percentile of the "resource utilization distribution", is also somewhat of an underestimate.

It should be noted again that the fish intake distribution generated by Puffer et al. (1981) (and by Price et al., 1994) was based only on fishermen who caught fish and ate the fish they caught. If all anglers were included, intake estimates would be somewhat lower. In contrast, the survey assumed that the number of fish caught at the time of the interview was all that would be caught that day. If it were possible to interview fishermen at the conclusion of their fishing day, intake estimates could be potentially higher. An additional factor potentially affecting intake rates is that fishing quarantines were imposed in early spring due to heavy sewage overflow (Puffer et al., 1981).

Pierce et al. (1981) - Commencement Bay Seafood Consumption Study - Pierce et al. (1981) performed a local creel survey to examine seafood consumption patterns and demographics of sport fishermen in Commencement Bay, Washington. The objectives of this survey included determining (1) seafood consumption habits and demographics of non-commercial anglers catching seafood; (2) the extent to which resident fish were used as food; and (3) the method of preparation of the fish to be consumed. Salmon were excluded from the survey since it was believed that they had little potential for contamination. The first half of this survey was conducted from early July to mid-September, 1980 and the second half from mid-September through most of November. During the summer months, interviewers visited each of 4 sub-areas of Commencement Bay on five mornings and five evenings; in the fall the areas were sampled 4 complete survey days. Interviews were conducted only with persons who had caught fish. The anglers were interviewed only once during the survey period. Data were recorded for species, wet weight, size of the living group (family, place of residence, fishing frequency, planned uses of the fish, age, sex, and race (Pierce et al., 1981). The analysis of Pierce et al. (1981) did not employ explicit sampling weights (i.e., all weights were set to 1).

There were 304 interviews in the summer and 204 in the fall. About 60 percent of anglers were white, 20 percent black, 19 percent Oriental and the rest Hispanic or Native American. Table 10-26 gives the distribution of fishing frequency calculated by Pierce et al. (1981); for both the summer and fall, more than half of the fishermen caught and consumed fish weekly. The dominant (by weight) species caught were Pacific Hake and Walleye Pollock. Pierce et al. (1981) did not present a distribution of fish intake or a mean fish intake rate.

Table 10-26. Percent of Fishing Frequency During the Summer and Fall Seasons in Commencement Bay, Washington

Fishing Frequency	Frequency Percent in the Summer[a]	Frequency Percent in the Fall[b]	Frequency Percent in the Fall[c]
Daily	10.4	8.3	5.8
Weekly	50.3	52.3	51.0
Monthly	20.1	15.9	21.1
Bimonthly	6.7	3.8	4.2
Biyearly	4.4	6.1	6.3
Yearly	8.1	13.6	11.6

[a] Summer - July through September, includes 5 survey days and 4 survey areas (i.e., area #1, #2, #3 and #4)
[b] Fall - September through November, includes 4 survey days and 4 survey areas (i.e., area #1, #2, #3 and #4)
[c] Fall - September through November, includes 4 survey days described in footnote [b] plus an additional survey area (5 survey areas) (i.e., area #1, #2, #3, #4 and #5)
Source: Pierce et al., 1981.

The U.S. EPA (1989) used the Pierce et al. (1981) fishing frequency distribution and an estimate of the average amount of fish consumed per angling trip to create an approximate intake distribution for the Pierce et al. (1981) survey. The estimate of the amount of fish consumed per angling trip (380 g/person-trip) was based on data on mean fish catch weight and mean number of consumers reported in Pierce et. al. (1981) and on an edible fraction of 0.5. EPA (1989) reported a median intake rate of 23 g/day.

Price et al. (1994) obtained the raw data from this survey and performed a re-analysis using sampling weights proportional to inverse fishing frequency. The rationale for these weights is explained in Section 10.1 and in the discussion above of the Puffer et al. (1981) study. In the re-analysis Price et al. (1994) found a median intake rate of 1.0 g/day and a 90th percentile rate of 13 g/day. The distribution of fishing frequency generated by Price et al. (1994) is shown in Table 10-27. Note that when equal weights were used, Price found a median rate of 19 g/day, which was close to the approximate EPA (1989) value reported above of 23 g/day.

Table 10-27. Selected Percentile Consumption Estimates (g/d) for the Survey and Total Angler Populations Based on the Reanalysis of the Puffer and Pierce Data

	50th Percentile	90th Percentile
Survey Population		
Puffer	37	225
Pierce	19	155
Average	28	190
Total Angler Population		
Puffer	2.9[a]	35[b]
Pierce	1.0	13
Average	2.0	24

[a] Estimated based on the average intake for the 0 - 90th percentile anglers.
[b] Estimated based on the average intake for the 91st - 96th percentile anglers.
Source: Price et al., 1994.

The same limitations apply to interpreting the results presented here to those presented above in the discussion of Puffer et al. (1981). The median intake rate found by Price et al. (1994) (using inverse frequency weights) is more reflective of median intake in the target population than is the value of 19 g/day (or 23 g/day); the latter value reflects more the 50th percentile of the resource utilization distribution, (i.e., that anglers with intakes above 19 g/day consume 50 percent of the recreational fish catch). Similarly, the fishing frequency distribution generated by Price et al. (1994) is more reflective of the fishing frequency distribution in the target population than is the distribution presented in Pierce et al. (1981). Note the target population is those anglers who fished at Commencement Bay during the time period of the survey.

As with the Puffer et al. (1981) data, these values (1.0 g/day and 19 g/day) are both probably underestimates since the sampling probabilities are less than proportional to fishing frequency; thus, the true target population median is probably somewhat above 1.0 g/day and the true 50th percentile of the resource utilization distribution is probably somewhat higher than 19 g/day. The data from this survey provide an indication of consumption patterns for the time period around 1980 in the Commencement Bay area. However, the data may not reflect current consumption patterns because fishing advisories were instituted due to local contamination.

Health Study to Assess the Human Health Effects of Mercury Exposure to Fish Consumed from the Everglades - A health study was conducted in two phases in the Everglades, Florida for the U.S. Department of Health and Human Services (U.S.DHHS, 1995). The objectives of the first phase were to: (a) describe the human populations at risk for mercury exposure through their consumption of fish and other contaminated animals from the Everglades and (b) evaluate the extent of mercury exposure in those persons consuming contaminated food and their compliance with the voluntary health advisory. The second phase of the study involved neurologic testing of all study participants who had total mercury levels in hair greater than 7.5 μg/g. Study participants were identified by using special targeted screenings, mailings to residents, postings and multi-media advertisements of the study throughout the Everglades region, and direct discussions with people fishing along the canals and waterways in the contaminated areas. The contaminated areas were identified by the interviewers and long-term Everglade residents. Of a total of 1,794 individuals sampled, 405 individuals were eligible to participate in the study because they had consumed fish or wildlife from the Everglades at least once per month in the last 3 months of the study period. The majority of the eligible participants (> 93 percent) were either subsistence fishermen, Everglade residents, or both. Of the total eligible participants, 55 individuals refused to participate in the survey. Useable data were obtained from 330 respondents ranging in age from 10-81 years of age (mean age 39 years ± 18.8) (U.S.DHHS, 1995). Respondents were administered a three page questionnaire from which demographic information, fishing and eating habits, and other variables were obtained (U.S.DHHS, 1995).

Table 10-28 shows the ranges, means, and standard deviations of selected characteristics by subgroups of the survey population. Sixty-two percent of the respondents were male with a slight preponderance of black individuals (43 percent white, 46 percent black non-Hispanic, and 11 percent Hispanic) (Table 10-28). Most of the respondents reported earning an annual income of $15,000 or less per family before taxes (U.S. DHHS, 1995). The mean number of years fished along the canals by the respondents was 15.8 years with a standard deviation of 15.8. The mean number of times per week fish consumers reported eating fish over the last 6 months and last month of the survey period was 1.8 and 1.5 per week with a standard deviation of 2.5 and 1.4, respectively (Table 10-28). Table 10-28 also indicates that 71 percent of the respondents reported knowing about the mercury health advisories. Of those who were aware, 26 percent reported that they had lowered their consumption of fish caught in the Everglades while the rest (74 percent) reported no change in consumption patterns (U.S.DHHS, 1995).

Table 10-28. Means and Standard Deviations of Selected Characteristics by Subpopulation Groups in Everglades, Florida

Variables ($N^a = 330$)	Mean ± Std. Dev.[b]	Range
Age (years)	38.6 ± 18.8	2 - 81
Sex		
Female	38%	--
Male	62%	--
Race/ethnicity		
Black	46%	--
White	43%	--
Hispanic	11%	--
Number of Years Fished	15.8 ± 15.8	0 - 70
Number Per Week Fished in Past 6 Months of Survey Period	1.8 ± 2.5	0 - 20
Number Per Week Fished in Last Month of Survey Period	1.5 ± 1.4	0 - 12
Aware of Health Advisories	71%	--

[a] Number of respondents who reported consuming fish
[b] Std. Dev. = standard deviation
Source: U.S. DHHS, 1995

A limitation of this study is that fish intake rates (g/day) were not reported. Another limitation is that the survey was site limited, and, therefore, not representative of the U.S. population. An advantage of this study is that it is one of the few studies targeting subsistence fishermen.

10.6. KEY FRESHWATER RECREATIONAL STUDIES

Chemrisk - Consumption of Freshwater Fish by Maine Anglers - Chemrisk conducted a study to characterize the rates of freshwater fish consumption among Maine residents (Chemrisk, 1991; Ebert et al., 1993). Since the only dietary source of local freshwater fish is recreational fish, the anglers in Maine were chosen as the survey population. The survey was designed to gather information on the consumption of fish caught by anglers from flowing (rivers and streams) and standing (lakes and ponds) water bodies. Respondents were asked to recall the frequency of fishing trips during the 1989-1990 ice-fishing season and the 1990 open water season, the number of fish species caught during both seasons, and estimate the number of fish consumed from 15 fish species. The respondents were also asked to describe the number, species, and average length of each sport-caught fish caught and consumed that had been gifts from other members of their households or other household. The weight of fish consumed by anglers was calculated by first multiplying the estimated weight of the fish by the edible fraction, and then dividing this product by the number of intended consumers. Species specific regression equations were utilized to estimate weight from the reported fish length. The edible fractions used were 0.4 for salmon, 0.78 for Atlantic smelt, and 0.3 for all other species (Ebert et al., 1993).

A total of 2,500 prospective survey participants were randomly selected from a list of anglers licensed in Maine. The surveys were mailed in during October, 1990. Since this was before the end of the open fishing season, respondents were also asked to predict how many more open water fishing trips they would undertake in 1990.

Chemrisk (1991) and Ebert et al. (1993) calculated distributions of freshwater fish intake for two populations, "all anglers" and "consuming anglers". All anglers were defined as licensed anglers who fished during either the 1989-1990 ice-fishing season or the 1990 open-water season (consumers and non-consumers) and licensed anglers who did not fish but consumed freshwater fish caught in Maine during these seasons while "consuming anglers" were defined as those anglers who consumed freshwater fish obtained from Maine sources during the 1989-1990 ice fishing or 1990 open water fishing season. In addition, the distribution of fish intake from rivers and streams was also calculated for two populations, those fishing on rivers and streams ("river anglers") and those consuming fish from rivers and streams (" consuming river anglers").

A total of 1,612 surveys were returned, giving a response rate of 64 percent; 1,369 (85 percent) of the 1,612 respondents were included in the "all angler" population and 1,053 (65 percent) were included in the "consuming angler" population. Freshwater fish intake distributions for these populations are presented in Table 10-29. The mean and 95th percentile was 5.0 g/day and 21.0 g/day, respectively, for " all anglers," and 6.4 g/day and 26.0 g/day, respectively, for "consuming anglers." Table 10-29 also presents intake distributions for fish caught from rivers and streams. Among "river anglers" the mean and 95th percentiles were 1.9 g/day and 6.2 g/day, respectively, while among "consuming river anglers" the mean was 3.7 g/day and the 95th percentile 12.0 g/day. Table 10-30 presents fish intake distributions by ethnic group for consuming anglers. The highest mean intake rates reported are for Native Americans (10 g/day) and French Canadians (7.4 g/day). Because there was a low number of respondents for Hispanic, Asian/Pacific Islander, and African Americans, intake rates within these subgroups were not calculated (Chemrisk, 1991).

The consumption, by species, of freshwater fish caught is presented in Table 10-31. The largest specie consumption was salmon from ice fishing (~292,000 grams); white perch (380,000 grams) for lakes and ponds; and Brooktrout (420,000 grams) for rivers and streams (Chemrisk, 1991).

EPA obtained the raw data tapes from the marine anglers survey and performed some specialized analyses. One analysis involved examining the percentiles of the "resource utilization distribution" (this distribution was defined in Section 10.1). The 50th, or more generally the pth, percentile of the resource utilization distribution is defined as the consumption level such that p percent of the resource is consumed by individuals with consumptions below this level and 100-p percent by individuals with consumptions above this level. EPA found that 90 percent of recreational fish consumption was by individuals with intake rates above 3.1 g/day and 50 percent was by individuals with intakes above 20 g/day. Those above 3.1 g/day make up about 30 percent of the "all angler" population and those above 20 g/day make up about 5 percent of this population; thus, the top 5 percent of the angler population consumed 50 percent of the recreational fish catch.

Table 10-29. Estimates of Fish Intake Rates of Licensed Sport Anglers in Maine During the 1989-1990 Ice Fishing or 1990 Open-Water Seasons[a]

Intake Rates (grams/day)				
Percentile Rankings	All Waters[b]		Rivers and Streams	
	All Anglers[c] (N = 1,369)	Consuming Anglers[d] (N = 1,053)	River Anglers[e] (N = 741)	Consuming Anglers[d] (N = 464)
50th (median)	1.1	2.0	0.19	0.99
66th	2.6	4.0	0.71	1.8
75th	4.2	5.8	1.3	2.5
90th	11.0	13.0	3.7	6.1
95th	21.0	26.0	6.2	12.0
Arithmetic Mean[f]	5.0 [79]	6.4 [77]	1.9 [82]	3.7 [81]

[a] Estimates are based on rank except for those of arithmetic mean.
[b] All waters based on fish obtained from all lakes, ponds, streams and rivers in Maine, from other household sources and from other non-household sources.
[c] Licensed anglers who fished during the seasons studied and did or did not consume freshwater fish, and licensed anglers who did not fish but ate freshwater fish caught in Maine during those seasons.
[d] Licensed anglers who consumed freshwater fish caught in Maine during the seasons studied.
[e] Those of the "all anglers" who fished on rivers or streams (consumers and nonconsumers).
[f] Values in brackets [ ] are percentiles at the mean consumption rates.
Source: Chemrisk, 1991; Ebert et al., 1993.

Table 10-30. Analysis of Fish Consumption by Ethnic Groups for "All Waters" (grams/day)[a]

	Consuming Anglers[b]					
	French Canadian Heritage	Irish Heritage	Italian Heritage	Native American Heritage	Other White Non-Hispanic Heritage	Scandinavian Heritage
N of Cases	201	138	27	96	533	37
Median (50th percentile)[c,d]	2.3	2.4	1.8	2.3	1.9	1.3
66th percentile[c,d]	4.1	4.4	2.6	4.7	3.8	2.6
75th percentile[c,d]	6.2	6.0	5.0	6.2	5.7	4.9
Arithmetic Mean[c]	7.4	5.2	4.5	10	6.0	5.3
Percentile at the Mean[d]	80	70	74	83	76	78
90th percentile[c,d]	15	12	12	16	13	9.4
95th percentile[c,d]	27	20	21	51	24	25
Percentile at 6.5 g/day[d,e]	77	75	81	77	77	84

[a] "All Waters" based on fish obtained from all lakes, ponds, streams and rivers in Maine, from other household sources and from other non-household sources.
[b] "Consuming Anglers" refers to only those anglers who consumed freshwater fish obtained from Maine sources during the 1989-1990 ice fishing or 1990 open water fishing season.
[c] The average consumption per day by freshwater fish consumers in the household.
[d] Calculated by rank without any assumption of statistical distribution.
[e] Fish consumption rate recommended by EPA (1984) for use in establishing ambient water quality standards.
Source: Chemrisk, 1991.

Table 10-31. Total Consumption of Freshwater Fish Caught by All Survey Respondents During the 1990 Season

Species	Ice Fishing		Lakes and Ponds		Rivers and Streams	
	Quantity Consumed (#)	Grams ($x10^3$) Consumed	Quantity Consumed (#)	Grams ($x10^3$) Consumed	Quantity Consumed (#)	Grams ($x10^3$) Consumed
Landlocked salmon	832	290	928	340	305	120
Atlantic salmon	3	1.1	33	9.9	17	11
Togue (Lake trout)	483	200	459	160	33	2.7
Brook trout	1,309	100	3,294	210	10,185	420
Brown trout	275	54	375	56	338	23
Yellow perch	235	9.1	1,649	52	188	7.4
White perch	2,544	160	6,540	380	3,013	180
Bass (smallmouth and largemouth)	474	120	73	5.9	787	130
Pickerel	1,091	180	553	91	303	45
Lake whitefish	111	20	558	13	55	2.7
Hornpout (Catfish and bullheads)	47	8.2	1,291	100	180	7.8
Bottom fish (Suckers, carp and sturgeon)	50	81	62	22	100	6.7
Chub	0	0	252	35	219	130
Smelt	7,808	150	428	4.9	4,269	37
Other	201	210	90	110	54	45
TOTALS	**15,463**	**1,583.4**	**16,587**	**1,590**	**20,046**	**1,168**

Source: Chemrisk, 1991.

EPA also performed an analysis of fish consumption among anglers and their families. This analysis was possible because the survey included questions on the number, sex, and age of each individual in the household and whether the individual consumed recreationally caught fish. The total population of licensed anglers in this survey and their household members was 4,872; the average household size for the 1,612 anglers in the survey was thus 3.0 persons. Fifty-six percent of the population was male and 30 percent were 18 or under.

A total of 55 percent of this population was reported to consume freshwater recreationally caught fish in the year of the survey. The sex and ethnic distribution of the consumers was similar to that of the overall population. The distribution of fish intake among the overall household population, or among consumers in the household, can be calculated under the assumption that recreationally caught fish was shared equally among all members of the household reporting consumption of such fish (note this assumption was used above to calculate intake rates for anglers). With this assumption, the mean intake rate among consumers was 5.9 g/day with a median of 1.8 and a 95th percentile of 23.1 g/day; for the overall population the mean was 3.2 g/day and the 95th percentile 14.1 g/day.

The results of this survey can be put into the context of the overall Maine population. The 1,612 anglers surveyed represent about 0.7 percent of the estimated 225,000 licensed anglers in Maine. It is reasonable to assume that licensed anglers and their families will have the highest exposure to recreationally caught freshwater fish. Thus, to estimate the number of persons in Maine with recreationally caught freshwater fish intake above, for instance, 6.5 g/day (the 80th percentile among household consumers in this survey), one can assume that virtually all persons came from the population of licensed anglers and their families. The number of persons above 6.5 g/day in the household survey population is calculated by taking 20 percent (i.e., 100 percent - 80 percent) of the consuming population in the survey; this number then is $0.2*(0.55*4872) = 536$. Dividing this number by the sampling fraction of 0.007 (0.7 percent) gives about 77,000 persons above 6.5 g/day of recreational freshwater fish consumption statewide. The 1990 census showed the population of Maine to be 1.2 million people; thus the 77,000 persons above 6.5 g/day represent about 6 percent of the state's population.

Chemrisk (1991) reported that the fish consumption estimates obtained from the survey were conservative because of assumptions made in the analysis. The assumptions included: a 40 percent estimate as the edible portion of land locked and Atlantic salmon; inclusion of the intended number of future fishing trips and an assumption that the average success and consumption rates for the individual angler during the trips already taken would continue through future trips. The data collected for this study were based on recall and self-reporting which may have resulted in a biased estimate. The social desirability of the sport and frequency of fishing are also bias contributing factors; successful anglers are among the highest consumers of freshwater fish (Chemrisk, 1991). Over reporting appears to be correlated with skill level and the importance of the activity to the individual; it is likely that the higher consumption rates may be substantially overstated (Chemrisk, 1991). Additionally, fish advisories are in place in these areas and may affect the rate of fish consumption among anglers. The survey results showed that in 1990, 23 percent of all anglers consumed no freshwater fish, and 55 percent of the river anglers ate no freshwater fish. An advantage of this study is that it presents area-specific consumption patterns and the sample size is rather large.

Michigan Sport Anglers Fish Consumption Survey, 1989 - West et al. (1989) surveyed a stratified random sample of Michigan residents with fishing licences. The sample was divided into 18 cohorts, with one cohort receiving a mail questionnaire each week between January and May 1989. The survey included both a short term recall component recording respondents' fish intake over a seven day period and a usual frequency component. For the short-term component, respondents were asked to identify all household members and list all fish meals consumed by each household member during the past seven days. The source of the fish for each meal was requested (self-caught, gift, market, or restaurant). Respondents were asked to categorize serving size by comparison with pictures of 8 oz. fish portions; serving sizes could be designated as either "about the same size", "less", or "more" than the 8 oz. picture. Data on fish species, locations of self-caught fish and methods of preparation and cooking were also obtained.

The usual frequency component of the survey asked about the frequency of fish meals during each of the four seasons and requested respondents to give the overall percentage of household fish meals that come from recreational sources. A sample of 2,600 individuals were selected from state records to receive survey questionnaires. A total of 2,334 survey questionnaires were deliverable and 1,104 were completed and returned, giving a response rate of 47.3 percent among individuals receiving questionnaires.

In the analysis of the survey data by West et. al. (1989), the authors did not attempt to generate the distribution of recreationally caught fish intake in the survey population. EPA obtained the raw data of this survey for the purpose of generating fish intake distributions and other specialized analyses.

As described elsewhere in this handbook, percentiles of the distribution of average daily intake reflective of long-term consumption patterns can not in general be estimated using short-term (e.g., one week) data. Such data can be used to estimate mean average daily intake rates (reflective of short or long term consumption); in addition, short term data can serve to validate estimates of usual intake based on longer recall.

EPA first analyzed the short term data with the intent of estimating mean fish intake rates. In order to compare these results with those based on usual intake, only respondents with information on both short term and usual intake were included in this analysis. For the analysis of the short term data, EPA modified the serving size weights used by West et al. (1989), which were 5, 8 and 10 oz., respectively, for portions that were less, about the same, and more than the 8 oz. picture. EPA examined the percentiles of the distribution of fish meal sizes reported in Pao et al. (1982) derived from the 1977-1978 USDA National Food Consumption Survey and observed that a lognormal distribution provided a good visual fit to the percentile data. Using this lognormal distribution, the mean values for serving sizes greater than 8 oz. and for serving sizes at least 10 percent greater than 8 oz. were determined. In both cases a serving size of 12 oz. was consistent with the Pao et al. (1982) distribution. The weights used in the EPA analysis then were 5, 8, and 12 oz. for fish meals described as less, about the same, and more than the 8 oz. picture, respectively. It should be noted that the mean serving size from Pao et al. (1982) was about 5 oz., well below the value of 8 oz. most commonly reported by respondents in the West et al. (1989) survey.

Table 10-32 displays the mean number of total and recreational fish meals for each household member based on the seven day recall data. Also shown are mean fish intake rates derived by applying the weights described above to each fish meal. Intake was calculated on both a grams/day and grams/kg body weight/day basis. This analysis was restricted to individuals who eat fish and who reside in households reporting some recreational fish consumption during the previous year. About 75 percent of survey respondents (i.e., licensed anglers) and about 84 percent of respondents who fished in the prior year reported some household recreational fish consumption.

The EPA analysis next attempted to use the short term data to validate the usual intake data. West et al. (1989) asked the main respondent in each household to

Table 10-32. Mean Fish Intake Among Individuals Who Eat Fish and Reside in Households With Recreational Fish Consumption

Group	All Fish meals/week	Recreational Fish meals/week	n	Total Fish grams/day	Recreational Fish grams/day	Total Fish grams/ kg/day	Recreational Fish grams/ kg/day
All household members	0.686	0.332	2196	21.9	11.0	0.356	0.178
Respondents (i.e., licensed anglers)	0.873	0.398	748	29.4	14.0	0.364	0.168
Age Groups (years) 1-5	0.463	0.223	121	11.4	5.63	0.737	0.369
6 to 10	0.49	0.278	151	13.6	7.94	0.481	0.276
1 to 20	0.407	0.229	349	12.3	7.27	0.219	0.123
21 to 40	0.651	0.291	793	22	10.2	0.306	0.139
40 to 60	0.923	0.42	547	29.3	14.2	0.387	0.186
60 to 70	0.856	0.431	160	28.2	14.5	0.377	0.193
71 to 80	1.0	0.622	45	32.3	20.1	0.441	0.271
80+	0.8	0.6	10	26.5	20	0.437	0.345

Source: U.S. EPA analysis using data from West et al., 1989.

provide estimates of their usual frequency of fishing and eating fish, by season, during the previous year. The survey provides a series of frequency categories for each season and the respondent was asked to check the appropriate range. The ranges used for all questions were: almost daily, 2-4 times a week, once a week, 2-3 times a month, once a month, less often, none, and don't know. For quantitative analysis of the data it is necessary to convert this categorical information into numerical frequency values. As some of the ranges are relatively broad, the choice of conversion values can have some effect on intake estimates. In order to obtain optimal values, the usual fish eating frequency reported by respondents for the season during which the questionnaire was completed was compared to the number of fish meals reportedly consumed by respondents over the seven day short-term recall period. The results of these comparisons are displayed in Table 10-33; it shows that, on average, there is general agreement between estimates made using one year recall and estimates based on seven day recall.

The average number of meals (1.96) was at the bottom of the range for the most frequent consumption group with data (2-4 meals/week). In contrast for the lower usual frequency categories the average number of meals was at the top, or exceeded the top of category range. This suggests some tendency for relatively infrequent fish eaters to underestimate their usual frequency of fish consumption. The last column of the table shows the estimated fish eating frequency per week that was selected for use in making quantitative estimates

Table 10-33. Comparison of Seven-Day Recall and Estimated Seasonal Frequency for Fish Consumption

Usual Fish Consumption Frequency Category	Mean Fish Meals/Week 7-day Recall Data	Usual frequency Value Selected for Data Aanalysis (times/week)
Almost daily	no data	4 [if needed]
2-4 times a week	1.96	2
Once a week	1.19	1.2
2-3 times a month	0.840 (3.6 times/month)	0.7 (3 times/month)
Once a month	0.459 (1.9 times/month)	0.4 (1.7 times/month)
Less often	0.306 (1.3 times/month)	0.2 (0.9 times/month)

Source: U.S. EPA analysis using data from West et al., 1989.

of usual fish intake. These values were guided by the values in the second column, except that frequency values that were inconsistent with the ranges provided to respondents in the survey were avoided.

Using the four seasonal fish eating frequencies provided by respondents and the above conversions for reported intake frequency, EPA estimated the average number of fish meals per week for each respondent. This estimate, as well as the analysis above, pertain to the total number of fish meals eaten (in Michigan) regardless of the source of the fish. Respondents were not asked to provide a seasonal breakdown for eating frequency of recreationally caught fish; rather, they provided an overall estimate for the past year of the percent of fish they ate that was obtained from different sources. EPA estimated the annual frequency of recreationally caught fish meals by multiplying the estimated total number of fish meals by the reported percent of fish meals obtained from recreational sources; recreational sources were defined as either self caught or a gift from family or friends.

The usual intake component of the survey did not include questions about the usual portion size for fish meals. In order to estimate usual fish intake, a portion size of 8 oz. was applied (the majority of respondents reported this meal size in the 7 day recall data). Individual body weight data were used to estimate intake on a g/kg-day basis. The fish intake distribution estimated by EPA is displayed in Table 10-34.

The distribution shown in Table 10-34 is based on respondents who consumed recreational caught fish. As mentioned above, these represent 75 percent of all respondents and 84 percent of respondents who reported having fished in the prior year. Among this latter population, the mean recreational fish intake rate is 14.4*0.84=12.1 g/day; the value of 38.7 g/day (95th percentile among consumers) corresponds to the 95.8th percentile of the fish intake distribution in this (fishing) population.

The advantages of this data set and analysis are that the survey was relatively large and contained both short-term and usual intake data. The presence of short term data allowed validation of the usual intake data which was based on long term recall; thus, some of the problems associated with surveys relying on long term recall are mitigated here.

The response rate of this survey, 47 percent, was relatively low. In addition, the usual fish intake distribution generated here employed a constant fish meal size, 8 oz.. Although use of this value as an average meal size was validated by the short-term recall results, the use of a constant meal size, even if correct on average, may seriously reduce the variation in the estimated fish intake distribution.

This study was conducted in the winter and spring months of 1988. This period does not include the summer months when peak fishing activity can be anticipated, leading to the possibility that intake results based on the 7 day recall data may understate individuals' usual (annual average) fish consumption. A second survey by West et al. (1993) gathered diary data on fish intake for respondents spaced over a full year. However, this later survey did not include questions about usual fish intake and has not been reanalyzed here. The mean recreational fish intake rates derived from the short term and usual components were quite similar, however, 14.0 versus 14.4 g/day.

Table 10-34. Distribution of Usual Fish Intake Among Survey Main Respondents Who Fished and Consumed Recreationally Caught Fish

	All Fish Meals/Week	Recreational Fish Meals/Week	All Fish Intake grams/day	Recreational Fish Intake grams/day	All Fish Intake grams/ kg/day	Recreational Fish Intake grams/ kg/day
n	738	738	738	738	726	726
mean	0.859	0.447	27.74	14.42	0.353	0.1806
10%	0.300	0.040	9.69	1.29	0.119	0.0159
25%	0.475	0.125	15.34	4.04	0.187	0.0504
50%	0.750	0.338	24.21	10.90	0.315	0.1357
75%	1.200	0.672	38.74	21.71	0.478	0.2676
90%	1.400	1.050	45.20	33.90	0.634	0.4146
95%	1.800	1.200	58.11	38.74	0.747	0.4920

Source: U.S. EPA analysis using data from West et al., 1989.

Michigan Sport Anglers Fish Consumption Study, 1991-1992 - This survey, financed by the Michigan Great Lakes Protection Fund, was a follow-up to the earlier 1989 Michigan survey described above. The major prupose of 1991-1992 survey was to provide short-term recall data of recreational fish consumption over a full year period; the 1989 survey, in contrast, was conducted over only a half year period (West et al., 1993).

This survey was similar in design to the 1989 Michigan survey. A sample of 7,000 persons with Michigan fishing licenses was drawn and surveys were mailed in 2-week cohorts over the period January, 1991 to January, 1992. Respondents were asked to report detailed fish consumption patterns during the preceding seven days, as well as demographic information; they were also asked if they currently eat fish. Enclosed with the survey were pictures of about a half pound of fish. Respondents were asked to indicate whether reported consumption at each meal was more, less or about the same as the picture. Based on responses to this question, respondents were assumed to have consumed 10, 5 or 8 ounces of fish, respectively.

A total of 2,681 surveys were returned. West et al. (1993) calculated a response rate for the survey of 46.8 percent; this was derived by removing from the sample those respondents who could not be located or who did not reside in Michigan for at least six months.

Of these 2,681 respondents, 2,475 (93 percent) reported that they currently eat fish; all subsequent analyses were restricted to the current fish eaters. The mean fish consumption rates were found to be 16.7 g/day for sport fish and 26.5 g/day for total fish (West et al., 1993). Table 10-35 shows mean sport-fish consumption rates by demographic categories. Rates were higher among minorities, people with low income, and people residing in smaller communities. Consumption rates in

Table 10-35. Mean Sport-Fish Consumption by Demographic Variables, Michigan Sport Anglers Fish consumption Study, 1991-1992

	N	Mean (g/day)	95% C.I.
Income[a]			
< $15,000	290	21.0	16.3 - 25.8
$15,000 - $24,999	369	20.6	15.5 - 25.7
$25,000 - $39,999	662	17.5	15.0 - 20.1
> $40,000	871	14.7	12.8 - 16.7
Education			
Some High School	299	16.5	12.9 - 20.1
High School Degree	1,074	17.0	14.9 - 19.1
Some College-College Degree	825	17.6	14.9 - 20.2
Post. Grad	231	14.5	10.5 - 18.6
Residence Size[b]			
Large City/Suburb (> 100,000)	487	14.6	11.8 - 17.3
Small City (20,000-100,000)	464	12.9	10.7 - 15.0
Town (2,000-20,000)	475	19.4	15.5 - 23.3
Small Town (100-2,000)	272	22.8	16.8 - 28.8
Rural, Non Farm	598	17.7	15.1 - 20.3
Farm	140	15.1	10.3 - 20.0
Age (years)			
16-29	266	18.9	13.9 - 23.9
30-39	583	16.6	13.5 - 19.7
40-49	556	16.5	13.4 - 19.6
50-59	419	16.5	13.6 - 19.4
60+	596	16.2	13.8 - 18.6
Sex[a]			
Male	299	17.5	15.8 - 19.1
Female	1,074	13.7	11.2 - 16.3
Race/Ethnicity[b]			
Minority	160	23.2	13.4 - 33.1
White	2,289	16.3	14.9 - 17.6

[a] $P < .01$, F test
[b] $P < .05$, F test
Source: West et al., 1993

g/day were also higher in males than in females; however, this difference would likely disappear if rates were computed on a g/kg-day basis.

West et al. (1993) estimated the 80th percentile of the survey fish consumption distribution. More extensive percentile calculations were performed by U.S. EPA (1995) using the raw data from the West et al. (1993) survey and calculated 50th, 90th, and 95th percentiles. However, since this survey only measured fish consumption over a short (one week) interval, the resulting distribution will not be indicative of the long-term fish consumption distribution and the upper percentiles reported from the EPA analysis will likely considerably overestimate the corresponding long term percentiles. The overall 95th percentile calculated by U.S. EPA (1995) was 77.9; this is about double the 95th percentile estimated using year long consumption data from the 1989 Michigan survey.

The limitations of this survey are the relatively low response rate and the fact that only three cateogries were used to assign fish portion size. The main study strengths were its relatively large size and its reliance on short-term recall.

Sportfish Consumption Patterns of Lake Ontario Anglers and the Relationship to Health Advisories, 1992 - The objectives of this study were to provide accurate estimates of fish consumption (overall and sport caught) among Lake Ontario anglers and to evaluate the effect of Lake Ontario health advisory recommendations (Connelly et al., 1996). To target Lake Ontario anglers, a sample of 2,500 names was randomly drawn from 1990-1991 New York fishing license records for licenses purchased in six counties bordering Lake Ontario. Participation in the study was solicited by mail with potential participants encouraged to enroll in the study even if they fished infrequently or consumed little or no sport caught fish. The survey design involved three survey techniques including a mail questionnaire asking for 12 month recall of 1991 fishing trips and fish consumption, self-recording information in a diary for 1992 fishing trips and fish consumption, periodic telephone interviews to gather information recorded in the diary and a final telephone interview to determine awareness of health advisories (Connelly et al., 1996).

Participants were instructed to record in the diary the species of fish eaten, meal size, method by which fish was acquired (sport-caught or other), fish preparation and cooking techniques used and the number of household members eating the meal. Fish meals were defined as finfish only. Meal size was estimated by participants by comparing their meal size to pictures of 8 oz. fish steaks and fillets on dinner plates. An 8 oz. size was assumed unless participants noted their meal size was smaller than 8 oz., in which case a 4 oz. size was assumed, or they noted it was larger than 8 oz., in which case a 12 oz. size was assumed. Participants were also asked to record information on fishing trips to Lake Ontario and species and length of any fish caught.

From the initial sample of 2,500 license buyers, 1,993 (80 percent) were reachable by phone or mail and 1,410 of these were eligible for the study, in that they intended to fish Lake Ontario in 1992. A total of 1,202 of these 1,410, or 85 percent, agreed to participate in the study. Of the 1,202 participants, 853 either returned the diary or provided diary information by telephone. Due to changes in health advisories for Lake Ontario which resulted in less Lake Ontario fishing in 1992, only 43 percent, or 366 of these 853 persons indicated that they fished Lake Ontario during 1992. The study analyses summarized below concerning fish consumption and Lake Ontario fishing participation are based on these 366 persons.

Anglers who fished Lake Ontario reported an average of 30.3 (S.E. = 2.3) fish meals per person from all sources in 1992; of these meals 28 percent were sport caught (Connelly et al., 1996). Less than 1 percent ate no fish for the year and 16 percent ate no sport caught fish. The mean fish intake rate from all sources was 17.9 g/day and from sport caught sources was 4.9 g/day. Table 10-36 gives the distribution of fish intake rates from all sources and from sport caught fish. The median rates were 14.1 g/day for all sources and 2.2 g/day for sport caught; the 95th percentiles were 42.3 g/day and 17.9 g/day for all sources and sport caught, respectively. As seen in Table 10-37, statistically significant differences in intake rates were seen across age and residence groups, with residents of large cities and younger people having lower intake rates on average.

The main advantage of this study is the diary format. This format provides more accurate information on fishing participation and fish consumption, than studies based on 1 year recall (Ebert et al., 1993). However, a considerable portion of diary respondents participated in the study for only a portion of the year and some errors may have been generated in extrapolating these respondents' results to the entire year (Connelly et al., 1996). In addition, the response rate for this study was relatively low, 853 of 1,410 eligible respondents, or 60 percent, which may have engendered some non-response bias.

Table 10-36. Distribution of Fish Intake Rates (from all sources and from sport-caught sources) For 1992 Lake Ontario Anglers

Percentile of Lake Ontario Anglers	Fish from All Sources (g/day)	Sport-Caught Fish (g/day)
25%	8.8	0.6
50%	14.1	2.2
75%	23.2	6.6
90%	34.2	13.2
95%	42.3	17.9
99%	56.6	39.8

Source. Connelly et al., 1996.

Table 10-37. Mean Annual Fish Consumption (g/day) For Lake Ontario Anglers, 1992, By Socio-demographic Characteristics

	Mean Consumption	
Demographic Group	Fish from all Sources	Sport-Caught Fish
Overall	17.9	4.9
Residence		
Rural	17.6	5.1
Small City	20.8	6.3
City (25-100,000)	19.8	5.8
City (> 100,000)	13.1	2.2
Income		
< $20,000	20.5	4.9
$21,000-34,000	17.5	4.7
$34,000-50,000	16.5	4.8
> $50,000	20.7	6.1
Age		
< 30	13.0	4.1
30-39	16.6	4.3
40-49	18.6	5.1
50+	21.9	6.4
Education		
< High School	17.3	7.1
High School Grad	17.8	4.7
Some College	18.8	5.5
College Grad	17.4	4.2
Some Post Grad.	20.5	5.9

Note - Scheffe's test showed statistically significant differences between residence types (for all sources and sport caught) and age groups (all sources).
Source: Connelly et al., 1996.

The presence of health advisories should be taken into account when evaluating the intake rates observed in this study. Nearly all respondents (>95 percent) were aware of the Lake Ontario health advisory. This advisory counseled to eat none of 9 fish species from Lake Ontario and to eat no more than one meal per month of another 4 species. In addition, New York State issues a general advisory to eat no more than 52 sport caught fish meals per year. Among participants who fished Lake Ontario in 1992, 32 percent said they would eat more fish if health advisories did not exist. A significant fraction of respondents did not totally adhere to the fish advisory; however, 36 percent of respondents, and 72 percent of respondents reporting Lake Ontario fish consumption, ate at least one species of fish over the advisory limit. Interestingly, 90 percent of those violating the advisory reported that they believed they were eating within advisory limits.

10.7. RELEVANT FRESHWATER RECREATIONAL STUDIES

Sport Fish Consumption and Body Burden Levels of Chlorinated Hydrocarbons: A Study of Wisconsin Anglers. This survey, reported by Fiore et al. (1989), was conducted to assess sociodemographic factors and sport fishing habits of anglers, to evaluate anglers' comprehension of and compliance with the Wisconsin Fish Consumption Advisory, to measure body burden levels of PCBs and DDE through analysis of blood serum samples and to examine the relationship between body burden levels and consumption of sport-caught fish. The survey targeted all Wisconsin residents who had purchased fishing or sporting licenses in 1984 in any of 10 pre-selected study counties. These counties were chosen in part based on their proximity to water bodies identified in Wisconsin fish advisories. A total of 1,600 anglers were sent survey questionnaires during the summer of 1985.

The survey questionnaire included questions about fishing history, locations fished, species targeted, kilograms caught for consumption, overall fish consumption (including commercially caught) and knowledge of fish advisories. The recall period was one year.

A total of 801 surveys were returned (50 percent response rate). Of these, 601 (75 percent) were from males and 200 from females; the mean age was 37 years. Fiore et al. (1989) reported that the mean number of fish meals for 1984 for all respondents was 18 for sport-caught meals and 24 for non-sport caught meals. Fiore et al. (1989) assumed that each fish meal consisted of 8 ounces (227 grams) of fish to generate means and percentiles of fish intake. The reported per-capita intake rate of sport-caught fish was 11.2 g/day; among consumers, who comprised 91 percent of all respondents, the mean sport-caught fish intake rate was 12.3 g/day and the 95th percentile 37.3 g/day. The mean daily fish intake from all sources (both sport caught and commercial) was 26.1 g/day with a 95th percentile of 63.4 g/day. The 95th percentile of 37.3 g/day of sport caught fish represents 60 fish meals per year; 63.4 g/day (the 95th percentile of total fish intake) represents 102 fish meals per year.

Fiore et al. (1988) assumed a (constant) meal size of 8 ounces (227 grams) of fish which may over-estimate average meal size. Pao et al. (1982), using data from the 1977-78 USDA NFCS, reported an average fish meal size of slightly less than 150 grams for adult males. EPA obtained the raw data from this study and calculated the distribution of the number of sport-caught fish meals and the distribution of fish intake rates (using 150 grams/meal); these distributions are presented in Table 10-38. With this average meal size, the per-capita estimate is 7.4 g/day.

Table 10-38. Percentile and Mean Intake Rates for Wisconsin Sport Anglers

Percentile	Annual Number of Sport Caught Meals	Intake Rate of Sport-Caught Meals (g/day)
25th	4	1.7
50th	10	4.1
75th	25	10.2
90th	50	20.6
95th	60	24.6
98th	100	41.1
100th	365	150
Mean	18	7.4

Source: Raw data on sport-caught meals from Fiore et al., 1989. EPA calculated intake rates using a value of 150 grams per fish meal; this value is dervied from Pao et al., 1982.

This study is limited in its ability to accurately estimate intake rates because of the absence of data on weight of fish consumed. Another limitation of this study is that the results are based on one year recall, which may tend to over-estimate the number of fishing trips (Ebert et al., 1993). In addition, the response rate was rather low (50 percent).

Effects of Health Advisory and Advisory Changes on Fishing Habits and Fish Consumption in New York Sport Fisheries - Connelly et al. (1992) conducted a study to assess the awareness and knowledge of New York anglers about fishing advisories and contaminants found in fish and their fishing and fish consuming behaviors. The survey sample consisted of 2,000 anglers with New York State fishing licenses for the year beginning October 1, 1990 through September 30, 1991. A questionnaire was mailed to the survey sample in January, 1992. The questionnaire was designed to measure catch and consumption of fish, as well as methods of fish preparation and knowledge of and attitudes towards health advisories (Connelly et al. , 1992). The survey adjusted response rate was 52.8 percent (1,030 questionnaires were completed and 51 were not deliverable).

The average and median number of fishing days per year were 27 and 15 days respectively (Connelly et al. 1992). The mean number of sport-caught fish meals was 11. About 25 percent of anglers reported that they did not consume sport-caught fish.

Connelly et al. (1992) found that 80 percent of anglers statewide did not eat listed species or ate them within advisory limits and followed the 1 sport-caught fish meal per week recommended maximum. The other 20 percent of anglers exceeded the advisory recommendations in some way; 15 percent ate listed species above the limit and 5 percent ate more than one sport caught meal per week.

Connelly et al. (1992) found that respondents eating more than one sport-caught meal per week were just as likely as those eating less than one meal per week to know the recommended level of sport-caught fish consumption, although less than 1/3 in each group knew the level. An estimated 85 percent of anglers were aware of the health advisory. Over 50 percent of respondents said that they made changes in their fishing or fish consumption behaviors in response to health advisories.

The advisory included a section on methods that can be used to reduce contaminant exposure. Respondents were asked what methods they used for fish cleaning and cooking. Summary results on preparation and cooking methods are presented in Section 10.9 and in Appendix 10B.

A limitation of this study with respect to estimating fish intake rates is that only the number of sport-caught meals was ascertained, not the weight of fish consumed. The fish meal data can be converted to an intake rate (g/day) by assuming a value for a fish meal such as that from Pao et al. (1982) (about 150 grams as the average amount of fish consumed per eating occasion for adult males - males comprised 88 percent of respondents in the current study). Using 150 grams/meal the mean intake rate among the angler population would be 4.5 g/day; note that about 25 percent of this population reported no sport-caught fish consumption.

The major focus of this study was not on consumption, per se, but on the knowledge of and impact of fish health advisories; Connelly et al. (1992) provides important information on these issues.

Hudson River Sloop Clearwater, Inc. - Hudson River Angler Survey - Hudson River Sloop Clearwater, Inc. (1993) conducted a survey of adherence to fish consumption health advisories among Hudson River anglers. All fishing has been banned on the upper Hudson River, where high levels of PCB contamination are well documented; while voluntary recreational fish consumption advisories have been issued for areas south of the Troy Dam (Hudson River Sloop Clearwater, Inc., 1993).

The survey consisted of direct interviews with 336 shore-based anglers between the months of June and November 1991, and April and July 1992. Socio-demographic characteristics of the respondents are presented in Table 10-39. The survey sites were selected based on observations of use by anglers, and legal accessibility. The selected sites included upper, mid-, and lower Hudson River sites located in both rural and urban settings. The interviews were conducted on weekends and weekdays during morning, midday, and evening periods. The anglers were asked specific questions concerning: fishing and fish consumption habits; perceptions of presence of contaminants in fish; perceptions of risks associated with consumption of recreationally caught fish; and awareness of, attitude toward, and response to fish consumption advisories or fishing bans.

Table 10-39. Socio-Demographic Characteristics of Respondents

Category	Subcategory	Percent of Total[a]
Geographic Distribution	Upper Hudson	18 %
	Mid Hudson	35 %
	Lower Hudson	48 %
Age Distribution (years)	< 14	3 %
	15 - 29	26 %
	30 - 44	35 %
	45 - 59	23 %
	> 60	12 %
Annual Household Income	< $10,000	16 %
	$10 - 29,999	41 %
	$30 - 49,999	29 %
	$50 - 69,999	10 %
	$70 - 89,999	2 %
	> $90,000	3 %
Ethnic Background	Caucasian American	67 %
	African American	21 %
	Hispanic American	10 %
	Asian American	1 %
	Native American	1 %

[a] A total of 336 shore-based anglers were interviewed
Source: Hudson River Sloop Clearwater, Inc., 1993

Approximately 92 percent of the survey respondents were male. The following statistics were provided by Hudson River Sloop Clearwater, Inc. (1993). The most common reason given for fishing was for recreation or enjoyment. Over 58 percent of those surveyed indicated that they eat their catch. Of those anglers who eat their catch, 48 percent reported being aware of advisories. Approximately 24 percent of those who said they currently do not eat their catch, have done so in the past. Anglers were more likely to eat their catch from the lower Hudson areas where health advisories, rather than fishing bans, have been issued. Approximately 94 percent of Hispanic Americans were likely to eat their catch, while 77 percent of African Americans and 47 percent of Caucasian Americans intended to eat their catch. Of those who eat their catch, 87 percent were likely to share their meal with others (including women of childbearing age, and children under the age of fifteen).

For subsistence anglers, more low-income than upper income anglers eat their catch (Hudson River Sloop Clearwater, Inc., 1993). Approximately 10 percent of the respondents stated that food was their primary reason for fishing; this group is more likely to be in the lowest per capita income group (Hudson River Sloop Clearwater, Inc., 1993).

The average frequency of fish consumption reported was just under one (0.9) meal over the previous week, and three meals over the previous month. Approximately 35 percent of all anglers who eat their catch exceeded the amounts recommended by the New York State health advisories. Less than half (48 percent) of all the anglers interviewed were aware of the State health advisories or fishing bans. Only 42 percent of those anglers aware of the advisories have changed their fishing habits as a result. The advantages of this study include: in-person interviews with 95 percent of all anglers approached; field-tested questions designed to minimize interviewer bias; and candid responses concerning consumption of fish from contaminated waters. The limitations of this study are that specific intake amounts are not indicated, and that only shore-based anglers were interviewed.

10.8. NATIVE AMERICAN FRESHWATER STUDIES

Columbia River Inter-Tribal Fish Commission (CRITFC) - A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin - CRITFC (1994) conducted a fish consumption survey among four Columbia River Basin Indian tribes during the fall and winter of 1991-1992. The target population included all adult tribal members who lived on or near the Yakama, Warm Springs, Umatilla or

Nez Perce reservations. The survey was based on a stratified random sampling design where respondents were selected from patient registration files at the Indian Health Service. Interviews were performed in person at a central location on the member's reservation.

Information requested included annual and seasonal numbers of fish meals, average serving size per fish meal, species and part(s) of fish consumed, preparation methods, changes in patterns of consumption over the last 20 years and during ceremonies and festivals, breast feeding practices and 24 hour dietary recall (CRITFC, 1994). Foam sponge food models approximating four, eight, and twelve ounce fish fillets were provided to help respondents estimate average fish meal size. Fish intake rates were calculated by multiplying the annual frequency of fish meals by the average serving size per fish meal.

The study was designed to give essentially equal sample sizes for each tribe. However, since the population sizes of the tribes were highly unequal it was necessary to weight the data (in proportion to tribal population size) in order that the survey results represent the overall population of the four tribes. Such weights were applied to the analysis of adults; however, because the sample size for children was considered small, only an unweighted analysis was performed for this population (CRITFC, 1994).

The survey respondents consisted of 513 tribal members, 18 years old and above. Of these, 58 percent were female and 59 percent were under 40 years old. In addition, information for 204 children 5 years old and less was provided by the participating adult respondent. The overall response rate was 69 percent.

The results of the survey showed that adults consumed an average of 1.71 fish meals/week and had an average intake of 58.7 grams/day (CRITFC, 1994). Table 10-40 shows the adult fish intake distribution; the median was between 29 and 32 g/day and the 95th percentile about 170 g/day. A small percentage (7 percent) of respondents indicated that they were not fish consumers. Table 10-41 shows that mean intake was slightly higher in males than females (63 g/d versus 56 g/d) and was higher in the over 60 years age group (74.4 g/d) than in the 18-39 years (57.6 g/d) or 40-59 years (55.8 g/d) age group. Intake also tended to be higher among those living on the reservation. The mean intake for nursing mothers, 59.1 g/d, was similar to the overall mean intake.

A total of 49 percent of respondents reported that they caught fish from the Columbia River basin and its tributaries for personal use or for tribal ceremonies and distributions to other tribe members and 88 percent reported that they obtained fish from either self-harvesting, family or friends, at tribal ceremonies or from tribal distributions. Of all fish consumed, 41 percent came from self or family harvesting, 11 percent from the harvest of friends, 35 percent from tribal ceremonies or distribution, 9 percent from stores and 4 percent from other sources (CRITFC, 1994).

Table 10-40. Number of Grams Per Day of Fish Consumed by All Adult Respondents (Consumers and Non-consumers Combined) - Throughout the Year

Number of Grams/Day	Cumulative Percent	Number of Grams/Day	Cumulative Percent
0.00	8.9%	64.8	80.6%
1.6	9.0%	72.9	81.2%
3.2	10.4%	77.0	81.4%
4.0	10.8%	81.0	83.3%
4.9	10.9%	97.2	89.3%
6.5	12.8%	130	92.2%
7.3	12.9%	146	93.7%
8.1	13.7%	162	94.4%
9.7	14.4%	170	94.8%
12.2	14.9%	194	97.2%
13.0	16.3%	243	97.3%
16.2	22.8%	259	97.4%
19.4	24.0%	292	97.6%
20.2	24.1%	324	98.3%
24.3	27.9%	340	98.7%
29.2	28.1%	389	99.0%
32.4	52.5%	486	99.6%
38.9	52.9%	648	99.7%
40.5	56.5%	778	99.9%
48.6	67.6%	972	100%

N = 500
Weighted Mean = 58.7 grams/day (gpd)
Weighted SE = 3.64
90th Percentile: 97.2 gpd < (90th) < 130 gpd
95th Percentile ≈ 170 gpd
99th Percentile = 389 gpd
Source: CRITFC, 1994

Table 10-41. Fish Intake Throughout the Year by Sex, Age, and Location by All Adult Respondents

	N	Weighted Mean (grams/day)	Weighted SE
Sex			
Female	278	55.8	4.78
Male	222	62.6	5.60
Total	500	58.7	3.64
Age. (years)			
18-39	287	57.6	4.87
40-59	155	55.8	4.88
60 & Older	58	74.4	15.3
Total	500	58.7	3.64
Location			
On Reservation	440	60.2	3.98
Off Reservation	60	47.9	8.25
Total	500	58.7	3.64

Source: CRITFC, 1994.

The analysis of seasonal intake showed that May and June tended to be high consumption months and December and January low consumption months. The mean adult intake rate for May and June was 108 g/d while the mean intake rate for December and January was 30.7 g/d. Salmon was the species eaten by the highest number of respondents (92 percent) followed by trout (70 percent), lamprey (54 percent), and smelt (52 percent). Table 10-42 gives the fish intake distribution for children under 5 years of age. The mean intake rate was 19.6 g/d and the 95th percentile was approximately 70 g/d.

The authors noted that some non-response bias may have occured in the survey since respondents were more likely to live near the reservation and were more likely to be female than non-respondents. In addition, they hypothesized that non fish consumers may have been more likely to be non-respondents than fish consumers since non consumers may have thought their contribution to the survey would be meaningless; if such were the case, this study would ovestimate the mean intake rate. It was also noted that the timing of the survey, which was conducted during low fish consumption months, may have led to underestimation of actual fish consumption; the authors conjectured that an individual may report higher annual consumption if interviewed during a relatively high consumption month and lower annual consumption if interviewed during a relatively low consumption month. Finally, with respect to children's intake, it was observed that some of the respondents provided the same information for their children as for themselves, thereby the reliability of some of these data is questioned.

Although the authors have noted these limitations, this study does present information on fish consumption patterns and habits for a Native American subpopulation. It should be noted that the number of surveys that address subsistence subpopulations is very limited.

Table 10-42. Children's Fish Consumption Rates - Throughout Year

Number of Grams/Day	Unweighted Cumulative Percent
0.0	21.1%
0.4	21.6%
0.8	22.2%
1.6	24.7%
2.4	25.3%
3.2	28.4%
4.1	32.0%
4.9	33.5%
6.5	35.6%
8.1	47.4%
9.7	48.5%
12.2	51.0%
13.0	51.5%
16.2	72.7%
19.4	73.2%
20.3	74.2%
24.3	76.3%
32.4	87.1%
48.6	91.2%
64.8	94.3%
72.9	96.4%
81.0	97.4%
97.2	98.5%
162.0	100%

N = 194
Unweighted Mean = 19.6 grams/day (gpd)
Unweighted SE = 1.94

Source: CRITFC, 1994.

Wolfe and Walker - Subsistence Economies in Alaska: Productivity, Geography, and Development Impacts - Wolfe and Walker (1987) analyzed a dataset from 98 communities for harvests of fish, land mammals, marine mammals, and other wild resources. The analysis was performed to evaluate the distribution and productivity of subsistence harvests in Alaska during the 1980s. Harvest levels were used as a measure of productivity. Wolfe and Walker (1987) defined harvest to represent a single year's production from a complete seasonal round. The harvest levels were derived primarily from a compilation of data from subsistence studies conducted between 1980 to 1985 by various researchers in the Alaska Department of Fish and Game, Division of Subsistence.

Of the 98 communities studied, four were large urban population centers and 94 were small communities. The harvests for these latter 94 communities were documented through detailed retrospective interviews with harvesters from a sample of households (Wolfe and

Walker, 1987). Harvesters were asked to estimate the quantities of a particular species that were harvested and used by members of that household during the previous 12-month period. Wolfe and Walker (1987) converted harvests to a common unit for comparison, pounds dressed weight per capita per year, by multiplying the harvests of households within each community by standard factors converting total pounds to dressed weight, summing across households, and then dividing by the total number of household members in the household sample. Dressed weight varied by species and community but in general was 70 to 75 percent of total fish weight; dressed weight for fish represents that portion brought into the kitchen for use (Wolfe and Walker, 1987).

Harvests for the four urban populations were developed from a statewide data set gathered by the Alaska Department of Fish and Game Divisions of Game and Sports Fish. Urban sport fish harvest estimates were derived from a survey that was mailed to a randomly selected statewide sample of anglers (Wolfe and Walker, 1987). Sport fish harvests were disaggregated by urban residency and the dataset was analyzed by converting the harvests into pounds and dividing by the 1983 urban population.

For the overall analysis, each of the 98 communities was treated as a single unit of analysis and the entire group of communities was assumed to be a sample of all communities in Alaska (Wolfe and Walker, 1987). Each community was given equal weight, regardless of population size. Annual per capita harvests were calculated for each community. For the four urban centers, fish harvests ranged from 5 to 21 pounds per capita per year (6.2 g/day to 26.2 g/day).

The range for the 94 small communities was 25 to 1,239 pounds per capita per year (31 g/day to 1,541 g/day). For these 94 communities, the median per capita fish harvest was 130 pounds per year (162 g/day). In most (68 percent) of the 98 communities analyzed, resource harvests for fish were greater than the harvests of the other wildlife categories (land mammal, marine mammal, and other) combined.

The communities in this study were not made up entirely of Alaska Natives. For roughly half the communities, Alaska Natives comprised 80 percent or more of the population, but for about 40 percent of the communities they comprised less than 50 percent of the population. Wolfe and Walker (1987) performed a regression analysis which showed that the per capita harvest of a community tended to increase as a function of the percentage of Alaska Natives in the community. Although this analysis was done for total harvest (i.e., fish, land mammal, marine mammal and others) the same result should hold for fish harvest since fish harvest is highly correlated with total harvest.

A limitation of this report is that it presents (per-capita) harvest rates as opposed to individual intake rates. Wolfe and Walker (1987) compared the per capita harvest rates reported to the results for the household component of the 1977-1978 USDA National Food Consumption Survey (NFCS). The NFCS showed that about 222 pounds of meat, fish, and poultry were purchased and brought into the household kitchen for each person each year in the western region of the United States. This contrasts with a median total resource harvest of 260 lbs/yr in the 94 communities studied. This comparison, and the fact that Wolfe and Walker (1987) state that "harvests represent that portion brought into the kitchen for use", suggest that the same factors used to convert household consumption rates in the NFCS to individual intake rates can be used to convert per capita harvest rates to individual intake rates. In Section 10.3, a factor of 0.5 was used to convert fish consumption from household to individual intake rates. Applying this factor, the median per capita individual fish intake in the 94 communities would be 81 g/day and the range 15.5 to 770 g/day.

A limitation of this study is that the data were based on 1-year recall from a mailed survey. An advantage of the study is that it is one of the few studies that present fish harvest patterns for subsistence populations.

Fish PCB Concentrations and Consumption Patterns Among Mohawk Women at Akwesasne - Akwesasne is a native American community of ten thousand plus persons located along the St. Lawrence River (Fitzgerald et al., 1995). The local food chain has been contaminated with PCBs and some species have levels that exceed the U.S. FDA tolerance limits for human consumption (Fitzgerald et al., 1995). Fitzgerald et al. (1995) conducted a recall study from 1986 to 1992 to determine the fish consumption patterns among nursing Mohawk women residing near three industrial sites. The study sample consisted of 97 Mohawk women and 154 nursing Caucasian controls. The Mohawk mothers were significantly younger (mean age 24.9) than the controls (mean age 26.4) and had significantly more years of education (mean 13.1 for Mohawks versus 12.4 for controls). A total of 97 out of 119 Mohawk nursing women responded, a response rate of 78 percent; 154 out of 287 control nursing Caucasian women responded, a response rate of 54 percent.

Potential participants were identified prior to, or shortly after, delivery. The interviews were conducted at home within one month postpartum and were structured to collect information for sociodemographics, vital statistics, use of medications, occupational and residential histories, behavioral patterns (cigarette smoking and alcohol consumption), drinking water source, diet, and fish preparation methods (Fitzgerald et al., 1995). The dietary data collected were based on recall for food intake during the index pregnancy, the year before the pregnancy, and more than one year before the pregnancy.

The dietary assessment involved the report by each participant on the consumption of various foods with emphasis on local species of fish and game (Fitzgerald et al., 1995). This method combined food frequency and dietary histories to estimate usual intake. Food frequency was evaluated with a checklist of foods for indicating the amount of consumption of a participant per week, month or year. Information gathered for the dietary history included duration of consumption, changes in the diet, and food preparation method.

Table 10-43 presents the number of local fish meals per year for both the Mohawk and control participants. The highest percentage of participants reported consuming between 1 and 9 local fish meals per year. Table 10-43 indicates that Mohawk respondents consumed statistically significantly more local fish than did control respondents during the two time periods prior to pregnancy; for thetime period during pregnancy there was no significant difference in fish consumption between the two groups. Table 10-44 presents the mean number of local fish meals consumed per year by time period for all respondents and for those ever consuming (consumers only). A total of 82 (85 percent) Mohawk mothers and 72 (47 percent) control mothers reported ever consuming local fish. The mean number of local fish meals consumed per year by Mohawk respondents declined over time, from 23.4 (over one year before pregnancy) to 9.2 (less than one year before pregnancy) to 3.9 (during pregnancy); a similar decline was seen among consuming Mohawks only. There was also a decreasing trend over time in consumption among controls, though it was much less pronounced.

Table 10-45 presents the mean number of fish meals consumed per year for all participants by time period and selected characteristics (age, education, cigarette smoking, and alcohol consumption). Participants over 34 years of age had the highest fish consumption. The most common fish consumed by Mohawk mothers was yellow perch; for controls the most common fish consumed was trout.

An advantage of this study is that it presents data for fish consumption patterns for Native Americans as compared to a demographically similar group of Caucasians. Although the data are based on nursing mothers as participants, the study also captures consumption patterns prior to pregnancy (up to 1 year before and more than 1 year before). Fitzgerald et al. (1995) noted that dietary recall for a period more than one year before pregnancy may be inaccurate, but this data was the best available measure of the more distant past. They also noted that the observed decrease in fish consumption among Mohawks from the period one year before pregnancy to the period of pregnancy is due to a secular trend of declining fish consumption over time in Mohawks. This decrease, which was more pronounced than that seen in controls, may be due to health advisories

Table 10-43. Number of Local Fish Meals Consumed Per Year by Time Period for all Respondents

Number of Local Fish Meals Consumed Per Year	Time Period											
	During Pregnancy				≤1 Yr. Before Pregnancy[a]				> Yr. Before Pregnancy[b]			
	Mohawk		Control		Mohawk		Control		Mohawk		Control	
	N[c]	%	N[c]	%	N[c]	%	N[c]	%	N[c]	%	N[c]	%
None	63	64.9	109	70.8	42	43.3	99	64.3	20	20.6	93	60.4
1 - 9	24	24.7	24	15.6	40	41.2	31	20.1	42	43.3	35	22.7
10 - 19	5	5.2	7	4.5	4	4.1	6	3.9	6	6.2	8	5.2
20 - 29	1	1.0	5	3.3	3	3.1	3	1.9	9	9.3	5	3.3
30 - 39	0	0.0	2	1.3	0	0.0	3	1.9	1	1.0	1	0.6
40 - 49	0	0.0	1	0.6	1	1.0	1	0.6	1	1.0	1	0.6
50+	4	4.1	6	3.9	7	7.2	11	7.1	18	18.6	11	7.1
Total	97	100.0	154	100.0	97	100.0	154	100.0	97	100.0	154	100.0

[a] $p < 0.05$ for Mohawk vs. Control.
[b] $p < 0.001$ for Mohawk vs. Control.
[c] N = number of respondents.
Source: Fitzgerald et al., 1995.

Table 10-44. Mean Number of Local Fish Meals Consumed Per Year by Time Period for all Respondents and Consumers Only

	All Respondents (N=97 Mohawks and 154 Controls)			Consumers Only (N=82 Mohawks and 72 Controls)		
	During Pregnancy	≤1 Yr. Before Pregnancy	>1 Yr. Before Pregnancy	During Pregnancy	≤1 Yr. Before Pregnancy	>1 Yr. Before Pregnancy
Mohawk	3.9 (1.2)	9.2 (2.3)	23.4 (4.3)[b]	4.6 (1.3)	10.9 (2.7)	27.6 (4.9)
Control	7.3 (2.1)	10.7 (2.6)	10.9 (2.7)	15.5 (4.2)[b]	23.0 (5.1)[a]	23.0 (5.5)

[a] $p < 0.05$ for Mohawk vs. Control
[b] $p < 0.001$ for Mohawk vs. Control.
( ) = standard error.

Test for linear trend:
$p < 0.001$ for Mohawk (All participants and consumers only);
$p = 0.07$ for Controls (All participants and consumers only).

Source: Fitzgerald et al., 1995.

Table 10-45. Mean Number of Local Fish Meals Consumed Per Year by Time Period and Selected Characteristics for all Respondents

	Time Period					
	During Pregnancy		≤1 Year Before Pregnancy		>1 Year Before Pregnancy	
Background Variable	Mohawk	Control	Mohawk	Control	Mohawk	Control
Age (Yrs)						
<20	7.7	0.8	13.5	13.9	27.4	10.4
20 - 24	1.3	5.9	5.7	14.5	20.4	15.9
25 - 29	3.9	9.9	15.5	6.2	25.1	5.4
30 - 34	12.0	7.6	9.5	2.9	12.0	5.6
>34	1.8	11.2	1.8	26.2	52.3	22.1[a]
Education (Yrs)						
<12	6.3	7.9	14.8	12.4	24.7	8.6
12	7.3	5.4	8.1	8.4	15.3	11.4
13 - 15	1.7	10.1	8.0	15.4	29.2	13.3
>15	0.9	6.8	10.7	0.8	18.7	2.1
Cigarette Smoking						
Yes	3.8	8.8	10.4	13.0	31.6	10.9
No	3.9	6.4	8.4	8.3	18.1	10.8
Alcohol Consumption						
Yes	4.2	9.9	6.8	13.8	18.0	14.8
No	3.8	6.3[b]	12.1	4.7[c]	29.8	2.9[d]

[a] $F(4,149) = 2.66$, $p=0.035$ for Age Among Controls.
[b] $F(1,152) = 3.77$, $p=0.054$ for Alcohol Among Controls.
[c] $F(1,152) = 5.20$, $p=0.024$ for Alcohol Among Controls.
[d] $F(1,152) = 6.42$, $p=0.012$ for Alcohol Among Controls.
Source: Fitzgerald et al., 1995.

promulgated by tribal, as well as state, officials. The authors note that this decreasing secular trend in Mohawks is consistent with a survey from 1979-1980 that found an overall mean of 40 fish meals per year among male and female Mohawk adults.

The data are presented as number of fish meals per year; the authors did not assign an average weight to fish meals. If assessors wanted to estimate the weight of fish consumed some average value of weight per fish meal would have to be assumed. Pao et al. (1982) reported 104 grams as the average weight of fish consumed per eating occasion for females 19-34 years old.

Peterson et al. (1994) - Fish Consumption Patterns and Blood Mercury Levels in Wisconsin Chippewa Indians - Peterson et al. (1994) investigated the extent of exposure of methylmercury to Chippewa Indians living on a Northern Wisconsin reservation who consume fish caught in northern Wisconsin lakes. The lakes in northern

Wisconsin are known to be contaminated with mercury and the Chippewa have a reputation for high fish consumption (Peterson et al., 1994). The Chippewa Indians fish by the traditional method of spearfishing. Spearfishing (for walleye) occurs for about two weeks each spring after the ice breaks, and although only a small number of tribal members participate in it, the spearfishing harvest is distributed widely within the tribe by an informal distribution network of family and friends and through traditional tribal feasts (Peterson et al., 1994).

Potential survey participants, 465 adults, 18 years of age and older, were randomly selected from the tribal registries (Peterson et al., 1994). Participants were asked to complete a questionnaire describing their routine fish consumption and, more extensively, their fish consumption during the two previous months. They were also asked to give a blood sample that would be tested for mercury content. The survey was carried out in May 1990. A follow-up survey was conducted for a random sample of 75 non-respondents (80 percent were reachable), and their demographic and fish consumption patterns were obtained. Peterson et al. (1994) reported that the non-respondents' socioeconomic and fish consumption were similar to the respondents.

A total of 175 of the original random sample (38 percent) participated in the study. In addition, 152 nonrandomly selected participants were surveyed and included in the data analysis; these participants were reported by Peterson et al. (1994) to have fish consumption rates similar to those of the randomly selected participants. Results from the survey showed that fish consumption varied seasonally, with 50 percent of the respondents reporting April and May (spearfishing season) as the highest fish consumption months (Peterson et al., 1994). Table 10-46 shows the number of fish meals consumed per week during the last 2 months (recent consumption) before the survey was conducted and during the respondents' peak consumption months grouped by gender, age, education, and employment level. During peak consumption months, males consumed more fish (1.9 meals per week) than females (1.5 meals per week), respondents under 35 consumed more fish (1.8 meals per week) than respondents 35 and over (1.6 meals per week), and the unemployed consumed more fish (1.9 meals per week) than the employed (1.6 meals per week). During the highest fish consumption season (April and May), 50 percent of respondents reported eating one or less fish meals per week and only 2 percent reported daily fish consumption (Figures 10-1 and 10-2). A total of 72 percent of respondents reported Walleye consumption in the previous two months. Peterson et al. (1994) also reported that the mean number of fish meals usually consumed per week by the respondents was 1.2.

The mean fish consumption rate reported (1.2 fish meals per week, or 62.4 meals per year) in this survey was compared with the rate reported in a previous survey of Wisconsin anglers (Fiore et al., 1989) of 42 fish meals per year. These results indicate that the Chippewa Indians

Table 10-46. Sociodemographic Factors and Recent Fish Consumption

	Peak Consumption[a]		Recent Consumption[b]			
	Average[c]	$\geq$3[d] (%)	Walleye	N. Pike	Muskellunge	Bass
All participants (N-323)	1.7	20	4.2	0.3	0.3	0.5
Gender						
Male (n-148)	1.9	26	5.1	0.5[a]	0.5	0.7[a]
Female (n-175)	1.5	15	3.4	0.2	0.1	0.3
Age (y)						
$<$ 35 (n-150)	1.8	23	5.3[a]	0.3	0.2	0.7
$\geq$35 (n-173)	1.6	17	3.2	0.4	0.3	0.3
High School Graduate						
No (n-105)	1.6	18	3.6	0.2	0.4	0.7
Yes (n-218)	1.7	21	4.4	0.4	0.2	0.4
Unemployed						
Yes (n-78)	1.9	27	4.8	0.6	0.6	1.1
No (n-245)	1.6	18	4.0	0.3	0.2	0.3

[a] Highest number of fish meals consumed/week.
[b] Number of meals of each species in the previous 2 months.
[c] Average peak fish consumption.
[d] Percentage of population reporting peak fish consumption of $\geq$3 fish meals/week.
Source: Peterson et al., 1994.

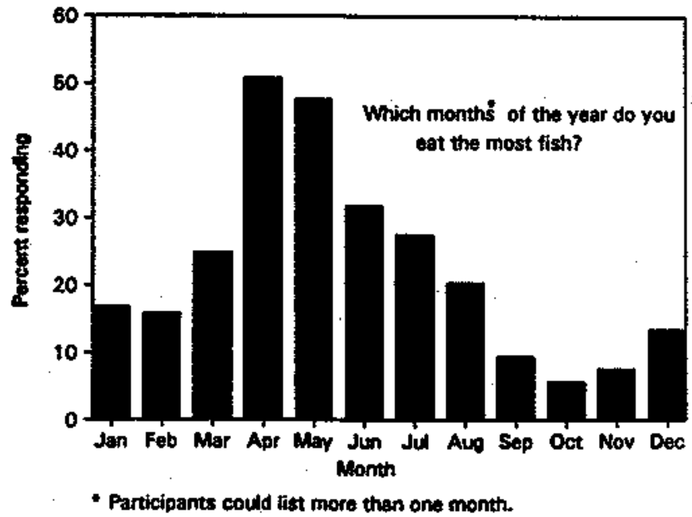


Figure 10-1. Seasonal Fish Consumption: Wisconsin Chippewa, 1990

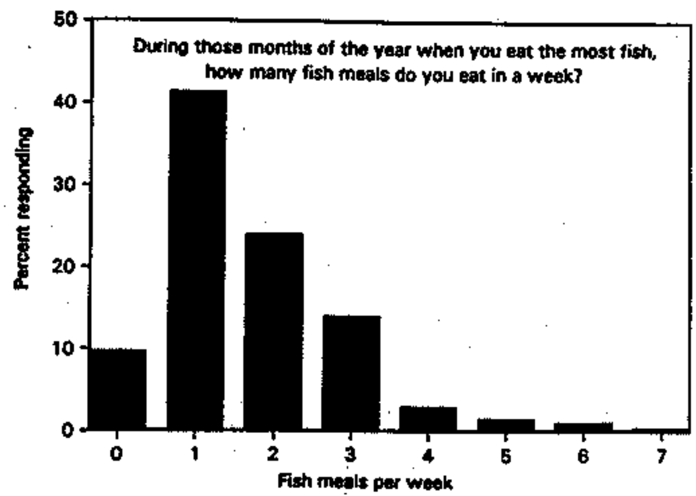


Figure 10-2. Peak Fish Consumption: Wisconsin Chippewa, 1990

Source: Peterson et al., 1994.

do not consume much more fish than the general Wisconsin angler population (Peterson et al., 1994). The differences in the two values may be attributed to differences in study methodology (Peterson et al., 1994). Note that this number (1.2 fish meals per week) includes fish from all sources. Peterson et al. (1994) noted that subsistence fishing, defined as fishing as a major food source, appears rare among the Chippewa. Using the rate from Pao et al. (1982) of 117 g/meal as the average weight of fish consumed per fish meal in the general population, the rate reported here of 1.2 fish meals per week translates into a mean fish intake rate of 20 g/day in this population.

AIHC (1994) - Exposure Factors Sourcebook - The Exposure Factors Sourcebook (AIHC, 1994) provides data for non-marine fish intake consistent with this document. However, the total fish intake rate recommended in AIHC (1994) is approximately 40 percent lower than that in this document. The fish intake rates presented in this handbook are based on more recent data from USDA CSFII (1989-1991). AIHC (1994) presents probability distributions in grams fish per kilogram of body weight for fish consumption based on data from U.S. EPA Guidance Manual, Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish. The @Risk formula is provided for direct use in the @Risk simulation software. The @Risk formula was provided for the distributions that were provided for the ingestion of freshwater finfish, saltwater finfish, and fish (unspecified) in the U.S. general population, children ages 1 to 6 years, and males ages 13 years and above. Distributions were also provided for saltwater finfish ingestion in the general population and for females and for males 13 years of age and older. Distributions for shellfish ingestion were provided for the general population, children ages 1 to 6 years, and for males and females 13 years of age and above. Additionally, distributions for “unspecified” fish ingestion were presented for the above mentioned populations.

The Sourcebook has been classified as a relevant rather than key study because it was not the primary source fo rthe data used to make recommendations in this document. The Sourcebook is very similar to this document in the sense that it summarizes exposure factor data and recommends values. Therefore, it can be used as an alternative information source on fish intake.

10.9 OTHER FACTORS

Other factors to consider when using the available survey data include location, climate, season, and ethnicity of the angler or consumer population, as well as the parts of fish consumed and the methods of preparation. Some contaminants (for example, some dioxin compounds) have the affinity to accumulate more in certain tissues, such as the fatty tissue, as well as in certain internal organs. The effects of cooking methods for various food products on the levels of dioxin-like compounds have been addressed by evaluating a number of studies in U.S. EPA (1996). These studies showed various results for contamination losses based on the methodology of the study and the method of food preparation. The reader is referred to U.S. EPA (1996) for a detailed review of these studies. In addition, some studies suggest that there is a significant decrease of contaminants in cooked fish when compared with raw fish (San Diego County, 1990). Several studies cited in this section have addressed fish preparation methods and parts of fish consumed. Table 10-47 provides summary results from these studies on fish preparation methods; further details on preparation methods, as well as results from some studies on parts of fish consumed, are presented in Appendix 10B.

The moisture content (percent) and total fat content (percent) measured and/or calculated in various fish forms (i.e., raw, cooked, smoked, etc.) for selected fish species are presented in Table 10-48, based on data from USDA (1979-1984). The total percent fat content is based on the sum of saturated, monounsaturated, and polyunsaturated fat. The moisture content is based on the percent of water present.

In some cases, the residue levels of contaminants in fish are reported as the concentration of contaminant per gram of fat. When using residue levels, the assessor should ensure consistency in the exposure assessment calculations by using consumption rates that are based on the amount of fat consumed for the fish species of interest. Alternately, residue levels for the "as consumed" portions of fish may be estimated by multiplying the levels based on fat by the fraction of fat (Table 10-48) per product as follows:

$$\text{residue level/g product} = \left(\frac{\text{residue level}}{\text{g-fat}}\right) \times \left(\frac{\text{g-fat}}{\text{g-product}}\right) \qquad \text{(Eqn. 10-4)}$$

Table 10-47. Percentage of Individuals Using Various Cooking Methods at Specified Frequencies

Study	Use Frequency	Bake	Pan Fry	Deep Fry	Broil or Grill	Poach	Boil	Smoke	Raw	Other
Connelly et al., 1992	Always	24(a)	51	13		24(a)				
	Ever	75(a)	88	59		75(a)				
Connelly et al., 1996	Always	13	4	4						
	Ever	84	72	42						
CRITFC, 1994	At least monthly	79	51	14	27	11	46	31	1	34(b) 29(c) 49(d)
	Ever	98	80	25	39	17	73	66	3	67(b) 71(c) 75(d)
Fitzgerald et al., 1995	Not Specified		94(e)(f)	71(e)(g)						
Puffer et al., 1981	As Primary Method	16.3	52.5	12					0.25	19(h)

[a] 24 and 75 listed as bake, BBQ, or poach
[b] Dried
[c] Roasted
[d] Canned
[e] Not specified whether deep or pan fried
[f] Mohawk women
[g] Control population
[h] boil, stew, soup, or steam

Table 10-48. Percent Moisture and Fat Content for Selected Species[a]

Species	Moisture Content (%)	Total Fat Content (%)[b]	Comments
		FINFISH	
Anchovy, European	73.37	4.101	Raw
	50.30	8.535	Canned in oil, drained solids
Bass	75.66	3.273	Freshwater, mixed species, raw
Bass, Striped	79.22	1.951	Raw
Bluefish	70.86	3.768	Raw
Butterfish	74.13	NA	Raw
Carp	76.31	4.842	Raw
	69.63	6.208	Cooked, dry heat
Catfish	76.39	3.597	Channel, raw
	58.81	12.224	Channel, cooked, breaded and fried
Cod, Atlantic	81.22	0.456	Atlantic, raw
	75.61	0.582	Canned, solids and liquids
	75.92	0.584	Cooked, dry heat
	16.14	1.608	Dried and salted
Cod, Pacific	81.28	0.407	Raw
Croaker, Atlantic	78.03	2.701	Raw
	59.76	11.713	Cooked, breaded and fried
Dolphinfish, Mahimahi	77.55	0.474	Raw
Drum, Freshwater	77.33	4.463	Raw
Flatfish, Flounder and Sole	79.06	0.845	Raw
	73.16	1.084	Cooked, dry heat
Grouper	79.22	0.756	Raw, mixed species
	73.36	0.970	Cooked, dry heat
Haddock	79.92	0.489	Raw
	74.25	0.627	Cooked, dry heat
	71.48	0.651	Smoked
Halibut, Atlantic & Pacific	77.92	1.812	Raw
	71.69	2.324	Cooked, dry heat
Halibut, Greenland	70.27	12.164	Raw
Herring, Atlantic & Turbot, domestic species	72.05	7.909	Raw
	64.16	10.140	Cooked, dry heat
	59.70	10.822	Kippered
	55.22	16.007	Pickled
Herring, Pacific	71.52	12.552	Raw
Mackerel, Atlantic	63.55	9.076	Raw
	53.27	15.482	Cooked, dry heat
Mackerel, Jack	69.17	4.587	Canned, drained solids
Mackerel, King	75.85	1.587	Raw
Mackerel, Pacific & Jack	70.15	6.816	Canned, drained solids
Mackerel, Spanish	71.67	5.097	Raw
	68.46	5.745	Cooked, dry heat
Monkfish	83.24	NA	Raw
Mullet, Striped	77.01	2.909	Raw
	70.52	3.730	Cooked, dry heat
Ocean Perch, Atlantic	78.70	1.296	Raw
	72.69	1.661	Cooked, dry heat
Perch, Mixed species	79.13	0.705	Raw
	73.25	0.904	Cooked, dry heat
Pike, Northern	78.92	0.477	Raw
	72.97	0.611	Cooked, dry heat
Pike, Walleye	79.31	0.990	Raw

Table 10-48. Percent Moisture and Fat Content for Selected Species[a] (continued)

Species	Moisture Content (%)	Total Fat Content (%)[b]	Comments
Pollock, Alaska & Walleye	81.56	0.701	Raw
	74.06	0.929	Cooked, dry heat
Pollock, Atlantic	78.18	0.730	Raw
Rockfish, Pacific, mixed species	79.26	1.182	Raw (Mixed species)
	73.41	1.515	Cooked, dry heat (mixed species)
Roughy, Orange	75.90	3.630	Raw
Salmon, Atlantic	68.50	5.625	Raw
Salmon, Chinook	73.17	9.061	Raw
	72.00	3.947	Smoked
Salmon, Chum	75.38	3.279	Raw
	70.77	4.922	Canned, drained solids with bone
Salmon, Coho	72.63	4.908	Raw
	65.35	6.213	Cooked, moist heat
Salmon, Pink	76.35	2.845	Raw
	68.81	5.391	Canned, solids with bone and liquid
Salmon, Red & Sockeye	70.24	4.560	Raw
	68.72	6.697	Canned, drained solids with bone
	61.84	9.616	Cooked, dry heat
Sardine, Atlantic	59.61	10.545	Canned in oil, drained solids with bone
Sardine, Pacific	68.30	11.054	Canned in tomato sauce, drained solids with bone
Sea Bass, mixed species	78.27	1.678	Cooked, dry heat
	72.14	2.152	Raw
Seatrout, mixed species	78.09	2.618	Raw
Shad, American	68.19	NA	Raw
Shark, mixed species	73.58	3.941	Raw
	60.09	12.841	Cooked, batter-dipped and fried
Snapper, mixed species	76.87	0.995	Raw
	70.35	1.275	Cooked, dry heat
Sole, Spot	75.95	3.870	Raw
Sturgeon, mixed species	76.55	3.544	Raw
	69.94	4.544	Cooked, dry heat
	62.50	3.829	Smoked
Sucker, white	79.71	1.965	Raw
Sunfish, Pumpkinseed	79.50	0.502	Raw
Swordfish	75.62	3.564	Raw
	68.75	4.569	Cooked, dry heat
Trout, mixed species	71.42	5.901	Raw
Trout, Rainbow	71.48	2.883	Raw
	63.43	3.696	Cooked, dry heat
Tuna, light meat	59.83	7.368	Canned in oil, drained solids
	74.51	0.730	Canned in water, drained solids
Tuna, white meat	64.02	NA	Canned in oil
	69.48	2.220	Canned in water, drained solids
Tuna, Bluefish, fresh	68.09	4.296	Raw
	59.09	5.509	Cooked, dry heat
Turbot, European	76.95	NA	Raw
Whitefish, mixed species	72.77	5.051	Raw
	70.83	0.799	Smoked
Whiting, mixed species	80.27	0.948	Raw
	74.71	1.216	Cooked, dry heat
Yellowtail, mixed species	74.52	NA	Raw

Table 10-48. Percent Moisture and Fat Content for Selected Species[a] (continued)

Species	Moisture Content (%)	Total Fat Content (%)[b]	Comments
		SHELLFISH	
Crab, Alaska King	79.57	NA	Raw
	77.55	0.854	Cooked, moist heat
			Imitation, made from surimi
Crab, Blue	79.02	0.801	Raw
	79.16	0.910	Canned (dry pack or drained solids of wet pack)
	77.43	1.188	Cooked, moist heat
	71.00	6.571	Crab cakes
Crab, Dungeness	79.18	0.616	Raw
Crab, Queen	80.58	0.821	Raw
Crayfish, mixed species	80.79	0.732	Raw
	75.37	0.939	Cooked, moist heat
Lobster, Northern	76.76	NA	Raw
	76.03	0.358	Cooked, moist heat
Shrimp, mixed species	75.86	1.250	Raw
	72.56	1.421	Canned (dry pack or drained solids of wet pack)
	52.86	10.984	Cooked, breaded and fried
	77.28	0.926	Cooked, moist heat
Spiny Lobster, mixed species	74.07	1.102	Imitation made from surimi, raw
Clam, mixed species	81.82	0.456	Raw
	63.64	0.912	Canned, drained solids
	97.70	NA	Canned, liquid
	61.55	10.098	Cooked, breaded and fried
	63.64	0.912	Cooked, moist heat
Mussel, Blue	80.58	1.538	Raw
	61.15	3.076	Cooked, moist heat
Octopus, common	80.25	0.628	Raw
Oyster, Eastern	85.14	1.620	Raw
	85.14	1.620	Canned (Solids and liquid based) raw
	64.72	11.212	Cooked, breaded and fried
	70.28	3.240	Cooked, moist heat
Oyster, Pacific	82.06	1.752	Raw
Scallop, mixed species	78.57	0.377	Raw
	58.44	10.023	Cooked, breaded and fried
	73.82	NA	Imitation, made from Surimi
Squid	78.55	0.989	Raw
	64.54	6.763	Cooked, fried

[a] Data are reported as is in the Handbook
[b] Total Fat Content - saturated, monosaturated and polyunsaturated
NA = Not available

Source: USDA, 1979-1984 - U.S. Agricultural Handbook No. 8

The resulting residue levels may then be used in conjunction with "as consumed" consumption rates.

Additionally, intake rates may be reported in terms of units as consumed or units of dry weight. It is essential that exposure assessors be aware of this difference so that they may ensure consistency between the units used for intake rates and those used for concentration data (i.e., if the unit of food consumption is grams dry weight/day, then the unit for the amount of pollutant in the food should be grams dry weight). If necessary, as consumed intake rates may be converted to dry weight intake rates using the moisture content percentages of fish presented in Table 10-48 and the following equation:

$$IR_{dw} = IR_{ac} * [(100-W)/100] \qquad \text{(Eqn. 10-5)}$$

"Dry weight" intake rates may be converted to "as consumed" rates by using:

$$IR_{ac} = IR_{dw}/[(100-W)/100] \qquad \text{(Eqn. 10-6)}$$

where:

IR_{dw} = dry weight intake rate;
IR_{ac} = as consumed intake rate; and
W = percent water content.

10.10. RECOMMENDATIONS

The survey designs, data generated, and limitations/advantages of the studies described in this report are summarized and presented in Table 10-49 (found at the end of this chapter). Fish consumption rates are recommended based on the survey results presented in the key studies described in the preceding sections. Considerable variation exists in the mean and upper percentile fish consumption rates obtained from these studies. This can be attributed largely to the characteristics of the survey population (i.e., general population, recreational anglers) and the type of water body (i.e., marine, estuarine, freshwater), but other factors such as study design, method of data collection and geographic location also play a role. Based on these study variations, recommendations for consumption rates were classified into the following categories:

- General Population;
- Recreational Marine Anglers;
- Recreational Freshwater Anglers; and
- Native American Subsistence Fishing Populations

The recommendations for each of these categories were rated according to the level of confidence the Agency has in the recommended values. These ratings were derived according to the principles outlined in Volume I, Section 1.3; the ratings and a summary of the rationale behind them are presented in tables which follow the discussion of each category.

For exposure assessment purposes, the selection of the appropriate category (or categories) from above will depend on the exposure scenario being evaluated. Assessors should use the recommended values (or range of values) unless specific studies are felt to be particularly relevant to their needs, in which case results from a specific study or studies may be used. This is particularly true for the last two categories where no nationwide key studies exist. Even where national data exist, it may be advantageous to use regional estimates if the assessment targets a particular region. In addition, seasonal, age, and gender variations should be considered when appropriate.

It should be noted that the recommended rates are based on mean (or median) values which represent a typical intake or central tendency for the population studied, and on upper estimates (i.e., 90th-99th percentiles) which represent the high-end fish consumption of the population studied. For the recreational angler populations, the recommended means and percentiles are based on all persons engaged in recreational fishing, not just those consuming recreationally caught fish.

10.10.1. Recommendations - General Population

The key study for estimating mean fish intake (reflective of both short-term and long-term consumption) is the USDA CSFII 1989-1991. The recommended values for mean intake by habitat and fish type are shown below. The confidence in recommendations is presented in Table 10-50 (found at the end of this chapter).

For all fish (finfish and shellfish) the values are 6.6 g/day for freshwater/estuarine fish, 13.5 g/day for marine fish and 20.1 g/day for all fish. Note these values are in terms of uncooked fish weight. Because the CSFII was based on short-term data, however, it could not be used to estimate the distribution over the long term of average daily fish intake. The long-term average daily fish intake distribution can be estimated using the TRI study which provided dietary data for a one month period. However, because the data from this study are now over 20 years old, it was felt that the distribution generated from these

Recommendations - General Population

Mean Intake (g/day)	95th Percentile of Long-term Intake Distribution (g/day)	Study (Reference)
	63 (Value of 42 from Javitz was adjusted upward by 50 percent to account for recent increase in fish consumption)	TRI (Javitz, 1980; Ruffle et al., 1994)
20.1 (Total Fish) 13.5 (Marine Fish) 6.6 (Freshwater/Estuarine Fish)		U.S. EPA Analysis of CSFII, 1989-91

data should be adjusted to account for the recent increase in fish consumption. The CSFII estimate of per capita intake, 20.1 g/day, is about 50 percent higher than the per-capita intake from the TRI study (13.4 g/day). Then, as suggested by Ruffle et al. (1994) the distributions generated from TRI should be shifted upward by 50 percent to estimate the current fish intake distribution. Thus, the recommended percentiles of long-term average daily fish intake are those of Javitz (1980) adjusted 50 percent upward (see Tables 10-3, 10-4). Alternatively, the log-normal distribution of Ruffle et al. (1994) (Table 10-6) may be used to approximate the long term fish intake distribution; adjusting the log mean μ by adding log(1.5) = 0.4 to it will shift the distribution upward by 50 percent.

The distribution of serving sizes may be useful for acute exposure assessments. The recommended values are 123 g/day for mean serving size and 305 g/day for the 95th percentile serving size (i.e., the midpoints of the values below).

10.10.2. Recommendations - Recreational Marine Anglers

The recommended values presented below are based on the surveys of the National Marine Fisheries Service (NMFS). The intake values are based on finfish consumption only. The confidence rating for recreational marine anglers is presented in Table 10-51 (found at the end of this chapter).

Recommendations - General Population - Fish Serving Size

Mean Intake (grams)	95th Percentile (grams)	Study (Reference)
117	284	1977-78 NFCS (Pao et al., 1982)
129	326	1989-1991 CSFII (U.S. EPA, 1996)

Recommendations - Recreational Marine Anglers

Mean Intake (g/day)	95th Percentile (g/day)	Study Location	Study
5.6	18.0	Atlantic	NMFS, 1993
7.2	26.0	Gulf	
2.0	6.8	Pacific	

10.10.3. Recommendations - Recreational Freshwater Anglers

The data presented below are based on mailed questionnaire surveys (Ebert et al., 1993 and West et al., 1989; 1993) and a diary study (Connelly et al., 1992). The mean intakes ranged from 5-17 g/day. In two relevant studies, (Connelly et al., 1992 and Fiore et al., 1989) only the number of fish meals was ascertained. Using average meal sizes taken from Pao et. al. (1982) to calculate intake rates for these studies gives mean rates similar to those reported above (4.5 g/day and 7.4 g/day). The recommended mean and 95th percentile values for recreational freshwater anglers are 8 g/day and 25 g/day, respectively; these were derived by averaging the values from the three populations surveyed in the key studies. Since the two West et al. surveys studied the same population, the average of the means from the two studies was used to represent the mean for this population. The estimate from the West et al. (1989) survey was used to represent the 95th percentile for this population since the long term consumption percentiles could not be estimated from the West et al. (1993) study. Confidence in fish intake recommendations for recreational freshwater fish consumption is presented in Table 10-52 (found at the end of this chapter).

Recommendations - Freshwater Anglers

Mean Intake (g/day)	Upper Percentile (g/day)	Study Location	Reference
5	13 (95th percentile)	Maine	Ebert et al., 1992
5	18 (95th percentile)	New York	Connelly et al., 1996
12	39 (96th percentile)	Michigan	West et al, 1989
17	---	Michigan	West et al, 1993

10.10.4. Recommendations - Native American

Subsistence Populations

Fish consumption data for Native American subsistence populations are very limited. The CRITFC (1994) study gives a per-capita fish intake rate of 59 g/day and a 95th percentile of 170 g/day. The report by Wolfe and Walker (1987) presents harvest rates for 94 small communities engaged in subsistence harvests of natural resources. A factor of 0.5 was employed to convert the per-capita harvest rates presented in Wolfe and Walker to per capita individual consumption rates; this is the same factor used to convert from per capita household consumption rates to per capita individual consumption rates in the analysis of homegrown fish consumption from the 1987-1988 NFCS. Based on this factor, the median

Recommendations - Native American Subsistence Populations

Per-Capita (or Mean) Intake (g/day)	Upper Percentile (g/day)	Study Population	Reference
59	170 (95th)	4 Columbia River Tribes	CRITFC, 1994
16	---	94 Alaska Communities (Lowest of 94)	Wolfe and Walker 1989
81	---	94 Alaska Communities (Median of 94)	Wolfe and Walker 1989
770	---	94 Alaska Communities (Highest of 94)	Wolfe and Walker 1989

per-capita harvest in the 94 communities of 162 g/day (and the range of 31-1,540 g/day) is converted to the median per capita intake rate of 81 g/day (range 16-770 g/day) shown in the table below. The recommended value for mean intake is 70 g/day and the recommended 95th percentile is 170 g/day. The confidence in ratings are presented in Table 10-53 (found at the end of this chapter).

It should be emphasized that the above recommendations refer only to Native American subsistence fishing populations, not the Native American population generally. Several studies show that intake rates of recreationally caught fish among Native Americans with state fishing licences (West et al., 1989; Ebert et al., 1993) are somewhat higher (50-100 percent) than intake rates among other anglers, but far lower than the above rates shown for Native American subsistence populations.

In addition, the studies of Peterson et al. (1994) and Fiore et al. (1989) show that total fish intake among a Native American population on a reservation (Chippewa in Wisconsin) is roughly comparable (50 percent higher) to total fish intake among licensed anglers in the same state, and the study of Fitzgerald et al. (1995) showed that pregnant women on a reservation (Mohawk in New York) have sport-caught fish intake rates comparable to those of a local white control population.

10.11 REFERENCES FOR CHAPTER 10

American Industrial Hygiene Council (AIHC) (1994) Exposure factors sourcebook. AIHC, Washington, DC.

ChemRisk (1991) Consumption of freshwater fish by maine anglers. Portland, ME: ChemRisk.

Columbia River Inter-Tribal Fish Commission (CRIFTC). (1994) A fish consumption survey of the Umatilla, Nez Perce, Yakama and Warm Springs tribes of the Columbia River Basin. Technical Report 94-3. Portland, OR: CRIFTC.

Connelly, N.A.; Brown, T.L.; Knuth, B.A. (1990) New York statewide angler survey 1988. New York State Department of Environmental Conservation, Bureau of Fisheries.

Connelly, N.A.; Knuth, B.A.; Bisogni, C.A. (1992) Effects of the health advisory changes on fishing habits and fish consumption in New York sport fisheries. Human Dimension Research Unit, Department of Natural Resources, New York State College of Agriculture and Life Sciences, Fernow Hall, Cornell University, Ithaca, NY. Report for the New York Sea Grant Institute Project No. R/FHD-2-PD. September.

Connelly, N.A.; Knuth, B.A.; Brown, T.L. (1996) Sportfish consumption patterns of Lake Ontario anglers (In press with N. Am. J. Fisheries Management).

Ebert, E.; Harrington, N.; Boyle, K.; Knight, J.; Keenan, R. (1993) Estimating consumption of freshwater fish among Maine anglers. North Am. J. Fisheries Management 13:737-745.

Fiore, B.J.; Anderson, H.A.; Hanrahan, L.P.; Olsen, L.J.; Sonzogni, W.C. (1989) Sport fish consumption and body burden levels of chlorinated hydrocarbons: A study of Wisconsin anglers. Arch. Environ. Health 44:82-88.

Fitzgerald, E.; Hwang, S.A.; Briz, K.A.; Bush, B.; Cook, K.; Worswick, P. (1995) Fish PCB concentrations and consumption patterns among Mohawk women at Akwesasne. J. Exp. Anal. Environ. Epid. 5(1):1-19.

Hudson River Sloop Clearwater, Inc. (1993) Hudson River angler survey. Hudson River Sloop Clearwater, Inc., Poughkeepsie, NY.

Javitz, H. (1980) Seafood consumption data analysis. SRI International. Final report prepared for EPA Office of Water Regulations and Standards. EPA Contract 68-01-3887.

National Marine Fisheries Service (NMFS). (1986a) Fisheries of the United States, 1985. Current Fisheries Statistics No. 8368. U.S. Department of Commerce. National Oceanic and Atmospheric Administration.

National Marine Fisheries Service (NMFS). (1986b) National Marine Fisheries Service. Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1985. Current Fisheries Statistics No. 8327. U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

National Marine Fisheries Service (NMFS). (1986c) National Marine Fisheries Service. Marine Recreational Fishery Statistics Survey, Pacific Coast. Current Fisheries Statistics No. 8328. U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

National Marine Fisheries Service (NMFS). (1993) Data tapes for the 1993 NMFS provided to U.S. EPA, National Center for Environmental Assessments.

Pao, E.M.; Fleming, K.H.; Guenther, P.M.; Mickle, S.J. (1982) Foods commonly eaten by individuals: amount per day and per eating occasion. U.S. Department of Agriculture. Home Economics Report No. 44.

Peterson, D.; Kanarek, M.; Kuykendall, M.; Diedrich, J.; Anderson, H.; Remington, P.; Sheffy, T. (1994) Fish consumption patterns and blood mercury levels in Wisconsin Chippewa Indians. Archives. Environ. Health, 49:53-58.

Pierce, R.S.; Noviello, D.T.; Rogers, S.H. (1981) Commencement Bay seafood consumption report. Preliminary report. Tacoma, WA: Tacoma-Pierce County Health Department.

Price, P.; Su, S.; Gray, M. (1994) The effects of sampling bias on estimates of angler consumption rates in creel surveys. Portland, ME: ChemRisk.

Puffer, H.W., Azen, S.P.; Duda, M.J.; Young, D.R. (1981) Consumption rates of potentially hazardous marine fish caught in the metropolitan Los Angeles area. EPA Grant #R807 120010.

Ruffle, B.; Burmaster, D.; Anderson, P.; Gordon, D. (1994) Lognormal distributions for fish consumption by the general U.S. population. Risk Analysis 14(4):395-404.

Rupp, E.; Miler, F.L.; Baes, C.F. III. (1980) Some results of recent surveys of fish and shellfish consumption by age and region of U.S. residents. Health Physics 39:165-175.

San Diego County (1990) San Diego Bay health risk study. San Diego, CA. San Diego County Department of Health Services.

Tsang, A.M.; Klepeis, N.E. (1996) Results tables from a detailed analysis of the National Human Activity Pattern Survey (NHAPS) response. Draft Report prepared for the U.S. Environmental Protection Agency by Lockheed Martin, Contract No. 68-W6-001, Delivery Order No. 13.

USDA. (1979-1984) Agricultural Handbook No. 8.

USDA. (1989-1991) Continuing Survey of Food Intakes by Individuals (CSFII). U.S. Department of Agriculture.

USDA. (1992a) Changes in food consumption and expenditures in American households during the 1980's. U.S. Department of Agriculture. Washington, D.C. Statistical Bulletin No. 849.

USDA. (1992b) U.S. Department of Agriculture, Human Nutrition Information Service. Food and nutrient intakes by individuals in the United States, 1 day, 1987-88: Nationwide Food Consumption Survey 1987-88, NFCS Rpt. No. 87-I-1, in preparation.

U.S. DHHS. (1995) Final Report: Health study to assess the human health effects of mercury exposure to fish consumed from the Everglades. Prepared by the Florida Department of Health and Rehabilitative Services for the U.S. Department of Health and Human Services, Atlanta, Georgia. PB95-167276.

U.S. EPA. (1989) Exposure factors handbook. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Washington, DC.

U.S. EPA. (1992) Consumption surveys for fish and shellfish; a review and analysis of survey methods. U.S. Environmental Protection Agency, Office of Water. EPA 822/R-92-001.

U.S. EPA. (1995) Fish consumption estimates based on the 1991-92 Michigan sport anglers fish consumption study. Final Report. Prepared by SAIC for the Office of Science and Technology.

U.S. EPA. (1996) Estimating exposure to dioxin-like compounds. (Draft). Office of Research and Development, National Center for Environmental Assessment.

West, P.C.; Fly, M.J.; Marans, R.; Larkin, F. (1989) Michigan sport anglers fish consumption survey. A report to the Michigan Toxic Substance Control Commission. Michigan Department of Management and Budget Contract No. 87-20141.

West, P.C.; Fly, J.M.; Marans, R.; Larkin, F.; Rosenblatt, D. (1993) 1991-92 Michigan sport anglers fish consumption study. Prepared by the University of Michigan, School of Natural Resources for the Michigan Department of Natural Resources, Ann Arbor, MI. Technical Report No. 6. May.

Wolfe, R.J.; Walker, R.J. (1987) Subsistence economics in Alaska: productivity, geography, and development impacts. Arctic Anthropology 24(2):56-81.

Table 10-49. Summary of Fish Intake Studies

Source of Data (Reference)	Relevance	Population Surveyed	Survey Time Period/Type	Analyses Performed (References)	Limitations/Advantages
General Population					
TRI Survey (Javitz 1980)	Key	25,162 individuals - general population	Sept 1973-Aug. 1974 (1 year survey). Completed diary over 1 month period on date of meal consumption, species of fish, packaging type, amount of fish prepared, number of servings consumed, etc.	Mean and distribution of fish consumption rates grouped by race, age, gender, census region, fish species, community type, and religion (Javitz, 1980). Lognormal distribution fit to fish intake distribution by age and region (Ruffle, 1994).	High response rate (80%); population was large and geographically and seasonally representative; consumption rates based on one month of diary data; survey data is over 20 years out of date
USDA 1977-1978 NCFS (Pao et al., 1982).	Key	37,874 individuals - general population	Participants provided 3 consecutive days of dietary data. Survey conducted between April, 1977 and March, 1978.	Mean and distribution of average daily fish intake and average fish intake per eating occasion; by age-sex groups and overall. (Pao et al., 1982)	Population was large and geographically representative; data were based on short-term dietary recall; data are almost 20 years out of date.
U.S. EPA Analysis of CSFII 1989-91	Key	11,912 individuals - general population	Participants provided 3 consecutive days of dietary data. Three survey years (1989-1991) combined into one data set.	Fish grouped by habitat (freshwater vs. marine) and type (finfish vs. shellfish). Per capita fish intake rates calculated using cooked and uncooked equivalent weight and reported in g/day and g/kg-day; also intake distribution per day eating fish. (U.S. EPA, 96)	Large, geographically representative study; relatively recent. Based on short-term (3 day) data so long-term percentiles of fish intake distribution could not be estimated.
NHAPS (Tsang and Klepeis, 1996)	Relevant	9,386 individuals - general population	Participants provided 24-hour diary data. Follow-up questionnaires, survey conducted between October 1992 and September 1994.	Frequency of eating fish and number of servings per month provided.	Population large and geographically and seasonally balanced; data based on recall; intake data not provided.
USDA 1987-88 NCFS (USDA, 1992)	Relevant	10,000 individuals- general population	Participants provided 3 consecutive days of dietary data. Survey conducted between April 1987 and March 1988.	Per capita fish intake rates and percent of population consuming fish in one day; by age and sex (USDA, 1992).	Population was large and geographically and seasonally balanced; data based on short-term dietary recall.
Sourcebook (AIHC, 1994)	Relevant	--	--	Distributions using @Risk simulation software.	Limited reviews of supporting studies; good alternative source of information.

Table 10-49. Summary of Fish Intake Studies (continued)

Source of Data (Reference)	Relevance	Population Surveyed	Survey Time Period/Type	Analyses Performed (References)	Limitations/Advantages
Recreational-Marine Fish					
National Marine Fisheries Service (NMFS 1986a, b, c; 1993)	Key	Atlantic and Gulf Coasts - 41,000 field interviews and 58,000 telephone interviews; Pacific Coast - 38,000 field interviews and 73,000 telephone interviews.	Telephone interviews with residents of coastal counties; information on fishing frequency and mode of fishing trips. Field interviews with marine anglers; information on area and mode fished, fishing frequency, species caught, weight of fish, and whether fish were intended to be consumed.	Intake rates were not calculated; total catch size grouped by marine species, seasons, and number of fishermen for each coastal region were presented. (NMFS 1986a, b, c; 1993)	Population was large geographically and seasonally balanced; fish caught were weighed in the field. No information on number of potential consumers of catch.
Commencement Bay Seafood Consumption Study (Pierce et al., 1981)	Relevant	~500 anglers in Commencement Bay, Washington	July-November 1980; creel survey interviews conducted consisting of 5 summer days and 4 fall days.	Distribution of fishing frequency; total weight of catch grouped by species (Pierce et al. 1981). Re-analysis by Price et al. (1994) using inverse fishing frequency as sample weights.	Local survey. Original analysis by Pierce et al. (1981) did not calculate intake rates; analysis over-estimated fishing frequency distribution by oversampling frequent anglers. Re-analysis by Price et. al. involves several assumptions; thus results are questionable.
Consumption of Potentially Hazardous Marine Fish in Los Angeles (Puffer et al., 1981)	Relevant	1,067 anglers in the Los Angeles area.	Creel survey conducted for the full 1980 calendar year.	Distribution of sport fish intake rates. Median rates by age, ethnicity and fish species (Puffer et al., 1981). Re-analysis by Price et al. (1994) using inverse fishing frequency as sample weights.	Local survey. Original (unweighted) analysis over-estimated fish intake by oversampling frequent anglers. Re-analysis by Price et al. (1994) involves several assumptions; thus results are questionable.
Recreational Fresh Water Fish					
Sportfish consumption patterns in Lake Ontario anglers (Connelly et al., 1996)	Key	825 anglers with NY State fishing licenses intending to fish Lake Ontario.	Survey consisted of self-recording information in a diary for 1992 fishing trips and fish consumption.	Distribution of intake rates of sport caught fish. (Connelly et al., 1996)	Meal size estimated by comparison with pictures of 8 oz. fish meals.
Freshwater fish consumption in Maine anglers (Chemrisk, 1991; Ebert et al., 1993)	Key	1,612 licensed Maine anglers	1989-1990 ice fishing season and 1990 open water season; mailed survey; one year recall of frequency of fishing trips, number and length of fish species caught.	Mean and distribution of fish consumption rates by ethnic groups and overall (Chemrisk, 1991). Mean and distribution of fish consumption rates for fish from rivers and streams (Chemrisk, 1991 and Ebert et al., 1993). EPA analysis of fish intake for household members.	Data based on one year recall; high response rate; area-specific consumption patterns.
Michigan Sport Anglers Fish Consumption Study (West et al., 1993)	Key	2,681 persons with Michigan fishing licenses	January 1991 through January 1992; mailed survey; 7-day recall; demographics information requested, and quantity of fish eaten, if any, at each meal based on a photograph of 1/2 lb of fish (more about same, or less).	Mean consumption rate for sport and total fish by demographic category (West et al., 1993) and 50th, 90th, and 95th percentile (U.S. EPA, 1995).	Relatively low response made and only three categories were used to assign fish portion size. Relatively large-scale study and reliance on short-term recall.

Table 10-49. Summary of Fish Intake Studies (continued)

Source of Data (Reference)	Relevance	Population Surveyed	Survey Time Period/Type	Analyses Performed (References)	Limitations/Advantages
Sportfish Consumption in Michigan anglers (West et al., 1989)	Key	1,171 Michigan residents with fishing licenses	January-May, 1988; anglers completed questionnaires based on 7-day and 1-year recall.	Mean intake rates of self-caught fish based on 7-day recall period and mean and percentiles of self-caught fish intake based on one year recall (West et al., 1989).	Weight of fish consumed was estimated using a picture of an 8 oz. fish meal; smaller meals were judged to be 5 oz., larger ones 10 oz.
Effects of the Health Advisory on New York sport fishing (Connelly et al., 1992)	Relevant	1,030 anglers licensed in New York	Survey mailed out in Jan. 1992; one year recall of the period Oct. 1990-Sept. 1991	Knowledge and effects of fish health advisories. Mean number of sport-caught fish meals. (Connelly et al., 1992)	Response rate of 52.8%; only number of fish mealsreported.
Sportfish consumption in Wisconsin anglers (Fiore et al., 1989).	Relevant	801 individuals with Wisconsin fish or sporting licenses	1985 summer; mailed survey; one year recall of sport fish consumption.	Mean number of sport caught fish meals of Wisconsin anglers. (Fiore et al., 1989)	Constant meal size assumed.
Hudson River Angler Survey (Hudson River Sloop Clearwater, Inc.)	Relevant	336 shore-based anglers	Survey conducted June-November 1991; April-July 1992. Onsite interview with anglers	Knowledge and adherance to health advsisories	Data collected from personal interviews; intake data not provided; fish meal data provided.
Native American					
Columbia River Intertribal Fish Commission (CRITFC, 1994)	Key	Four tribes in Washington state; total of 513 adults and 204 children under five	Fall and Winter of 1991-1992; stratified random sampling approach; in-person interviews; information requested included 24-hour dietary recall, seasonal and annual number of fish meals, average weight of fish meals and species consumed.	Mean and distribution of fish intake rates for adults and for children. Mean intake rates by age and gender. Frequency of cooking and preparation methods. (CRITFC, 1994).	Survey was done at only one time of the year and involved one year recall; fish intake rates were based on all fish sources but great majority was locally caught; study provides consumption and habits for subsistence subpopulation group.
Mohawk Women in N.Y. State (Fitzgerald et al. 1995)	Key	97 Mohawk women; 154 Caucasian women; nursing mothers	1988-1992, up to 3-year recall	Mean number of sport-caught fish meals per year. (Fitzzgerald et al., 1995)	Survey for nursing mothers only, recall for up to 3 years; small sample size; may be representative of Mohawk women; measured in fish meals.
Chippewa in Wisconsin (Petersen et al., 1994)	Key	327 residents of Chippewa reservation, Wisconsin	Self-administered questionaire completed in May, 1990.	Mean number of fish meals per year. (Petersen et al., 1994)	Did not distinguish between commercial and sport-caught meals.
Subsistence Economies in Alaska (Wolfe and Walker, 1987)	Key	Ninety-eight communities in Alaska surveyed by various researchers	Surveys conducted between 1980 and 1985; data based on 1-year recall period. Annual per capita harvest of fish, land mammals, marine mammals and other resources estimated for each community.	Distribution among communities of annual per-capita harvests for each resource category. (Wolfe and Walker, 1987).	Data based on 1-year recall; data provided are harvest data that must be converted to individual intake rates; surveyed communities are only a sample of all Alaska communities.

[a] NFMS - National Marine Fisheries Services.

Table 10-50. Confidence in Fish Intake Recommendations for General Population		
Considerations	Rationale	Rating
Study Elements		
• Level of peer review	USDA and EPA review	High
• Accessibility		
• Reproducibility		
• Focus on factor of interest	Yes	High
• Data pertinent to U.S.	U.S. studies	High
• Primary data	Yes	High
• Currency	Studies from 1973-1974 to 1989-1991	High (Mean, Serving-size Distribution) Low (Long-Term Distribution)
• Adequacy of data collection period	Long-term distribution based on one month data collection period	High (Mean, Serving-size Distribution) Medium (Long-term distribution)
• Validity of approach	Diaries and one-day recall	High
• Study size	Range 10,000 -37,000	High
• Representativeness of the population	Representative of overall U.S. population.	High
• Characterization of variability	Long-term distribution (generated from 1973-1974 data) was shifted upward based on recent increase in mean consumption.	Medium
• Lack of bias in study design (high rating is desirable)	Response rates fairly high; no obvious source of bias.	High
• Measurement error	Estimates of intake amounts imprecise	Medium
Other Elements		
• Number of studies	1 for mean, 2 for serving size distribution, results of 2 studies utilized for long-term distribution	Medium
• Agreement between researchers		Medium
Overall Rating		High (Mean, Serving-size distribution) Medium (Long-term distribution)

Table 10-51. Confidence in Fish Intake Recommendations for Recreational Marine Anglers

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	NMFS and EPA review	High
• Accessibility	Details in Handbook and NMFS publications	
• Reproducibility	See above	High
• Focus on factor of interest	Focus on fish catch rather than fish consumption per se.	Medium
• Data pertinent to U.S.	U.S. studies	High
• Primary data	Yes	High
• Currency	Data from 1993	High
• Adequacy of data collection period	Data collected once for each angler. Yearly catch of angler estimated from catch on intercepted trip and reported fishing frequency.	Medium
• Validity of approach	Creel survey provided data on fishing frequency and fish weight; telephone survey provided number of anglers. Average value used for number of intended fish consumers and edible fraction.	Medium
• Study size	Over 100,000	High
• Representativeness of the population	Representative of overall U.S. coastal state population.	High
• Characterization of variability	Distributions generated	High
• Lack of bias in study design (high rating is desirable)	Response rates fairly high; no obvious source of bias.	High
• Measurement error	Fish were weighed in field	High
Other Elements		
• Number of studies	1	Low
• Agreement between researchers	N/A	
Overall Rating		Medium

Table 10-52. Confidence in Recommendations for Fish Consumption - Recreational Freshwater		
Considerations	Rationale	Rating
Study Elements		
• Level of peer review	Peer reviewed journals and EPA review	High
• Accessibility	Original study analyses reported in accessible journals. Subsequent EPA analyses detailed in Handbook.	High
• Reproducibility	See above	High
• Focus on factor of interest	Yes	High
• Data pertinent to U.S.	U.S. studies	High
• Primary data	Yes	High
• Currency	Studies range from 1988-1992	High
• Adequacy of data collection period	Data for one year period collected for 3 studies; one week period for one study.	High
• Validity of approach	One year recall of fishing trips (2 studies), one week recall of fish consumption (1 study), and one year diary survey (1 study). Weight of fish consumed estimated using approximate weight of fish catch and edible fraction or approximate weight of fish meal.	Medium
• Study size	800-2600	High
• Representativeness of the population	Each study localized to a single state.	Low
• Characterization of variability	Distributions generated	High
• Lack of bias in study design (high rating is desirable)	Response rates fairly high. One year recall of fishing trips may result in overestimate.	Medium
• Measurement error	Weight of fish portions estimated in one study, fish weight estimated from reported fish length in another.	Medium
Other Elements		
• Number of studies	4	High
• Agreement between researchers	Rates in different parts of country may be expected to show some variation.	Medium
Overall Rating	Main drawback is studies are not nationally representative.	Medium

Table 10-53. Confidence in Recommendations for Native American Subsistence Fish Consumption

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	Peer reviewed journal (1 study), technical report (1study)	Medium
• Accessibility	See above	Medium
• Reproducibility	Studies adequately detailed	High
• Focus on factor of interest	Yes	High
• Data pertinent to U.S.	U.S. studies	High
• Primary data	One study used primary data, the other secondary data	Medium
• Currency	Data from early 1980's to 1992.	Medium
• Adequacy of data collection period	Data for one year period collected.	High
• Validity of approach	One study used fish harvest data; EPA used factor to convert to individual intake. Other study measured individual intake directly.	Medium
• Study size	500 for study with primary data	Medium
• Representativeness of the population	Only two states represented.	Low
• Characterization of variability	Individual variation not described in summary study	Medium
• Lack of bias in study design (high rating is desirable)	Response rate 69% in study with primary data. Bias hard to evaluate in summary study.	Medium
• Measurement error	Weight of fish estimated	Medium
Other Elements		
• Number of studies	2; only one study described individual variation in intake	Medium
• Agreement between researchers	Range of per-capita rates from summary study includes per-capita rate from study with primary data.	High
Overall Rating	Studies are not nationally representative. Upper percentiles based on only one study.	Medium (per capita intake) Low (upper percentiles)

APPENDIX 10A

RESOURCE UTILIZATION DISTRIBUTION

Appendix 10A. Resource Utilization Distribution

For any quantity Y that is consumed by individuals in a population, the percentiles of the "resource utilization distribution" of Y can be formally defined as follows: Y_p (R) is the pth percentile of the resource utilization distribution if p percent of the overall consumption of Y in the population is done by individuals with consumption below Y_p (R) and 100-p percent is done by individuals with consumption above Y_p(R).

The percentiles of the resource utilization distribution of Y are to be distinguished from the percentiles of the (standard) distribution of Y. The latter percentiles show what percentage of individuals in the population are consuming below a given level. Thus, the 50th percentile of the distribution of Y is that level such that 50 percent of individuals consume below it; on the other hand, the 50th percentile of the resource utilization distribution is that level such that 50 percent of the overall consumption in the population is done by individuals consuming below it.

The percentiles of the resource utilization distribution of Y will always be greater than or equal to the corresponding percentiles of the (standard) distribution of Y, and, in the case of recreational fish consumption, usually considerably exceed the standard percentiles.

To generate the resource utilization distribution, one simply weights each observation in the data set by the Y level for that observation and performs a standard percentile analysis of weighted data. If the data already have weights, then one multiplies the original weights by the Y level for that observation, and then performs the percentile analysis.

Under certain assumptions, the resource utilization percentiles of fish consumption may be related (approximately) to the (standard) percentiles of fish consumption derived from the analysis of creel studies. In this instance, it is assumed that the creel survey data analysis did not employ sampling weights (i.e., weights were implicitly set to one); this is the case for many of the published analyses of creel survey data. In creel studies the fish consumption rate for the ith individual is usually derived by multiplying the amount of fish consumption per fishing trip (say C_i) by the frequency of fishing (say f_i). If it is assumed that the probability of sampling of an angler is proportional to fishing frequency, then sampling weights of inverse fishing frequency ($1/ f_i$) should be employed in the analysis of the survey data. Above it was stated that for data that are already weighted the resource utilization distribution is generated by multiplying the original weights by the individual's fish consumption level to create new weights. Thus, to generate the resource utilization distribution from the data with weights of ($1/ f_i$), one multiplies ($1/ f_i$) by the fish consumption level of $f_i C_i$ to get new weights of C_i.

Now if C_i (amount of consumption per fishing trip) is constant over the population, then these new weights are constant and can be taken to be one. But weights of one is what (it is assumed) were used in the original creel survey data analysis. Hence, the resource utilization distribution is exactly the same as the original (standard) distribution derived from the creel survey using constant weights.

The accuracy of this approximation of the resource utilization distribution of fish by the (standard) distribution of fish consumption derived from an unweighted analysis of creel survey data depends then on two factors, how approximately constant the C_i 's are in the population and how approximately proportional the relationship between sampling probability and fishing frequency is. Sampling probability will be roughly proportional to frequency if repeated sampling at the same site is limited or if re-interviewing is performed independent of past interviewing status.

APPENDIX 10B

FISH PREPARATION AND COOKING METHODS

Table 10B-1. Percent of Fish Meals Prepared Using Various Cooking Methods by Residence Size[a]

Residence Size	Large City/Suburb	Small City	Town	Small Town	Rural Non-Farm	Farm
			Total Fish			
Cooking Method						
Pan Fried	32.7	31.0	36.0	32.4	38.6	51.6
Deep Fried	19.6	24.0	23.3	24.7	26.2	15.7
Boiled	6.0	3.0	3.4	3.7	3.4	3.5
Grilled/Broiled	23.6	20.8	13.8	21.4	13.7	13.1
Baked	12.4	12.4	10.0	10.3	12.7	6.4
Combination	2.5	6.0	8.3	5.0	2.3	7.0
Other (Smoked, etc.)	3.2	2.8	5.2	1.9	2.9	1.8
Don't Know	0.0000	0.0000	0.0000	0.5	0.2	--
Total (N)[b]	393	317	388	256	483	94
			Sport Fish			
Pan Fried	45.8	45.7	47.6	41.4	51.2	63.3
Deep Fried	12.2	14.5	17.5	15.2	21.9	7.3
Boiled	2.8	2.3	2.9	0.5	3.6	0
Grilled/Broiled	20.2	17.6	10.6	25.3	8.2	10.4
Baked	11.8	8.8	6.3	8.7	9.7	6.9
Combination	2.7	8.5	10.4	6.7	1.9	9.3
Other (smoked, etc.)	4.5	2.7	4.9	1.5	3.5	2.8
Don't Know	0	0	0	0.7	0	0
Total (N)	205	171	257	176	314	62

[a] Large City = over 100,000; Small City = 20,000-100,000; Town = 2,000-20,000; Small Town = 100-2,000.
[b] N = Total number of respondents
Source: West et al., 1993.

Table 10B-2. Percent of Fish Meals Prepared Using Various Cooking Methods by Age

Age (years)	17-30	31-40	41-50	51-64	> 64	Overall
		Total Fish				
Cooking Method						
Pan Fried	45.9	31.7	30.5	33.9	40.7	35.3
Deep Fried	23.0	24.7	26.9	23.7	14.0	23.5
Boiled	0.0000	6.0	3.6	3.9	4.3	3.9
Grilled or Boiled	15.6	15.2	24.3	16.1	18.8	17.8
Baked	10.8	13.0	8.7	12.8	11.5	11.4
Combination	3.1	5.2	2.2	6.5	6.8	4.7
Other (Smoked, etc.)	1.6	4.2	3.5	2.7	4.0	3.2
Don't Know	0.0000	0.0000	0.3	0.4	0.0000	0.2
Total (N)[a]	246	448	417	502	287	1946
		Sport Fish				
Pan Fried	57.6	42.6	43.4	46.6	54.1	47.9
Deep Fried	18.2	21.0	17.3	14.8	7.7	16.5
Boiled	0.0000	4.4	0.8	3.2	3.1	2.4
Grilled/Broiled	15.0	10.1	25.9	12.2	12.2	14.8
Baked	3.6	10.4	6.4	11.7	9.9	8.9
Combination	3.8	7.2	3.0	7.5	8.2	5.9
Other (Smoked, etc.)	1.7	4.3	3.2	3.5	4.8	3.5
Don't Know	0.0000	0.0000	0.0000	0.4	0.0000	0.1
Total (N)	174	287	246	294	163	1187

[a] N = Total number of respondents.
Source: West et al., 1993.

Table 10B-3. Percent of Fish Meals Prepared Using Various Cooking Methods by Ethnicity

Ethnicity	Black	Native American	Hispanic	White	Other
			Total Fish		
Cooking Method					
Pan Fried	40.5	37.5	16.1	35.8	18.5
Deep Fried	27.0	22.0	83.9	22.7	18.4
Boiled	0	1.1	0	4.3	0
Grilled/Broiled	19.4	9.8	0	17.7	57.6
Baked	1.9	16.3	0	11.7	5.4
Combination	9.5	6.2	0	4.5	0
Other (Smoked, etc.)	1.6	4.2	3.5	2.7	4.0
Don't Know	0	0	0.3	0.4	0
Total (N)[a]	52	84	12	1,744	33
			Sport Fish		
Pan Fried	44.9	47.9	52.1	48.8	22.0
Deep Fried	36.2	20.2	47.9	15.7	9.6
Boiled	0	0	0	2.7	0
Grilled/Broiled	0	1.5	0	14.7	61.9
Baked	5.3	18.2	0	8.6	6.4
Combination	13.6	8.6	0	5.6	0
Other (Smoked, etc.)	0	3.6	0	3.7	0
Total (N)	19	60	4	39	0

[a] N = Total number of respondents.
Source: West et al., 1993.

Table 10B-4. Percent of Fish Meals Preapred Using Various Cooking Methods by Education

Education	Through Some H.S.	H.S. Degree	College Degree	Post Graduate Education
		Total Fish		
Cooking Method				
Pan Fried	44.7	41.8	28.8	22.9
Deep Fried	23.6	23.6	23.8	19.4
Boiled	2.2	2.8	5.1	5.8
Grilled/Broiled	8.9	10.9	23.8	34.1
Baked	8.1	12.1	11.6	12.8
Combination	10.0	5.1	3.0	3.8
Other (Smoked, etc.)	2.1	3.4	4.0	1.3
Don't Know	0.5	0.3	0	0
Total (N)[a]	236	775	704	211
		Sport Fish		
Pan Fried	56.1	52.4	41.8	36.3
Deep Fried	13.6	15.8	18.6	12.9
Boiled	2.8	2.4	3.0	0
Grilled/Baked	6.3	9.4	21.7	28.3
Baked	7.4	10.6	6.1	14.9
Combination	10.1	6.3	3.9	6.5
Other (Smoked, etc.)	2.8	3.3	4.6	1.0
Don't Know	0.8	0	0	0
Total (N)	146	524	421	91

[a] N = Total number of respondents.
Source: West et al., 1993.

Table 10B-5. Percent of Fish Meals Prepared Using Various Cooking Methods by Income

Income	0 - $24,999	$25,000 - $39,999	$40,000 - or more
Total Fish			
Cooking Method			
Pan Fried	44.8	39.1	26.5
Deep Fried	21.7	22.2	23.4
Boiled	2.1	3.5	5.6
Grilled/Broiled	11.3	15.8	25.0
Baked	9.1	12.3	13.3
Combination	8.7	2.9	2.5
Other (Smoked, etc.)	2.4	4.0	3.5
Don't Know	0	0.2	0.3
Total (N)[a]	544	518	714
Sport Fish			
Pan Fried	51.5	51.4	42.0
Deep Fried	15.8	15.8	17.2
Boiled	1.8	2.1	3.7
Grilled/Broiled	12.0	12.2	19.4
Baked	7.2	10.0	10.0
Combination	9.1	3.8	3.5
Other (Smoked, etc.)	2.7	4.6	3.8
Don't Know	0	0	0.3
Total (N)	387	344	369

[a] N = Total number of respondents.
Source: West et al., 1993.

Table 10B-6. Percent of Fish Meals where Fat was Trimmed or Skin was Removed, by Demographic Variables				
	Total Fish		Sport Fish	
Population	Trimmed Fat (%)	Skin Off (%)	Trimmed Fat (%)	Skin Off (%)
Residence Size				
Large City/Suburb	51.7	31.6	56.7	28.9
Small City	56.9	34.1	59.3	36.2
Town	50.3	33.4	51.7	33.7
Small Town	52.6	45.2	55.8	51.3
Rural Non-Farm	42.4	32.4	46.2	34.6
Farm	37.3	38.1	39.4	42.1
Age (years)				
17-30	50.6	36.5	53.9	39.3
31-40	49.7	29.7	51.6	29.9
41-50	53.0	32.2	58.8	37.0
51.65	48.1	35.6	48.8	37.2
Over 65	41.6	43.1	43.0	42.9
Ethnicity				
Black	25.8	37.1	16.0	40.1
Native American	50.0	41.4	56.3	36.7
Hispanic	59.5	7.1	50.0	23.0
White	49.3	34.0	51.8	35.6
Other	77.1	61.6	75.7	65.5
Education				
Some H.S.	50.8	43.9	49.7	47.1
H.S. Degree	47.2	37.1	49.5	37.6
College Degree	51.9	31.9	55.9	33.8
Post-Graduate	47.6	26.6	53.4	38.7
Income				
< $25,000	50.5	43.8	50.6	47.3
$25-39,999	47.8	34.0	54.9	34.6
$40,000 or more	50.2	28.6	51.7	27.7
Overall	49.0	34.7	52.1	36.5

Source: Modified from West et. al., 1993.

Table 10B-7. Method of Cooking of Most Common Species Kept by Sportfishermen

Species	Percent of Anglers Catching Species	Use as Primary Cooking Method (Percent)				
		Deep Fry	Pan Fry	Bake and Charcoal Broil	Raw	Other[b]
White Croaker	34%	19%	64%	12%	0%	5%
Pacific Mackerel	25%	10%	41%	28%	0%	21%
Pacific Bonito	18%	5%	33%	43%	2%	17%
Queenfish	17%	15%	70%	6%	1%	8%
Jacksmelt	13%	17%	57%	19%	0%	7%
Walleye Perch	10%	12%	69%	6%	0%	13%
Shiner Perch	7%	11%	72%	8%	0%	11%
Opaleye	6%	16%	56%	14%	0%	14%
Black Perch	5%	18%	53%	14%	0%	15%
Kelp Bass	5%	12%	55%	21%	0%	12%
California Halibut	4%	13%	60%	24%	0%	3%
Shellfish[a]	3%	0%	0%	0%	0%	100%

(n = 1059)
[a] Crab, mussels, lobster, abalone
[b] Boil, soup, steam, stew
Source: Modified from Puffer et al., 1981.

Table 10B-8. Adult Consumption of Fish Parts

Species	Number Consuming	Weighted Percent Consuming Specific Parts					
		Fillet	Skin	Head	Eggs	Bones	Organs
Salmon	473	95.1%	55.8%	42.7%	42.8%	12.1%	3.7%
Lamprey	249	86.4%	89.3%	18.1%	4.6%	5.2%	3.2%
Trout	365	89.4%	68.5%	13.7%	8.7%	7.1%	2.3%
Smelt	209	78.8%	88.9%	37.4%	46.4%	28.4%	27.9%
Whitefish	125	93.8%	53.8%	15.4%	20.6%	6.0%	0.0%
Sturgeon	121	94.6%	18.2%	6.2%	11.9%	2.6%	0.3%
Walleye	46	100%	20.7%	6.2%	9.8%	2.4%	0.9%
Squawfish	15	89.7%	34.1%	8.1%	11.1%	5.9%	0.0%
Sucker	42	89.3%	50.0%	19.4%	30.4%	9.8%	2.1%
Shad	16	93.5%	15.7%	0.0%	0.0%	3.3%	0.0%

Source: CRITFC, 1994.

APPENDIX 10C

PER CAPITA ESTIMATES BY SPECIES BASED ON THE USDA CSFII DATA

Table 10C-1. Daily Average Per Capita Estimates of Fish Consumption
U.S. Population - Mean Consumption by Species Within Habitat - As Consumed Fish

Habitat	Species	Estimated Mean Grams/Person/Day
Estuarine	Shrimp	1.38883
	Perch	0.52580
	Flatfish (Estuarine)	0.43485
	Crab (Estuarine)	0.29086
	Flounder	0.24590
	Oyster	0.17840
	Clam (Estuarine)	0.14605
	Mullet	0.07089
	Croaker	0.05021
	Herring	0.02937
	Smelts	0.02768
	Scallop (Estuarine)	0.00247
	Anchovy	0.00228
	Scup	0.00050
	Sturgeon	0.00040
Freshwater	Catfish	1.06776
	Trout	0.43050
	Carp	0.04846
	Pike	0.01978
	Salmon (Freshwater)	0.00881
Marine	Tuna	4.19998
	Clam (Marine)	1.66153
	Cod	1.22627
	Flatfish (Marine)	1.06307
	Salmon (Marine)	0.73778
	Haddock	0.51533
	Pollock	0.44970
	Crab (Marine)	0.33870
	Ocean Perch	0.31878
	Porgy	0.29844
	Scallop (Marine)	0.21805
	Sea Bass	0.20794
	Lobster	0.20001
Marine (Cont)	Swordfish	0.13879
	Squid	0.12196
	Sardine	0.10013
	Pompano	0.09131
	Sole	0.07396
	Mackerel	0.06379
	Whiting	0.05498
	Halibut	0.02463
	Mussels	0.02217
	Shark	0.01901
	Whitefish	0.00916
	Seafood	0.00574
	Snapper	0.00539
	Octopus	0.00375
	Barracuda	0.00111
	Abalone	0.00075
Unknown	Fish	0.00186
All Species	Tuna	4.19998
	Clam (Marine)	1.66153
	Shrimp	1.38883
	Cod	1.22827
	Catfish	1.06776
	Faltfish (Marine)	1.06307
	Salmon (Marine)	0.73778
	Perch	0.52580
	Haddock	0.51533
	Pollock	0.44970
	Flatfish (Estuarine)	0.43485
	Trout	0.43050
	Crab (Marine)	0.33870
	Ocean Perch	0.31878
	Porgy	0.29844
	Crab (Estuarine)	0.29088
All Species (Cont)	Flounder	0.24590
	Scallop (Marine)	0.21805
	Sea Bass	0.20794
	Lobster	0.20001
	Oyster	0.17840
	Clam (Estuarine)	0.14605
	Swordfish	0.13879
	Squid	0.12196
	Sardine	0.10313
	Pompano	0.09131
	Sole	0.07396
	Mullet	0.07089
	Mackarel	0.06379
	Whiting	0.05498
	Croaker	0.05021
	Carp	0.04846
	Herring	0.02937
	Smelts	0.02768
	Halibut	0.02463
	Mussels	0.02217
	Pike	0.01978
	Shark	0.01901
	Whitefish	0.00916
	Salmon (Freshwater)	0.00881
	Seafood	0.00574
	Snapper	0.00539
	Octopus	0.00375
	Scallop (Estuarine)	0.00247
	Anchovy	0.00228
	Fish	0.00166
	Barracuda	0.00111
	Abalone	0.00075
	Scup	0.00050
	Sturgeon	0.00040

Notes: Estimates are projected from a sample of 11,912 individuals to the U.S. population of 242,707,000 using 3-year combined survey weights. The population for this survey consisted of individuals in the 48 conteminous states.

Source of individual consumption data: USDA Combined 1989, 1990, and 1991 Continuing Survey of Food Intakes by Individuals (CSFII).

The fish component of foods containing fish was calculated using data from the recipe file for release 7 of the USDA's Nutrient Data Base for Individual Food Intake Surveys.

TABLE OF CONTENTS

11. INTAKE OF MEAT AND DAIRY PRODUCTS

Consumption of meat, poultry, and dairy products is a potential pathway of exposure to toxic chemicals. These food sources can become contaminated if animals are exposed to contaminated media (i.e., soil, water, or feed crops).

The U.S. Department of Agriculture's (USDA) Nationwide Food Consumption Survey (NFCS) and Continuing Survey of Food Intakes by Individuals (CSFII) are the primary sources of information of intake rates of meat and dairy products in the United States. Data from the NFCS have been used in various studies to generate consumer-only and per capita intake rates for both individual meat and dairy products and total meat and dairy products. CSFII 1989-1991 survey data have been analyzed by EPA to generate per capita intake rates for various food items and food groups. As described in Volume II, Chapter 9, consumer-only intake is defined as the quantity of meat and dairy products consumed by individuals who ate these food items during the survey period. Per capita intake rates are generated by averaging consumer-only intakes over the entire population of users and non-users. In general, per capita intake rates are appropriate for use in exposure assessments for which average dose estimates for the general population are of interest because they represent both individuals who ate the foods during the survey period and individuals who may eat the food items at some time, but did not consume them during the survey period.

Intake rates may be presented on either an as consumed or dry weight basis. As consumed intake rates (g/day) are based on the weight of the food in the form that it is consumed. In contrast, dry weight intake rates are based on the weight of the food consumed after the moisture content has been removed. In calculating exposures based on ingestion, the unit of weight used to measure intake should be consistent with those used in measuring the contaminant concentration in the produce. Fat content data are also presented for various meat and dairy products. These data are needed for converting between residue levels on a whole-weight or as consumed basis and lipid basis. Intake data from the individual component of the NFCS and CSFII are based on "as eaten" (i.e., cooked or prepared) forms of the food items/groups. Thus, corrections to account for changes in portion sizes from cooking losses are not required.

The purpose of this section is to provide: (1) intake data for individual meat and dairy products, total meat, and total dairy; (2) guidance for converting between as consumed and dry weight intake rates; and (3) data on the fat content in meat and dairy products. Recommendations are based on average and upper-percentile intake among the general population of the U.S. Available data have been classified as being either a key or a relevant study based on the considerations discussed in Volume I, Section 1.3.1 of the Introduction. Recommendations are based on data from the CSFII survey, which was considered the only key intake study for meats and dairy products. Although Pao et al. (1982) was not considered a key study for intake of meats and dairy products because it is based on data from NFCS 1977-1978, it was included as a key study for serving size. Other relevant studies are also presented to provide the reader with added perspective on this topic. It should be noted that most of the studies presented in this section are based on data from USDA's NFCS and CSFII. The USDA NFCS and CSFII are described below.

11.1. INTAKE STUDIES

11.1.1. U.S. Department of Agriculture Nationwide Food Consumption Survey and Continuing Survey of Food Intake by Individuals

The NFCS and CSFII are the basis of much of the data on meat and dairy intake presented in this section. Data from the 1977-78 NFCS are presented because the data have been published by USDA in various reports and reanalyzed by various EPA offices according to the food items/groups commonly used to assess exposure. Published one-day data from the 1987-88 NFCS are also presented. Recently, EPA conducted an analysis of USDA's 1989/91 CSFII. These data are the most recent food survey data that are available to the public. The results of EPA's analyses are presented here. Detailed descriptions of the NFCS and CSFII data are presented in Volume II, Chapter 9 - Intake of Fruits and Vegetables.

Individual average daily intake rates calculated from NFCS data are based on averages of reported individual intakes over one day or three consecutive days. Such short term data are suitable for estimating average daily intake rates representative of both short-term and long-term consumption. However, the distribution of average daily intake rates generated using short term data (e.g., 3 day) do not necessarily reflect the long-term distribution of average daily intake rates. The distributions generated from short term and long term data will differ to the extent that each individual's intake varies from day to day; the distributions will be similar to the extent that individuals' intakes are constant from day to day.

Day-to-day variation in intake among individuals will be great for food item/groups that are highly seasonal and for items/groups that are eaten year around but that are not typically eaten every day. For these foods, the intake distribution generated from short term data will not be a good reflection of the long term distribution. On the other hand, for broad categories of foods (e.g., total vegetables) which are eaten on a daily basis throughout the year with minimal seasonality, the short term distribution may be a reasonable approximation of the true long term distribution, although it will show somewhat more variability. In this and the following section then, distributions are shown only for the following broad categories of foods: meats and dairy products. Because of the increased variability of the short-term distribution, the short-term upper percentiles shown will overestimate somewhat the corresponding percentiles of the long-term distribution.

11.1.2. Key Meat and Dairy Products Intake Study Based on the CSFII

U.S. EPA Analysis of 1989/91 USDA CSFII Data - EPA conducted an analysis of USDA's 1989-91 CSFII data set. The general methodology used in analyzing the data is presented in Volume II, Chapter 9 (Fruits and Vegetables) of this Handbook. Intake rates were generated for the following meat and dairy products: total meats, total dairy, beef, pork, poultry, game, and eggs. These data have been corrected to account for mixtures as described in Volume II, Chapter 9 and Appendix 9A. Per capita intake rates for total meat and total dairy are presented in Tables 11-1 and 11-2 at the end of this Chapter. Table 11-3 presents per capita intake data for individual meats. The results are presented in units of g/kg-day. Thus, use of these data in calculating potential dose does not require the body weight factor to be included in the denominator of the average daily dose (ADD) equation. It should be noted that converting these intake rates into units of g/day by multiplying by a single average body weight is inappropriate, because individual intake rates were indexed to the actual body weights of the survey respondents. However, if there is a need to compare the total intake data presented here to other intake data in units of g/day, a body weight less than 70 kg (i.e., approximately 60 kg; calculated based on the number of respondents in each age category and the average body weights for these age groups, as presented in Volume I, Chapter 7) should be used because the total survey population included children as well as adults.

The advantages of using the CSFII data set are that the data are expected to be representative of the U.S. population and that it includes data on a wide variety of food types. The data set is the most recent of a series of publicly available data sets (i.e., NFCS 1977/78; NFCS 1987/88; CSFII 1989-91) from USDA, and should reflect current eating patterns in the United States. The data set includes three years of intake data combined. However, the CSFII data are based on a three day survey period. Short-term dietary data may not accurately reflect long-term eating patterns. This is particularly true for the tails of the distribution of food intake. In addition, the adjustment for including mixtures adds uncertainty to the intake rate distributions. The calculation for including mixtures assumes that intake of any mixture includes all of the foods identified and the proportions specified in Appendix Table 9A-1. This assumption yields valid estimates of per capita consumption, but results in overestimates of the proportion of the population consuming individual meats; thus, the quantities reported in Table 11-3 should be interpreted as upper bounds on the proportion consuming beef, pork, and poultry, not as valid point estimates.

11.1.3. Key Meat and Dairy Products Serving Size Study Based on the USDA NFCS

Pao et al. (1982) - Foods Commonly Eaten by Individuals - Using data gathered in the 1977-78 USDA NFCS, Pao et al. (1982) calculated percentiles for the quantities of meat, poultry, and dairy products consumed per eating occasion by members of the U.S. population. The data were collected during NFCS home interviews of 37,874 respondents, who were asked to recall food intake for the day preceding the interview, and record food intake the day of the interview and the day after the interview. Quantities consumed per eating occasion, are presented in Table 11-4.

The advantages of using these data are that they were derived from the USDA NFCS and are representative of the U.S. population. This data set provides distributions of serving sizes for a number of commonly eaten meat, poultry, and dairy products, but the list of foods is limited and does not account for meat, poultry, and dairy products included in complex food dishes. Also, these data are based on short-term dietary recall and may not accurately reflect long-term consumption patterns. Although these data are based on the NFCS 1977-78 survey, serving size data have been collected but not published for the more recent USDA surveys.

11.1.4. Relevant Meat and Dairy Products Intake Studies

The U.S. EPA's Dietary Risk Evaluation System (DRES) - U.S. EPA, Office of Pesticide Programs (OPP) - EPA OPP's DRES contains per capita intake rate data for various items of meat, poultry, and dairy products for 22 subgroups (age, regional, and seasonal) of the population. As described in Volume II, Chapter 9 - Fruits and Vegetables, intake data in DRES were generated by determining the composition of NFCS food items and disaggregating complex food dishes into their component raw agricultural commodities (RACs) (White et al. 1983). The DRES per capita, as consumed intake rates for all age/sex/demographic groups combined are presented in Table 11-5. These data are based on both consumers and non-consumers of these food items. Data for specific subgroups of the population are not presented in this section, but are available through OPP via direct request. The data in Table 11-5 may be useful for estimating the risks of exposure associated with the consumption of the various meat, poultry, and dairy products presented. It should be noted that these data are indexed to the actual body weights of the survey respondents and are expressed in units of grams of food consumed per kg body weight per day. Consequently, use of these data in calculating potential dose does not require the body weight factor in the denominator of the average daily dose (ADD) equation. It should also be noted that conversion of these intake rates into units of g/day by multiplying by a single average body weight is not appropriate because the DRES data base did not rely on a single body weight for all individuals. Instead, DRES used the body weights reported by each individual surveyed to estimate consumption in units of g/kg-day.

The advantages of using these data are that complex food dishes have been disaggregated to provide intake rates for a variety of meat, poultry, and dairy products. These data are also based on the individual body weights of the respondents. Therefore, the use of these data in calculating exposure to toxic chemicals may provide more representative estimates of potential dose per unit body weight. However, because the data are based on NFCS short-term dietary recall, the same limitations discussed previously for other NFCS data sets also apply here. In addition, consumption patterns may have changed since the data were collected in 1977-78. OPP is in the process of translating consumption information from the USDA CSFII 1989-91 survey to be used in DRES.

Food and Nutrient Intakes of Individuals in One Day in the U.S., USDA (1980, 1992) -USDA (1980; 1992) calculated mean per capita intake rates for total meat, total poultry, and dairy products using NFCS data from 1977-78 and 1987-88. The mean intake rates for meat and dairy products are presented in Tables 11-6 and 11-7 for meats and Tables 11-8 and 11-9 for dairy for the two survey years. These values are based on intake data for one day for consumers and non-consumers from the 1977-78 and 1987-88 USDA NFCSs.

The advantages of using these data are that they provide mean intake estimates for all meat, poultry, and dairy products. The consumption estimates are based on short-term (i.e., 1-day) dietary data which may not reflect long-term consumption.

U.S. EPA - Office of Radiation Programs - The U.S. EPA Office of Radiation Programs (ORP) has also used the USDA 1977-1978 NFCS to estimate daily food intake. ORP uses food consumption data to assess human intake of radionuclides in foods (U.S. EPA, 1984a; 1984b). The 1977-1978 NFCS data have been reorganized by ORP, and food items have been classified according to the characteristics of radionuclide transport. The mean per capita dietary intake of food sub classes (milk, other dairy products, eggs, beef, pork, poultry, and other meat) grouped by age for the U.S. population is presented in Table 11-10. The mean daily intake rates of meat, poultry, and dairy products for the U.S. population grouped by regions are presented in Table 11-11. Because this study was based on the USDA NFCS, the limitations and advantages associated with the USDA NFCS data also apply to these data.

U.S. EPA - Office of Science and Technology - The U.S. EPA Office of Science and Technology (OST) within the Office of Water (formerly the Office of Water Regulations and Standards) used data from the FDA revision of the Total Diet Study Food Lists and Diets (Pennington, 1983) to calculate food intake rates. OST uses these consumption data in its risk assessment model for land application of municipal sludge. The FDA data used are based on the combined results of the USDA 1977-1978 NFCS and the second National Health and Nutrition Examination Survey (NHANES II), 1976-1980 (U.S. EPA, 1989). Because food items are listed as prepared complex foods in the FDA Total Diet Study, each item was broken down into its component parts so that the amount of raw commodities consumed could be determined. Table 11-12 presents intake rates for meat, poultry, and dairy products for various age groups. Estimated lifetime ingestion rates derived by U.S. EPA (1989) are also presented in Table 11-12. Note that these are per capita intake rates tabulated as grams dry weight/day. Therefore, these rates differ from those in the previous tables because Pao et al. (1982) and U.S. EPA (1984a, 1984b) report intake rates on an as consumed basis.

The EPA-OST analysis provides intake rates for additional food categories and estimates of lifetime average daily intake on a per capita basis. In contrast to the other analyses of USDA NFCS data, this study reports the data in terms of dry weight intake rates. Thus, conversion is not required when contaminants are provided on a dry weight basis.

USDA (1993) - Food Consumption, Prices, and Expenditures, 1970-92 - The USDA's Economic Research Service (ERS) calculates the amount of food available for human consumption in the United States annually. Supply and utilization balance sheets were generated. These were based on the flow of food items from production to end uses. Total available supply was estimated as the sum of production (i.e., some products were measured at the farm level or during processing), starting inventories, and imports (USDA, 1993). The availability of food for human use commonly termed as "food disappearance" was determined by subtracting exported foods, products used in industries, farm inputs (seed and feed) and end-of-the year inventories from the total available supply (USDA, 1993). USDA (1993) calculated the per capita food consumption by dividing the total food disappearance by the total U.S. population.

USDA (1993) estimated per capita consumption data for meat, poultry, and dairy products from 1970-1992 (1992 data are preliminary). In this section, the 1991 values, which are the most recent final data, are presented. The meat consumption data were reported as carcass weight, retail weight equivalent, and boneless weight equivalent. The poultry consumption data were reported as ready-to-cook (RTC) weight, retail weight, and boneless weight (USDA, 1993). USDA (1993) defined beef carcass weight as the chilled hanging carcass, which includes the kidney and attached internal fat (kidney, pelvic, and heart fat), excludes the skin, head, feet, and unattached internal organs. The pork carcass weight includes the skin and feet, but excludes the kidney and attached internal fat. Retail weight equivalents assume all food was sold through retail foodstores; therefore, conversion factors (Table 11-13) were used to correct carcass or RTC to retail weight to account for trimming, shrinkage, or loss of meat and chicken at these retail outlets (USDA, 1993). Boneless equivalent values for meat (pork, veal, beef) and poultry excludes all bones, but includes separable fat sold on retail cuts of red meat. Pet food was considered as an apparent source of food disappearance for poultry in boneless weight estimates, while pet food was excluded for beef, veal, and pork (USDA, 1993). Table 11-13 presents per capita consumption in 1991 for red meat (carcass weight, retail equivalent, and boneless trimmed equivalent) and poultry (RTC, retail equivalent for chicken only, and boneless trimmed equivalent). Per capita consumption estimates based on boneless weights appear to be the most appropriate data for use in exposure assessments, because boneless meats are more representative of what people would actually consume. Table 11-14 presents per capita consumption in 1991 for dairy products including eggs, milk, cheese, cream, and sour cream.

One of the limitations of this study is that disappearance data do not account for losses from the food supply from waste, spoilage, or foods fed to pets. Thus, intake rates based on these data will overestimate daily consumption because they are based on the total quantity of marketable commodity utilized. Therefore, these data may be useful for estimating bounding exposure estimates. It should also be noted that per capita estimates based on food disappearance are not a direct measure of actual consumption or quantity ingested, instead the data are used as indicators of changes in usage over time (USDA, 1993). An advantage of this study is that it provides per capita consumption rates for meat, poultry, and dairy products which are representative of long-term intake because disappearance data are generated annually. Daily per capita intake rates are generated by dividing annual consumption by 365 days/year.

National Live Stock and Meat Board (1993) - Eating in America Today: A Dietary Pattern and Intake Report - The National Live Stock and Meat Board (1993) assessed the nutritional value of the current American diet based on two factors: (1) the composition of the foods consumed, and (2) the amount of food consumed. Data used in this study were provided by MRCA Information Services, Inc. through MRCA's Nutritional Marketing Information Division. The survey conducted by MRCA consisted of a 2,000 household panels of over 4,700 individuals. The survey sample was selected to be representative of the U.S. population. Information obtained from the survey by MRCA's Menu Census included food and beverage consumption over a period of 14 consecutive days. The head of the household recorded daily food and beverage consumption in-home and away-from-home in diaries for each household member. The survey period was from July 1, 1990 through June 30, 1991. This ensured that all days carried equal weights and provided a seasonally balanced data set. In addition, nutrient intake data calculated by the MRCA's Nutrient Intake Database (NID) (based on the 1987-88 USDA Food Intake Study) and information on food attitudes were also collected. It should be noted, however, that the 14 daily diaries provide only the incidence of eating each food product by an individual, but not the quantity eaten by each person. The intake rate for each individual is estimated by multiplying the eating frequency of a particular food item by the average amount eaten per eating occasion. The data on the average amount eaten per eating occasion was obtained from the USDA NFCS survey.

Table 11-15 presents the adult daily mean intake of meat and poultry grouped by region and gender. The adult population was defined as consumers ages 19 and above (National Live Stock and Meat Board, 1993). Beef consumption was high in all regions compared to other meats and poultry (Table 11-15). The average daily consumption of meat in the U.S. was 114.2 g/day which included beef (57 percent), veal (0.5 percent), lamb (0.5 percent), game/variety meats (8 percent), processed meats (18 percent), and pork (16 percent) (National Live Stock and Meat Board, 1993). Table 11-16 shows the amount of meat consumed by the adult population grouped as non-meat eaters (1 percent), light meat eaters (30 percent), medium meat eaters (33 percent), and heavy meat eaters (36 percent).

The advantage of this study is that the survey period is longer (i.e., 14 days) than any other food consumption survey. The survey is also based on a nationally representative sample. The survey also accounts for foods eaten as mixtures. However, only mean values are provided. Therefore, distribution of long-term consumption patterns cannot be derived. In addition, the survey collects data on incidence of eating each food item and not actual consumption rates. This may introduce some bias in the results. The direction of this bias is unknown.

AIHC (1994) - Exposure Factors Sourcebook - The AIHC Sourcebook (AIHC, 1994) uses the data presented in the 1989 version of the Exposure Factors Handbook which reported data from the USDA 1977-78 NFCS. In this Handbook, new analyses of more recent data from the USDA 1989/91 CSFII are presented. Numbers, however, cannot be directly compared with previous values since the results from the new analysis are presented on a body weight basis.

The Sourcebook was selected as a relevant study because it was not the primary source for the data used to make recommendations in this document. However, it is an alternative information source. The advantage of using the CSFII and USDA NFCS data set instead, is they are the largest publicly available data source on food intake patterns in the United States. Data are available for a wide variety of meat, poultry, and dairy products and are intended to be representative of the U.S. population.

11.2. FAT CONTENT OF MEAT AND DAIRY PRODUCTS

In some cases, the residue levels of contaminants in meat and dairy products are reported as the concentration of contaminant per gram of fat. When using these residue levels, the assessor should ensure consistency in the exposure assessment calculations by using consumption rates that are based on the amount of fat consumed for the meat or dairy product of interest. Alternately, residue levels for the "as consumed" portions of these products may be estimated by multiplying the levels based on fat by the fraction of fat per product as follows:

$$\frac{residue\ level}{g{-}product} = \frac{residue\ level}{g{-}fat} \; x \; \frac{g{-}fat}{g{-}product} \quad \text{(Eqn. 11-1)}$$

The resulting residue levels may then be used in conjunction with "as consumed" consumption rates. The percentages of lipid fat in meat and dairy products have been reported in various publications. USDA's Agricultural Handbook Number 8 (USDA, 1979-1984) provides composition data for agricultural products. It includes a listing of the total saturated, monounsaturated, and polyunsaturated fats for various meat and dairy items. Table 11-17 presents the total fat content for selected meat and dairy products taken from Handbook Number 8. The total percent fat content is based on the sum of saturated, monounsaturated, and polyunsaturated fats.

The National Livestock and Meat Board (NLMB) (1993) used data from Agricultural Handbook Number 8 and consumption data to estimate the fat contribution to the U.S. diet. Total fat content in grams, based on a 3-ounce (85.05 g) cooked serving size, was reported for several categories (retail composites) of meats. These data are presented in Table 11-18 along with the corresponding percent fat content values for each product. NLMB (1993) also reported that 0.17 grams of fat are consumed per gram of meat (i.e., beef, pork, lamb, veal, game, processed meats, and variety meats) (17 percent) and 0.08 grams of fat are consumed per gram of poultry (8 percent).

The average total fat content of the U.S. diet was reported to be 68.3 g/day. The meat group (meat, poultry, fish, dry beans, eggs, and nuts) was reported to contribute the most to the average total fat in the diet (41 percent) (NLMB, 1993). Meats (i.e., beef, pork, lamb, veal, game, processed meats, and variety meats) reportedly contribute less than 30 percent to the total fat of the average U.S. diet. The milk group contributes approximately 12 percent to the average total fat in the U.S. diet (NLMB, 1993). Fat intake rates and the contributions of the major food groups to fat intake for heavy, medium, and light meat eaters, and non meat eaters are presented in Table 11-19 (NLMB, 1993). NLMB (1993) also reported the average meat fat intake to be 19.4 g/day, with beef contributing about 50 percent of the fat to the diet from all meats. Processed meats contributed 31 percent; pork contributed 14 percent; game and variety meats contributed 4 percent; and lamb and veal contributed 1 percent to the average meat fat intake.

The Center for Disease Control (CDC) (1994) used data from NHANES III to calculate daily total food energy intake (TFEI), total dietary fat intake, and saturated fat intake for the U.S. population during 1988 to 1991. The sample population comprised 20,277 individuals ages 2 months and above, of which 14,001 respondents (73 percent response rate) provided dietary information based on a 24-hour recall. TFEI was defined as "all nutrients (i.e., protein, fat, carbohydrate, and alcohol) derived from consumption of foods and beverages (excluding plain drinking water) measured in kilocalories (kcal)." Total dietary fat intake was defined as "all fat (i.e., saturated and unsaturated) derived from consumption of foods and beverages measured in grams."

CDC (1994) estimated and provided data on the mean daily TFEI and the mean percentages of TFEI from total dietary fat grouped by age and gender. The overall mean daily TFEI was 2,095 kcal for the total population and 34 percent (or 82 g) of their TFEI was from total dietary fat (CDC, 1994). Based on this information, the mean daily fat intake was calculated for the various age groups and genders (see Appendix 11A for detailed calculation). Table 11-20 presents the grams of fat per day obtained from the daily consumption of foods and beverages grouped by age and gender for the U.S. population.

11.3. CONVERSION BETWEEN AS CONSUMED AND DRY WEIGHT INTAKE RATES

As noted previously, intake rates may be reported in terms of units as consumed or units of dry weight. It is essential that exposure assessors be aware of this difference so that they may ensure consistency between the units used for intake rates and those used for concentration data (i.e., if the unit of food consumption is grams dry weight/day, then the unit for the amount of pollutant in the food should be grams dry weight). If necessary, as consumed intake rates may be converted to dry weight intake rates using the moisture content percentages of meat, poultry and dairy products presented in Table 11-21 and the following equation:

$$IR_{dw} = Ir_{ac} * [(100-W)/100] \qquad \text{(Eqn. 11-2)}$$

Dry weight" intake rates may be converted to "as consumed" rates by using:

$$IR_{ac} = IR_{dw}/[(100-W)/100] \qquad \text{(Eqn. 11-3)}$$

where:

IR_{dw} = dry weight intake rate;
IR_{ac} = as consumed intake rate; and
W = percent water content.

11.4. RECOMMENDATIONS

The CSFII data described in this section was used in selecting recommended meat, poultry, and dairy product intake rates for the general population and various subgroups of the United States population. The general design of both key and relevant studies are summarized in Table 11-22. The recommended values for intake of meat and dairy products are summarized in Table 11-23 and the confidence ratings for the recommended values for meat and dairy intake rates are presented in Table 11-24. Per capita intake rates for specific meat items, on a g/kg-day basis, may be obtained from Table 11-3. Percentiles of the intake rate distribution in the general population for total meat and total dairy, as well as per capita rates, are presented in Tables 11-1 and 11-2. From these tables, the mean and 95th percentile intake rates for meats are 2.1 g/kg-day and 5.1 g/kg-day, respectively. The mean and 95th percentile intake rates for dairy products are 8.0 g/kg-day and 29.7 g/kg-day. It is important to note that the distributions presented in Tables 11-1 through 11-3 are based on data collected over a 3-day period and may not necessarily reflect the long-term distribution of average daily intake rates. However, for these broad categories of food (i.e., total meats and total dairy products), because they may be eaten on a daily basis throughout the year with minimal seasonality, the short-term distribution may be a reasonable approximation of the long-term distribution, although it will display somewhat increased variability. This implies that the upper percentiles shown here will tend to overestimate the corresponding percentiles of the true long-term distribution. Intake rates for the homeproduced form of these food items/groups are presented in Volume II Chapter 12.

This section also presents recommendations for serving size for various meats and dairy products. These recommendations are based on the USDA NFCS 1977-78 data. The confidence rating for serving size recommendations are presented in Table 11-25. Percentiles of the serving size, as well as mean values, can be obtained from Table 11-4.

11.5. REFERENCES FOR CHAPTER 11

American Industrial Health Council (AIHC). (1994) Exposure factors sourcebook. Washington, DC., AIHC, .

CDC. (1994) Dietary fat and total food-energy intake. Third National Health and Nutrition Examination Survey, Phase 1, 1988-91. Morbidity and Mortality Weekly Report, February 25, 1994: 43(7)118-125.

Finley, B.L.; Paustenbach, B.L. (1992) Opportunities for improving exposure assessments using population distribution estimates. Presented for the Committee on Risk Assessment Methodology, February 10-11, Washington, DC.

National Livestock and Meat Board. (1993) Eating in America today: A dietary pattern and intake report. National Livestock and Meat Board. Chicago, IL.

Pao, E.M.; Fleming, K.H.; Guenther, P.M.; Mickle, S.J. (1982) Foods commonly eaten by individuals: amount per day and per eating occasion. U.S. Department of Agriculture. Home Economics Report No. 44.

Pennington, J.A.T. (1983) Revision of the total diet study food list and diets. J. Am. Diet. Assoc. 82:166-173.

USDA. (1979-1984) Agricultural Handbook No. 8. United States Department of Agriculture.

USDA. (1980) Food and nutrient intakes of individuals in one day in the United States, Spring 1977. U.S. Department of Agriculture. Nationwide Food Consumption Survey 1977-1978. Preliminary Report No. 2.

USDA. (1992) Food and nutrient intakes by individuals in the United States, 1 day, 1987-88. U.S. Department of Agriculture, Human Nutrition Information Service. Nationwide Food Consumption Survey 1987-88, NFCS Rpt. No. 87-I-1.

USDA. (1993) Food consumption prices and expenditures (1970-1992) U.S. Department of Agriculture, Economic Research Service. Statistical Bulletin, No. 867.

U.S. EPA. (1984a) An estimation of the daily average food intake by age and sex for use in assessing the radionuclide intake of individuals in the general population. EPA-520/1-84-021.

U.S. EPA. (1984b) An estimation of the daily food intake based on data from the 1977-1978 USDA Nationwide Food Consumption Survey. Washington, DC: Office of Radiation Programs. EPA-520/1-84-015.

U.S. EPA. (1989) Development of risk assessment methodologies for land application and distribution and marketing of municipal sludge. Washington, DC: Office of Science and Technology. EPA 600/-89/001.

White, S.B.; Peterson, B.; Clayton, C.A.; Duncan, D.P. (1983) Interim Report Number 1: The construction of a raw agricultural commodity consumption data base. Prepared by Research Triangle Institute for EPA Office of Pesticide Programs.

Table 11-1. Intake of Total Meats (g/kg-day)

Population Group	Percent Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	96.4%	2.146	0.014	0	0.33	0.63	1.13	1.84	2.78	4.06	5.06	7.67	25.67
Age													
< 01	66.7%	2.867	0.187	0	0	0	0	2.34	4.72	6.52	8.56	11.52	25.67
01-02	95.6%	4.384	0.116	0	1.07	1.58	2.70	4.13	5.38	7.69	8.41	11.88	21.61
03-05	97.5%	3.873	0.092	0	1.12	1.38	2.21	3.50	5.04	6.64	8.23	11.25	15.00
06-11	97.6%	3.011	0.052	0	0.66	1.02	1.80	2.78	3.98	5.12	6.08	8.38	11.68
12-19	97.7%	2.078	0.034	0	0.42	0.67	1.19	1.99	2.79	3.49	4.40	5.95	8.28
20-39	97.9%	1.923	0.019	0	0.39	0.64	1.09	1.73	2.54	3.49	4.14	5.46	8.37
40-69	97.3%	1.700	0.017	0	0.36	0.59	1.03	1.58	2.20	2.95	3.47	4.73	7.64
70 +	97.1%	1.531	0.028	0	0.32	0.49	0.89	1.42	2.03	2.73	3.20	4.28	6.63
Season													
Fall	97.1%	2.182	0.029	0	0.37	0.66	1.15	1.85	2.80	4.11	5.16	8.06	25.67
Spring	95.8%	2.053	0.027	0	0.26	0.61	1.09	1.75	2.63	3.93	4.91	7.31	15.00
Summer	96.3%	2.178	0.031	0	0.35	0.63	1.11	1.86	2.84	4.10	5.18	7.86	18.19
Winter	96.4%	2.173	0.029	0	0.30	0.63	1.18	1.88	2.87	4.06	5.05	7.35	14.61
Urbanization													
Central City	96.7%	2.163	0.028	0	0.25	0.59	1.09	1.79	2.82	4.14	5.22	7.97	25.67
Nonmetropolitan	95.7%	2.168	0.028	0	0.30	0.63	1.15	1.90	2.79	4.04	5.12	7.69	14.61
Suburban	96.6%	2.126	0.021	0	0.39	0.64	1.13	1.84	2.74	4.03	4.94	7.31	15.00
Race													
Asian	89.3%	2.233	0.131	0	0	0.60	1.10	1.86	3.23	4.49	4.66	6.86	8.13
Black	95.5%	2.434	0.053	0	0.33	0.62	1.15	1.94	3.02	5.03	6.14	9.87	25.67
Native American	86.5%	2.269	0.131	0	0	0.41	1.32	1.87	3.38	4.64	5.09	7.32	8.57
Other/NA	95.1%	2.628	0.109	0	0	0.65	1.40	2.29	3.34	4.90	6.03	11.25	11.25
White	96.9%	2.083	0.015	0	0.34	0.63	1.12	1.81	2.72	3.87	4.87	7.18	18.19
Region													
Midwest	96.5%	2.204	0.029	0	0.44	0.69	1.21	1.85	2.82	4.08	5.05	7.86	21.61
Northeast	96.5%	2.148	0.033	0	0.35	0.67	1.16	1.89	2.75	3.98	4.99	8.27	15.00
South	96.7%	2.249	0.025	0	0.37	0.68	1.18	1.90	2.88	4.35	5.34	7.73	13.42
West	95.8%	1.903	0.030	0	0.08	0.47	0.92	1.60	2.54	3.69	4.57	6.64	25.67

NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analyses of the 1989/91 CSFII

Table 11-2. Intake of Total Dairy Products (g/kg-day)

Population Group	Percent Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	97.1%	8.015	0.147	0	0.15	0.40	1.36	3.61	8.18	18.55	29.72	72.16	390.53
Age													
< 01	89.6%	62.735	2.800	0	0	0.61	24.68	45.78	91.12	136.69	170.86	210.72	390.53
01-02	95.6%	26.262	0.743	0	2.69	8.19	15.22	23.48	36.13	45.72	55.07	69.42	108.95
03-05	97.5%	21.149	0.517	0	3.27	6.75	11.89	19.52	28.31	39.54	44.16	57.58	62.88
06-11	97.4%	13.334	0.264	0	1.81	3.54	6.72	11.88	18.58	25.38	28.76	39.60	62.55
12-19	97.9%	6.293	0.147	0	0.27	0.61	2.31	5.29	9.20	12.75	15.12	23.58	53.47
20-39	97.9%	3.618	0.062	0	0.12	0.30	0.95	2.64	5.04	8.15	10.64	17.23	43.31
40-69	96.9%	3.098	0.053	0	0.10	0.26	0.94	2.23	4.36	6.99	9.05	12.99	34.42
70 +	97.6%	3.715	0.104	0	0.16	0.47	1.46	3.03	4.93	8.03	9.63	16.49	26.33
Season													
Fall	97.7%	8.262	0.286	0	0.17	0.38	1.32	3.53	8.31	20.16	32.71	75.83	351.48
Spring	96.8%	8.273	0.335	0	0.13	0.39	1.37	3.50	7.88	18.02	27.02	116.00	390.53
Summer	96.8%	7.561	0.257	0	0.14	0.37	1.37	3.51	7.93	18.01	30.86	64.95	347.93
Winter	97.1%	7.964	0.293	0	0.16	0.43	1.39	3.90	8.77	17.60	27.34	63.27	307.54
Urbanization													
Central City	97.2%	8.528	0.309	0	0.17	0.41	1.44	3.78	8.05	18.25	29.51	106.93	318.93
Nonmetropolitan	96.6%	7.224	0.261	0	0.10	0.28	1.08	3.34	7.82	17.28	24.70	59.17	390.53
Suburban	97.4%	8.058	0.209	0	0.17	0.43	1.42	3.61	8.45	19.50	32.04	69.42	351.48
Race													
Asian	94.0%	8.730	1.264	0	0	0.14	0.63	3.86	7.23	21.62	36.16	72.01	124.26
Black	94.8%	7.816	0.498	0	0.03	0.11	0.64	2.49	7.29	17.28	27.78	116.00	347.93
Native American	88.9%	6.987	1.057	0	0.02	0.14	0.81	2.83	8.06	20.20	24.17	66.71	139.37
Other/NA	97.1%	10.727	1.002	0	0.12	0.33	1.03	4.15	11.28	34.64	40.33	121.50	166.48
White	97.7%	7.943	0.156	0	0.22	0.49	1.50	3.76	8.24	18.16	28.76	66.11	390.53
Region													
Midwest	97.3%	9.291	0.341	0	0.20	0.50	1.66	4.20	9.61	21.33	34.35	90.88	390.53
Northeast	97.2%	7.890	0.330	0	0.18	0.42	1.42	3.41	7.54	18.07	32.04	78.15	307.54
South	97.3%	6.926	0.225	0	0.11	0.27	1.01	3.10	7.49	15.86	25.76	54.94	347.93
West	96.7%	8.454	0.313	0	0.17	0.49	1.60	3.93	8.67	19.88	29.89	84.46	174.65

NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analyses of the 1989/91 CSFII

Table 11-3. Intake of Individual Meat and Dairy Products and Mixtures (g/kg-day)

	Beef			Pork			Poultry			Game		
Population Group	Percent Consuming [a]	Mean	SE	Percent Consuming [a]	Mean	SE	Percent Consuming [a]	Mean	SE	Percent Consuming [a]	Mean	SE
Total	91.5%	0.825	0.007	90.2%	0.261	0.005	91.7%	0.598	0.007	1.2%	0.010	0.010
Age												
< 01	63.7%	0.941	0.075	63.0%	0.291	0.040	64.9%	0.816	0.087	0.5%	0.014	0.091
01-02	93.1%	1.460	0.056	92.4%	0.492	0.041	94.2%	1.156	0.064	0.9%	0.026	0.125
03-05	94.9%	1.392	0.050	95.0%	0.473	0.035	95.0%	1.068	0.049	1.5%	0.010	0.040
06-11	95.4%	1.095	0.028	94.5%	0.352	0.018	95.7%	0.871	0.028	1.1%	0.004	0.016
12-19	95.4%	0.830	0.020	94.0%	0.270	0.013	94.3%	0.558	0.017	1.0%	0.004	0.019
20-39	93.9%	0.789	0.012	92.5%	0.230	0.007	94.6%	0.530	0.010	1.3%	0.010	0.021
40-69	90.1%	0.667	0.011	88.3%	0.212	0.007	90.5%	0.477	0.010	1.3%	0.012	0.017
70 +	87.4%	0.568	0.018	86.5%	0.207	0.011	86.7%	0.463	0.017	1.1%	0.002	0.010
Season												
Fall	92.4%	0.834	0.014	91.9%	0.254	0.008	92.9%	0.635	0.015	1.7%	0.016	0.022
Spring	90.8%	0.797	0.014	88.8%	0.264	0.009	91.0%	0.538	0.013	0.7%	0.006	0.019
Summer	90.5%	0.845	0.017	89.4%	0.245	0.010	90.4%	0.625	0.015	0.7%	0.003	0.012
Winter	92.1%	0.823	0.015	90.6%	0.279	0.009	92.6%	0.595	0.014	1.6%	0.013	0.021
Urbanization												
Central City	90.8%	0.808	0.013	89.5%	0.258	0.009	91.7%	0.627	0.014	0.7%	0.005	0.014
Nonmetropolitan	90.8%	0.841	0.015	90.3%	0.299	0.010	90.6%	0.540	0.013	2.0%	0.019	0.018
Suburban	92.3%	0.828	0.011	90.6%	0.244	0.006	92.4%	0.608	0.011	1.1%	0.008	0.018
Race												
Asian	88.6%	0.895	0.072	85.9%	0.256	0.049	88.6%	0.790	0.068	0.0%	0	0
Black	86.5%	0.665	0.019	89.2%	0.418	0.019	91.9%	0.798	0.025	0.1%	0.001	0.027
Native American	81.9%	0.995	0.088	83.6%	0.188	0.024	80.7%	0.540	0.051	0.6%	0.001	0.012
Other/NA	90.3%	1.159	0.069	88.3%	0.191	0.021	91.7%	0.810	0.049	0.3%	0.003	0.046
White	92.6%	0.833	0.008	90.6%	0.241	0.005	92.0%	0.559	0.007	1.4%	0.011	0.011
Region												
Midwest	92.3%	0.853	0.015	91.3%	0.284	0.009	91.7%	0.551	0.014	2.2%	0.012	0.012
Northeast	92.5%	0.805	0.017	90.4%	0.236	0.010	92.7%	0.651	0.017	0.5%	0.005	0.026
South	90.2%	0.846	0.013	89.5%	0.283	0.008	91.7%	0.643	0.012	0.8%	0.009	0.025
West	91.7%	0.775	0.016	89.7%	0.220	0.009	91.0%	0.526	0.014	1.3%	0.012	0.022

Table 11-3. Intake of Individual Meat and Dairy Products and Mixtures (g/kg-day) (continued)

Population Group	Eggs			Meat Mixtures			Grain Mixtures		
	Percent Consuming[a]	Mean	SE	Percent Consuming[a]	Mean	SE	Percent Consuming[a]	Mean	SE
Total	41.4%	0.317	0.009	67.1%	1.602	0.024	57.3%	1.719	0.033
Age									
< 01	32.3%	0.791	0.126	42.9%	2.431	0.336	44.1%	3.465	0.429
01-02	43.3%	0.822	0.087	65.1%	3.194	0.227	69.1%	4.710	0.326
03-05	39.6%	0.677	0.088	66.8%	2.734	0.155	74.0%	4.195	0.223
06-11	36.6%	0.414	0.033	70.2%	2.155	0.093	75.1%	2.820	0.109
12-19	36.0%	0.244	0.023	71.0%	1.523	0.062	71.2%	2.066	0.079
20-39	43.3%	0.271	0.012	69.3%	1.519	0.036	63.0%	1.476	0.040
40-69	44.0%	0.225	0.009	66.7%	1.222	0.031	44.6%	0.862	0.034
70 +	42.0%	0.218	0.017	64.3%	1.130	0.056	34.4%	0.682	0.063
Season									
Fall	40.1%	0.291	0.017	70.5%	1.875	0.049	58.2%	1.775	0.065
Spring	42.7%	0.307	0.017	64.3%	1.384	0.045	56.9%	1.687	0.068
Summer	40.5%	0.344	0.020	63.7%	1.403	0.044	56.5%	1.741	0.071
Winter	42.2%	0.325	0.019	70.0%	1.745	0.054	57.4%	1.672	0.063
Urbanization									
Central City	41.6%	0.315	0.018	63.8%	1.516	0.044	56.1%	1.625	0.055
Nonmetropolitan	43.8%	0.338	0.018	68.8%	1.693	0.047	54.5%	1.591	0.063
Suburban	39.7%	0.309	0.013	68.5%	1.613	0.036	59.8%	1.839	0.054
Race									
Asian	38.9%	0.452	0.094	68.5%	1.670	0.225	57.0%	2.633	0.426
Black	48.9%	0.385	0.023	65.2%	1.560	0.068	47.7%	1.493	0.097
Native American	49.7%	0.491	0.170	70.8%	2.076	0.247	52.6%	1.947	0.320
Other/NA	55.1%	0.472	0.056	58.6%	2.196	0.229	64.9%	2.490	0.228
White	39.5%	0.297	0.010	67.7%	1.579	0.026	58.7%	1.708	0.036
Region									
Midwest	36.9%	0.288	0.019	69.7%	1.816	0.052	60.3%	1.713	0.060
Northeast	35.9%	0.264	0.020	66.2%	1.461	0.056	59.2%	1.915	0.085
South	44.3%	0.325	0.014	66.9%	1.564	0.039	52.0%	1.590	0.057
West	46.6%	0.392	0.022	65.4%	1.552	0.051	60.7%	1.746	0.072

[a] Upper bound on percent consuming (see text)
NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analyses of the 1989/91 CSFII

Table 11-4. Quantity (as consumed) of Meat, Poultry, and Dairy Products Consumed per Eating Occasion and the Percentage of Individuls Using These Foods in 3 Days

Food category	% Indiv. using food in 3 days	Quantity consumed per eating occasion (g)		Consumers-only Quantity consumed per eating occasion at Specified Percentiles (g)						
		Average	Standard Deviation	5	25	50	75	90	95	99
Meat[a]	84.6	107	85	16	46	86	140	224	252	432
Beef	67.3	133	85	41	84	112	168	224	280	448
Pork	49.9	69	69	8	16	44	92	160	194	320
Lamb	1.5	146	84	43	88	123	184	227	280	448
Veal	2.3	130	71	42	84	112	168	224	276	352
Poultry	42.8	128	77	42	82	112	168	224	280	388
Chicken	38.7	131	76	43	84	112	170	224	280	388
Turkey	5.8	105	73	28	57	86	129	172	240	350
Dairy Products										
Eggs	54.3	82	44	40	50	64	100	128	150	237
Butter	31.4	12	13	2	5	7	14	28	28	57
Margarine	43.1	11	11	2	5	7	14	28	28	57
Milk[b]	82.5	203	134	15	122	244	245	366	488	552
Cheese[c]	40	41	28	14	28	28	56	58	85	140

[a] Meat - beef, pork, lamb, and veal.
[b] Milk - fluid milk, milk beverages, and milk-based infant formulas.
[c] Cheese - natural and processed cheese.
Source: Pao et al., 1982.

Table 11-5.Mean Per Capita Intake Rates for Meat, Poultry, and Dairy Products (g/Kg-d as consumed) Based on All Sex/Age/Demographic Subgroups

Raw Agricultural Commodity[a]	Average Consumption (Grams/kg Body Weight/Day)	Standard Error
Milk-Non-Fat Solids	0.9033354	0.0134468
Milk-Non-Fat Solids (Food additive)	0.9033354	0.0134468
Milk-Fat Solids	0.4297199	0.0060264
Milk-Fat Solids (Food additive)	0.4297199	0.0060264
Milk Sugar (Lactose)	0.0374270	0.0033996
Beef-Meat Byproducts	0.0176621	0.0005652
Beef (Organ Meats) - Other	0.0060345	0.0007012
Beef - Dried	0.0025325	0.0004123
Beef (Boneless) - Fat (Beef Tallow)	0.3720755	0.0048605
Beef (Organ Meats) - Kidney	0.0004798	0.0003059
Beef (Organ Meats) - Liver	0.0206980	0.0014002
Beef (Boneless) - Lean (w/o Removeable Fat)	1.1619987	0.0159453
Goat-Meat Byproducts	0.0000000	NA
Goat (Organ Meats) - Other	0.0000000	NA
Goat (Boneless) - Fat	0.0000397	0.0000238
Goat (Organ Meats) - Kidney	0.0000000	NA
Goat (Organ Meats) - Liver	0.0000000	NA
Goat (Boneless) - Lean (w/o Removeable Fat)	0.0001891	0.0001139
Horse	0.0000000	NA
Rabbit	0.0014207	0.00003544
Sheep - Meat Byproducts	0.0000501	0.0000381
Sheep (Organ Meats) - Other	0.0000109	0.0000197
Sheep (Boneless) - Fat	0.0042966	0.0005956
Sheep (Organ Meats) - Kidney	0.0000090	0.0000079
Sheep (Organ Meats) - Liver	0.0000000	NA
Sheep (Boneless) - Lean (w/o Removeable Fat)	0.0124842	0.0015077
Pork - Meat Byproducts	0.0250792	0.0022720
Pork (Organ Meats) - Other	0.0038496	0.0003233
Pork (Boneless) - Fat (Including Lard)	0.2082022	0.0032032
Pork (Organ Meats) - Kidney	0.0000168	0.0000106
Pork (Organ Meats) - Liver	0.0048194	0.0004288
Pork (Boneless) - Lean (w/o Removeable Fat)	0.3912467	0.0060683
Meat, Game	0.0063507	0.0010935
Turkey - Byproducts	0.0002358	0.0000339
Turkey - Giblets (Liver)	0.0000537	0.0000370
Turkey - Flesh (w/o Skin, w/o Bones)	0.0078728	0.0007933
Turkey - Flesh (+ Skin, w/o Bones)	0.0481655	0.0026028
Turkey - Unspecified	0.0000954	0.0000552
Poultry, Other - Byproducts	0.0000000	NA
Poultry, Other - Giblets (Liver)	0.0002321	0.0001440
Poultry, Other - Flesh (+ Skin, w/o Bones)	0.0053882	0.0007590
Eggs - Whole	0.5645020	0.0076651
Eggs - White Only	0.0092044	0.0004441
Eggs - Yolk Only	0.0066323	0.0004295
Chicken - Byproducts	0.0000000	NA
Chicken - Giblets (Liver)	0.0050626	0.0005727
Chicken - Flesh (w/o Skin, w/o Bones)	0.0601361	0.0021616
Chicken - Flesh (+ Skin, w/o Bones)	0.3793205	0.0104779

NA = Not applicable
[a] Consumed in any raw or prepared form.
Source: DRES database

Table 11-6. Mean Meat Intakes per Individual in a Day by Sex and Age (g/day as consumed)[a] for 1977-1978

Group Age (yrs.)	Total Meat, Poultry and Fish	Beef	Pork	Lamb, Veal, Game	Frankfurters, Sausages, Luncheon Meats, Spreads	Total Poultry	Chicken Only	Meat Mixtures[c]
Males and Females								
1 and Under	72	9	4	3	2	4	1	51
1-2	91	18	6	(b)	15	16	13	32
3-5	121	23	8	(b)	15	19	19	49
6-8	149	33	15	1	17	20	19	55
Males								
9-11	188	41	22	3	19	24	21	71
12-14	218	53	18	(b)	25	27	24	87
15-18	272	82	24	1	25	37	32	93
19-22	310	90	21	2	33	45	43	112
23-34	285	86	27	1	30	31	29	94
35-50	295	75	28	1	26	31	28	113
51-64	274	70	32	1	29	31	29	86
65-74	231	54	25	2	22	29	26	72
75 and Over	196	41	39	7	19	28	25	54
Females								
9-11	162	38	17	1	20	27	23	55
12-14	176	47	19	1	18	23	22	61
15-18	180	46	14	2	16	28	27	61
19-22	184	52	19	1	18	26	24	61
23-34	183	48	17	1	16	24	22	66
35-50	187	49	19	2	14	24	21	63
51-64	187	52	19	2	12	26	24	60
65-74	159	34	21	4	12	30	25	47
75 and Over	134	31	17	2	9	19	16	49
Males and Females								
All Ages	207	54	20	2	20	27	24	72

[a] Based on USDA Nationwide Food Consumption Survey (1977-1978) data for one day.
[b] Less than 0.5 g but more than 0.
[c] Includes mixtures containing meat, poultry, or fish as a main ingredient.
Source: USDA, 1980.

Table 11-7. Mean Meat Intakes per Individual in a Day by Sex and Age (g/day as consumed)[a] for 1987-1988

Group Age (yrs.)	Total Meat, Poultry, and Fish	Beef	Pork	Lamb, Veal, Game	Frankfurters, Sausages, Luncheon Meats	Total Poultry	Chicken Only	Meat Mixturess[b]
Males and Females								
5 and Under	92	10	9	< 0.5	11	14	12	39
Males								
6-11	156	22	14	< 0.5	13	27	24	74
12-19	252	38	17	1	20	27	20	142
20 and over	250	44	19	23	2	31	25	108
Females								
6-11	151	26	9	1	11	20	17	74
12-19	169	31	10	< 0.5	18	17	13	80
20 and over	170	29	12	1	13	24	18	73
All individuals	193	32	14	1	17	26	20	86

[a] Based on USDA Nationwide Food Consumption Survey (1987 to 1988) data for one day.
[b] Includes mixtures containing meat, poultry, or fish as a main ingredient.
Source: USDA, 1992.

Table 11-8. Mean Dairy Product Intakes per Individual in a Day, by Sex and Age (g/day as consumed)[a] for 1977-1978

Group Age (yrs.)	Total Milk	Fluid Milk	Cheese	Eggs
1 and Under	618	361	1	5
1-2	404	397	8	20
3-5	353	330	9	22
6-8	433	401	10	18
9-11	432	402	8	26
12-14	504	461	9	28
15-18	519	467	13	31
19-22	388	353	15	32
23-34	243	213	21	38
35-50	203	192	18	41
51-64	180	173	17	36
65-74	217	204	14	36
75 and Over	193	184	18	41
9-11	402	371	7	14
12-14	387	343	11	19
15-18	316	279	11	21
19-22	224	205	18	26
23-34	182	158	19	26
35-50	130	117	18	23
51-64	139	128	19	24
65-74	166	156	14	22
75 and Over	214	205	20	19
All Ages	266	242	15	27

[a] Based on USDA Nationwide Food Consumption Survey (1977-1978) data for one day.
Source: USDA, 1980.

Table 11-9. Mean Dairy Product Intakes per Individual in a Day, by Sex and Age (g/day as consumed)[a] for 1987-1988

Group Age (yrs.)	Total Fluid Milk	Whole Milk	Lowfat/Skim Milk	Cheese	Eggs
Males and Females					
5 and under	347	177	129	7	11
Males					
6-11	439	224	159	10	17
12-19	392	183	168	12	17
20 and over	202	88	94	17	27
Females					
6-11	310	135	135	9	14
12-19	260	124	114	12	18
20 and over	148	55	81	15	17
All inividuals	224	99	102	14	20

[a] Based on USDA Nationwide Food Consumption Survey (1987 to 1988) data for one day.
Source: USDA, 1992.

Table 11-10.Mean and Standard Error for the Dietary Intake of Food Sub Classes per Capita by Age (g/day as consumed)

Age (yrs.)	Fresh Cows' Milk	Other Dairy Products	Eggs	Beef	Pork	Poultry	Other Meat
All Ages	253.5 ± 4.9	55.1 ± 1.2	26.9 ± 0.5	87.6 ± 1.1	28.2 ± 0.6	31.3 ± 0.8	25.1 ± 0.4
< 1	272.0 ± 31.9	296.7 ± 7.6	4.9 ± 3.2	18.4 ± 7.4	5.8 ± 3.6	18.4 ± 4.9	2.6 ± 2.8
1-4	337.3 ± 15.6	41.0 ± 3.7	19.8 ± 1.6	42.2 ± 3.7	13.6 ± 1.8	19.0 ± 2.4	17.6 ± 1.4
5-9	446.2 ± 13.1	47.3 ± 3.1	17.0 ± 1.3	63.4 ± 3.1	18.2 ± 1.5	24.7 ± 2.0	22.3 ± 1.2
10-14	456.0 ± 12.3	53.3 ± 2.9	19.3 ± 1.2	81.9 ± 2.9	22.2 ± 1.4	30.0 ± 1.9	26.1 ± 1.1
15-19	404.8 ± 12.9	52.9 ± 3.1	24.8 ± 1.3	99.5 ± 3.0	29.5 ± 1.5	33.0 ± 2.0	27.6 ± 1.1
20-24	264.3 ± 16.4	44.2 ± 4.0	28.3 ± 1.7	103.7 ± 3.9	29.6 ± 1.9	33.0 ± 2.6	28.8 ± 1.5
25-29	217.6 ± 17.2	51.5 ± 4.1	27.9 ± 1.7	103.8 ± 4.0	31.8 ± 2.0	33.8 ± 2.7	28.9 ± 1.5
30-39	182.9 ± 13.5	53.8 ± 3.2	30.1 ± 1.4	105.8 ± 3.2	33.0 ± 1.5	34.0 ± 2.1	28.4 ± 1.2
40-59	169.1 ± 10.5	52.0 ± 2.5	31.1 ± 1.0	99.0 ± 2.5	33.5 ± 1.2	33.8 ± 1.6	27.4 ± 0.9
≥60	192.4 ± 11.8	55.9 ± 2.8	28.7 ± 1.2	74.3 ± 2.8	27.5 ± 1.3	31.5 ± 1.8	21.1 ± 1.0

Source: U.S. EPA, 1984a.

Table 11-11. Mean and Standard Error for the Daily Intake of Food Class and Sub Class by Region (g/day as consumed)

	US Population	Northeast	North Central	South	West
<u>Dairy Products (Total)</u>	308.6 ± 5.3	318.6 ± 10.4	336.1 ± 10.0	253.6 ± 8.4	348.1 ± 12.3
Fresh Cows Milk	253.5 ± 4.9	256.1 ± 9.7	279.7 ± 9.4	211.0 ± 7.8	283.5 ± 11.5
Other	55.1 ± 1.2	62.5 ± 2.3	56.5 ± 2.2	42.6 ± 1.9	64.6 ± 2.7
<u>Eggs</u>	26.9 ± 0.5	23.8 ± 1.0	23.5 ± 0.9	31.0 ± 0.8	29.1 ± 1.2
<u>Meats (Total)</u>	172.2 ± 1.6	169.9 ± 3.3	176.9 ± 3.1	171.9 ± 2.6	168.6 ± 3.9
Beef and Veal	87.6 ± 1.1	82.3 ± 2.3	92.9 ± 2.2	84.0 ± 1.8	92.9 ± 2.7
Pork	28.2 ± 0.6	28.8 ± 1.1	29.6 ± 1.1	30.1 ± 0.9	22.1 ± 1.3
Poultry	31.3 ± 0.8	31.7 ± 1.5	26.6 ± 1.4	36.5 ± 1.2	28.9 ± 1.8
Other	25.1 ± 0.4	27.1 ± 0.9	27.8 ± 0.8	21.3 ± 0.7	24.7 ± 1.0

NOTE: Northeast = Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania.

North Central = Ohio, Illinois, Indiana, Wisconsin, Michigan, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas.

South = Maryland, Delaware, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Texas, and Oklahoma.

West = Montana, Idaho, Wyoming, Utah, Colorado, New Mexico, Arizona, Nevada, Washington, Oregon, and California.

Source: U.S. EPA, 1984b.

Table 11-12. Consumption of Meat, Poultry, and Dairy Products for Different Age Groups (averaged across sex), and Estimated Lifetime Average Intakes for 70 Kg Adult Citizens Calculated from the FDA Diet Data.

Produce	Baby (0-1 yrs)	Toddler 1-6 yrs)	Child (6-14 yrs)	Teen (14-20 yrs)	Adult (20-45 yrs)	Old (45-70 yrs)	Estimated Lifetime Intake[a]
				g - dry weight/day			
Beef	3.99	9.66	15.64	21.62	23.28	18.34	19.25
Beef Liver	0.17	0.24	0.30	0.36	1.08	1.2	0.89
Lamb	0.14	0.08	0.06	0.05	0.30	0.21	0.20
Pork	1.34	4.29	6.57	8.86	10.27	9.94	9.05
Poultry	2.27	3.76	5.39	7.03	7.64	6.87	6.70
Dairy	40.70	32.94	38.23	43.52	27.52	22.41	28.87
Eggs	3.27	6.91	7.22	7.52	8.35	9.33	8.32
Beef Fat	2.45	6.48	11.34	16.22	20.40	14.07	15.50
Beef Liver Fat	0.05	0.07	0.08	0.10	0.29	0.33	0.25
Lamb Fat	0.14	0.08	0.07	0.06	0.31	0.22	0.21
Dairy Fat	38.99	16.48	20.46	24.43	18.97	14.51	18.13
Pork Fat	2.01	8.19	10.47	12.75	14.48	13.04	12.73
Poultry Fat	1.10	0.83	1.12	1.41	1.54	1.31	1.34

[a] The estimated lifetime dietary intakes were estimated by:

$$\text{Estimated lifetime intake} = \frac{\text{CR}(0.1) + 5\text{yrs} * \text{CR}(1\text{-}5) + 8\text{ yrs} * \text{CR}(6\text{-}13) + 6\text{ yrs} * \text{CR}(14\text{-}19) + 25\text{ yrs} * \text{CR}(20\text{-}44) + 25\text{ yrs} * \text{CR}(45\text{-}70)}{70\text{ years}}$$

where CR = the consumption rate for a specific age group.
Source: U.S. EPA, 1989.

Table 11-13. Per Capita Consumption of Meat and Poultry in 1991[a]

Food Item	Per Capita Consumption Carcass[b] Weight (g/day)[f]	Per Capita Consumption RTC[c] (g/day)[f]	Per Capita Consumption Retail Cut Equivalent[d] (g/day)[f]	Per Capita Consumption Boneless Trimmed Equivalent[e] (g/day)[f]
<u>Red Meat</u>				
Beef	118.3	---	82.8	78.4
Veal	1.5	---	1.2	0.99
Pork	8.0	---	62.1	58.3
Lamb and Mutton	2.0	---	1.7	1.2
Total[g]	201.7	---	147.9	139.1
<u>Poultry</u>				
Young Chicken	---	---	78.3	---
Other Chicken	---	---	1.7	---
Chicken	---	91.3	---	54.5[h,i]
Turkey	---	22.2	---	17.5[h]
Total[g]	---	109.2	77.0	72.1

[a] Includes processed meats and poultry in a fresh basis; excludes shipments to U.S. territories; uses U.S. total population, July 1, and does not include residents of the U.S. territories.
[b] Beef-Carcass-Weight is the weight of the chilled hanging carcass, which includes the kidney and attached internal fat [kidney, pelvic, and heart fat (kph)] but not head, feet, and unattached internal organs. Definitions of carcass weight for other red meats differ slightly.
[c] RTC - ready-to-cook poultry weight is the entire dressed bird which includes bones, skin, fat, liver, heart, gizzard, and neck.
[d] Retail equivalents in 1991 were converted from carcass weight by multiplying by a factor of 0.7, 0.83, 0.89, and 0.776 for beef, veal, lamb, and pork, respectively; 0.877 was the factor used each for young chicken and other chicken.
[e] Boneless equivalent for red meat derived from carcass weight in 1991 by using conversion factors of 0.663, 0.685, 0.658 and 0.729 for beef, veal, lamb, and pork, respectively; 0.597, 0.597 and 0.790 were the factors used for young chicken, other chicken, and turkey.
[f] Original data were presented in lbs; converted to g/day by multiplying by a factor of 453.6 g/lb and dividing by 365 days/yr.
[g] Computed from unrounded data.
[h] Includes skin, neck, and giblets.
[i] Excludes amount of RTC chicken going to pet food as well as some water leakage that occurs when chicken is cut-up before packaging.
Source: USDA, 1993.

Table 11-14. Per Capita Consumption of Dairy Products in 1991[a]

Food Item	Per Capita Consumption (g/day)[j]	Food Item	Per Capita Consumption (g/day)[j]
Eggs		Cheese	
Farm Weight[b,e]	37.8	American	
Retail Weight[c,e]	37.3	Cheddar	11.2
		Other[d]	2.5
Fluid Milk and Cream	289.7	Italian	
Plain Whole Milk	105.3	Provolone	0.8
Lowfat Plain Milk (2%)	98.1	Romano	0.2
Lowfat Plain Milk (1%)	25.8	Parmesan	0.6
Skim Plain Milk	29.7	Mozzarella	9.0
Whole Flavored Milk and Drink	3.4	Ricotta	1.0
Lowfat Flavored Milk and Drink	8.5	Other	0.07
Buttermilk (lowfat and skim)	4.2	Miscellaneous	
Half and Half Cream	3.9	Swiss[f]	1.5
Light Cream	0.4	Brick	0.07
Heavy Cream	1.6	Muenster	0.5
Sour Cream	3.2	Cream	1.9
Eggnog	0.5	Neufchatel	0.3
		Blue[g]	0.2
Evaporated and Condensed Milk[i]		Other	1.2
Canned Whole Milk	2.6	Processed Products	
Bulk Whole Milk	1.4	Cheese	6.1
Bulk and Canned Skim Milk	6.2	Foods and spreads	4.7
Total[e]	10.2	Cheese Content	8.5
		Consumed as Natural	22.6
Dry Milk Products[i]		Cottage Cheese (lowfat)	1.6
Dry Whole Milk	0.5		
Nonfat Dry Milk	3.2	Frozen Dairy Products	
Dry Buttermilk	0.3	Ice Cream	20.3
Total[e]	4.0	Ice Milk	9.2
Dried Whey	4.5	Sherbet	1.5
		Other Frozen Products[h]	5.3
Butter	5.2	Total[e]	36.4
		All Diary Products	
		USDA Donations	17.1
		Commercial Sales	685.2
		Total	702.4

[a] All per capita consumption figures use U.S. total populations, except fluid milk and cream data, which are based on U.S. residential population. For eggs, excludes shipments to U.S. territories, uses U.S. total population, July 1, which does not include U.S. territories.
[b] A dozen eggs converted at 1.57 pounds.
[c] The factor for converting farm weight to retail weight was 0.97 in 1960 and was increased 0.003 per year until 0.985 was reached in 1990.
[d] Includes Colby, washed curd, Monterey, and Jack.
[e] Computed from unrounded data.
[f] Includes imports of Gruyere and Emmenthaler.
[g] Includes Gorgonzola.
[h] Includes mellorine, frozen yogurt beginning 1981, and other nonstandardized frozen diary products.
[i] Includes quantities used in other dairy products.
[j] Original data were presented in lbs, conversions to g/day were calculated by multiplying by a factor of 453.6 and dividing by 365 days.
Source: USDA, 1993.

Table 11-15. Adult Mean Daily Intake (as consumed) of Meat and Poultry Grouped by Region and Gender[a]

Food Item	Pacific		Mountain		North Central		Northeast		South	
	Mean Daily Intake (g/day) — Region									
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Beef	84.8	52.8	89.8	59.6	86.8	55.9	71.8	46.6	87.3	54.9
Pork	18.6	12.6	23.7	16.8	26.5	18.8	22.4	15.9	24.4	17.2
Lamb	1.3	1.2	0.5	0.3	0.4	0.4	1.3	1.0	0.5	0.3
Veal	0.4	0.2	0.2	0.2	0.4	0.4	2.8	1.5	0.3	0.3
Variety Meats/Game	11.1	7.9	9.1	7.4	11.9	8.0	8.1	6.8	9.4	7.8
Processed Meats	22.8	15.4	22.9	13.2	26.3	15.8	21.2	15.5	26.0	17.0
Poultry	67.3	56.1	51.0	45.2	51.7	44.7	56.2	49.2	57.7	50.2

[a] Adult population represents consumers ages 19 and above.

NOTE: Pacific = Washington, Oregon and California

Mountain = Montana, Idaho, Wyoming, Utah, Colorado, New Mexico, Arizona, and Nevada

North Central = Ohio, Illinois, Indiana, Wisconsin, Michigan, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas.

Northeast = Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania.

South = Maryland, Delaware, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Texas, and Oklahoma.

Source: National Livestock and Meat Board, 1993.

Table 11-16. Amount (as consumed) of Meat Consumed by Adults Grouped by Frequency of Eatings[e]

Frequency of Eatings	Percent of Total Eaters	Percent of Eaters: Male	Percent of Eaters: Female	Total Consumption for 14 Days (g)	Median Daily Intake (g/day)
Non-Meat Eaters[a]	1%	20	80	None	None
Light Meat Eaters[b]	30%	27	73	<1025	54
Medium Meat Eaters[c]	33%	39	61	1025-1584	93
Heavy Meat Eaters[d]	36%	73	27	>1548	144

[a] A female who is employed and on a diet. She lives alone or in a small household (without children).
[b] Female who may or may not be on a diet. There are probably 2-4 people in her household but that number is not likely to include children.
[c] This person may be of either sex, might be on a diet, and probably lives in a household of 2-4 people, which may include children.
[d] Male who is not on a diet and lives in a household of 2-4 individuals, which may include children.
[e] Adult population represents consumers ages 19 and above.
Source: National Livestock and Meat Board, 1993.

Table 11-17. Percentage Lipid Content (Expressed as Percentages of 100 Grams of Edible Portions) of Selected Meat and Dairy Products[a]

Product	Fat Percentage	Comment
<u>Meats</u>		
Beef	6.16	Raw
Lean only	9.91	Cooked
	19.24	Raw
Lean and fat, 1/4 in. fat trim	21.54	Cooked
Brisket (point half)		
Lean and fat		
Brisket (flat half)		
Lean and fat	22.40	Raw
Lean only	4.03	Raw
Pork		
Lean only	5.88	Raw
	9.66	Cooked
Lean and fat	14.95	Raw
	17.18	Cooked
Cured shoulder, blade roll, lean and fat	20.02	Unheated
Cured ham, lean and fat	12.07	Center slice
Cured ham, lean only	7.57	Raw, center, country style
Sausage	38.24	Raw, fresh
Ham	4.55	Cooked, extra lean (5% fat)
Ham	9.55	Cooked, (11% fat)
Lamb		
Lean	5.25	Raw
	9.52	Cooked
Lean and fat	21.59	Raw
	20.94	Cooked
Veal		
Lean	2.87	Raw
	6.58	Cooked
Lean and fat	6.77	Raw
	11.39	Cooked
Rabbit		
Composite of cuts	5.55	Raw
	8.05	Cooked
Chicken		
Meat only	3.08	Raw
	7.41	Cooked
Meat and skin	15.06	Raw
	13.60	Cooked
Turkey		
Meat only	2.86	Raw
	4.97	Cooked
Meat and skin	8.02	Raw
	9.73	Cooked
Ground	6.66	Raw

Table 11-17. Percentage Lipid Content (Expressed as Percentages of 100 Grams of Edible Portions) of Selected Meat and Dairy Products[a]

Product	Fat Percentage	Comment
Dairy		
Milk	3.16	3.3% fat, raw or pasteurized
Whole	4.17	Whole, mature, fluid
Human	0.83	Fluid
Lowfat (1%)	1.83	Fluid
Lowfat (2%)	0.17	Fluid
Skim		
Cream		
Half and half	18.32	Table or coffee, fluid
Medium	23.71	25% fat, fluid
Heavy-whipping	35.09	Fluid
Sour	19.88	Cultured
Butter	76.93	Regular
Cheese		
American	29.63	Pasteurized
Cheddar	31.42	
Swiss	26.02	
Cream	33.07	
Parmesan	24.50; 28.46	Hard; grated
Cottage	1.83	Lowfat, 2% fat
Colby	30.45	
Blue	27.26	
Provolone	25.24	
Mozzarella	20.48	
Yogurt	1.47	Plain, lowfat
Eggs	8.35	Chicken, whole raw, fresh or frozen

[a] Based on the lipid content in 100 grams, edible portion.
Source: USDA, 1979-1986.

Table 11-18. Fat Content of Meat Products

Meat Product 3-oz cooked serving (85.05 g)	Total Fat (g)	Percent Fat Content (%)
Beef, retail composite, lean only	8.4	9.9
Pork, retail composite, lean only	8.0	9.4
Lamb, retail composite, lean only	8.1	9.5
Veal, retail composite, lean only	5.6	6.6
Broiler chicken, flesh only	6.3	7.4
Turkey, flesh only	4.2	4.9

Source: National Livestock and Meat Board, 1993

.

Table 11-19. Fat Intake, Contribution of Various Food Groups to Fat Intake, and Percentage of the Population in Various Meat Eater Groups of the U.S. Population

	Total Population	Heavy Meat Eaters	Medium Meat Eaters	Light Meat Eaters	Non-Meat Eaters
Average Fat Intake (g)	68.3	84.5	62.5	53.5	32.3
Percent of Population	100	36	33	30	1
Meat Group (%)[a]	41	44	40	37	33
Bread Group (%)	24	23	24	26	25
Milk Group (%)	12	11	13	14	14
Fruits (%)	1	1	1	1	1
Vegetables (%)	9	9	9	9	11
Fats/oil/sweets (%)	13	12	13	14	17

[a] Meat Group includes meat, poultry, dry beans, eggs, and nuts.
Source: National Livestock and MeatBoard, 1993.

Table 11-20. Mean Total Daily Dietary Fat Intake (g/day) Grouped by Age and Gender[a]

	Total		Males		Females	
Age (yrs)	N	Mean Fat Intake (g/day)	N	Mean Fat Intake (g/day)	N	Mean Fat Intake (g/day)
2-11 (months)	871	37.52	439	38.31	432	36.95
1-2	1,231	49.96	601	51.74	630	48.33
3-5	1,647	60.39	744	70.27	803	61.51
6-11	1,745	74.17	868	79.45	877	68.95
12-16	711	85.19	338	101.94	373	71.23
16-19	785	100.50	308	123.23	397	77.46
20-29	1,882	97.12	844	118.28	638	76.52
30-39	1,628	93.84	736	114.28	791	74.06
40-49	1,228	84.90	626	99.26	602	70.80
50-59	929	79.29	473	96.11	456	63.32
60-69	1,108	69.15	646	80.80	560	59.52
70-79	851	61.44	444	73.35	407	53.34
≥ 80	809	54.61	290	68.09	313	47.84
Total	14,801	81.91	7,322	97.18	7,479	67.52
≥ 2	13,314	82.77	6,594	98.74	8,720	68.06

[a] Total dietary fat intake includes all fat (i.e., saturated and unsaturated) derived from consumption of foods and beverages (excluding plain drinking water).
Source: Adapted from CDC, 1994.

Table 11-21. Percentage Mean Moisture Content (Expressed as Percentages of 100 Grams of Edible Portions)[a]

Food	Moisture Content Percent	Comments
Meat		
Beef	71.60	Raw, composite, trimmed, retail cuts
Beef liver	68.99	Raw
Chicken (light meat)	74.86	Raw, without skin
Chicken (dark meat)	75.99	Raw, without skin
Duck - domestic	73.77	Raw
Duck - wild	75.51	Raw
Goose - domestic	68.30	Raw
Ham - cured	66.92	Raw
Horse	72.63	Raw, roasted
	63.98	Cooked, roasted
Lamb	73.42	Raw, composite, trimmed, retail cuts
Lard	0.00	
Pork	70.00	Raw
Rabbit - domestic	72.81	Raw
	69.11	Raw, roasted
Turkey	74.16	Cooked, roasted
Dairy Products		
Eggs	74.57	Raw
Butter	15.87	Raw
Cheese American pasteurized	39.16	Regular
Cheddar	36.75	
Swiss	37.21	
Parmesan, hard	29.16	
Parmesan, grated	17.66	
Cream, whipping, heavy	57.71	
Cottage, lowfat	79.31	
Colby	38.20	
Blue	42.41	
Cream	53.75	
Yogurt		
Plain, lowfat	85.07	
Plain, with fat	87.90	Made from whole milk
Human milk - estimated from USDA Survey		
Human	87.50	Whole, mature, fluid
Skim	90.80	
Lowfat	90.80	1%

[a] Based on the water content in 100 grams, edible portion.
Source: USDA, 1979-1986.

Table 11-22. Summary of Meat, Poultry, and Dairy Intake Studies

Study	Survey Population Used in Calculating Intake	Types of Data Used	Units	Food Items
KEY STUDIES				
EPA Analysis of 1989/91 CSFII Data	Per capita	1989/91 CSFII data; Based on 3-day average individual intake rates.	g/kg-day; as consumed	Distributions of intake rates for total meats and total dairy; individual food items.
Pao et al., 1982	Consumers only serving size data provided	1977/78 NFCS 3-day individual intake data	g; as consumed	Distributions of serving sizes for meats, poultry, and diary products.
RELEVANT STUDIES				
AIHC, 1994	Adults, Per Capita	USDA NFCS 1977-78 data presented in the 1989 version of the Exposure Factors Handbook that were analyzed by Finley and Paustenbach (1992).	g/day	Distribution for beef consumption presented in @Risk format.
EPA's DRES (White et al., 1983)	Per capita (i.e., consumers and nonconsumers)	1977/78 NFCS 3-day individual intake data	g/kg-day; as consumed	Intake for a wide variety of meats, poultry, and dairy products presented; complex food groups were disaggregated
NLMB, 1993	Adult daily mean intake rates	MRCA's Menu Census	g/day; as consumed	Intake rates for various meats by region and gender.
USDA, 1980, 1992	Per capita and consumer only grouped by age and sex	1977/78 and 1987/88 NFCS 1-day individual intake data	g/day; as consumed	Total meat, poultry and fish, total poultry, total milk, cheese and eggs.
USDA, 1993	Per capita consumption based on "food disappearance"	Based on food supply and utilization data which were provided by National Agricultural Statistics Service (NASS), Customs Service reports, and trade associations.	g/day; as consumed	Intake rates of meats, poultry, and diary products; intake rates of individual food items.
U.S. EPA/ORP, 1984a; 1984b	Per capita	1977/78 NFCS Individual intake data	g/day; as consumed	Mean intake rates for total meats, total diary products, and individual food items.
U.S. EPA/OST, 1989	Estimated lifetime dietary intake	Based on FDA Total Diet Study Food List which used 1977/78 NFCS data, and NHANES II data	g/day; dry weight	Various food groups; complex foods disaggregated

Table 11-23. Summary of Recommended Values for Per Capita Intake of Meat and Dairy Products and Serving Size

Mean	95th Percentile	Multiple Percentiles	Study
Total Meat Intake			
2.1 g/kg-day	5.1 g/kg-day	see Table 11-1	EPA Analysis of CSFII 1989-91 Data
Total Dairy Intake			
8.0 g/kg-day	29.7 g/kg-day	see Table 11-2	EPA Analysis of CSFII 1989-91 Data
Individual Meat and Dairy Products			
see Table 11-3	see Table 11-3	see Table 11-3	EPA Analysis of CSFII 1989-91 Data
Serving Size			
see Table 11-4	see Table 11-4	see Table 11-4	Pao et al., 1982

Table 11-24. Confidence in Meats and Dairy Products Intake Recommendation

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	USDA CSFII survey receives high level of peer review. EPA analysis of these data has not been peer reviewed outside the Agency. (Peer review will be conducted as part of the peer review of this Handbook)	Medium (This will become a "high" once the Handbook's peer review is completed)
• Accessibility	CSFII data is publicly available	High
• Reproducibility	Enough information is included to reproduce results	High
• Focus on factor of interest	Analysis is specifically designed to address food intake	High
• Data pertinent to U.S.	Data focuses on the U.S. population	High
• Primary data	This is new analysis of primary data	High
• Currency	Is the most current data publicly available	High
• Adequacy of data collection period	Survey is designed to collect short-term data.	Medium confidence for average values; Low confidence for long term percentile distribution
• Validity of approach	Survey methodology was adequate	High
• Study size	Study size was very large and therefore adequate	High
• Representativeness of the population	The population studied was the U.S. population.	High
• Characterization of variability	Survey was not designed to capture long term day-to-day variability. Short term distributions are provided for various age groups, regions, etc.	Medium
• Lack of bias in study design (high rating is desirable)	Response rate was adequate?	Medium
• Measurement error	No measurements were taken. The study relied on survey data.	N/A
Other Elements		
• Number of studies	1 CSFII is the most recent data publicly available. Therefore, it was the only study classified as key study.	Low
• Agreement between researchers	Although the CSFII was the only study classified as key study, the results are in good agreement with earlier data.	High
Overall Rating	The survey is representative of U.S. population; Although there was only one study considered key, these data are the most recent and are in agreement with earlier data; the approach used to analyzed the data was adequate. However, due to the limitations of the survey design estimation of long-term percentile values (especially the upper percentiles) is uncertain.	High confidence in the average; Low confidence in the long-term upper percentiles

Table 11-25. Confidence in Meat and Dairy Serving Size Recommendations

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	USDA NFCS survey receives high level of peer review.	High
• Accessibility	The NFCS data are publicly available	High
• Reproducibility	Methodology is clearly explained	High
• Focus on factor of interest	Analysis is specifically designed to address food intake	High
• Data pertinent to U.S.	Data focuses on the U.S. population	High
• Primary data	The study analyzed primary data	High
• Currency	The data are old (i.e. 1977-78)	Low
• Adequacy of data collection period	Survey is designed to collect short-term data.	Medium
• Validity of approach	Survey methodology was adequate	High
• Study size	Study size was very large and therefore adequate	High
• Representativeness of the population	The population studied was the U.S. population.	High
• Characterization of variability	Survey was not designed to capture long term day-to-day variability. Short term distributions are provided	Medium
• Lack of bias in study design (high rating is desirable)	Response rate was adequate	Medium
• Measurement error	No measurements were taken. The study relied on survey data.	N/A
Other Elements		
• Number of studies	1	Low
• Agreement between researchers	Although serving size data may have been collected in other surveys, they have not been reported in any other study.	Low
Overall Rating	The survey is representative of U.S. population; the approach used to analyzed the data was adequate. However, due to the limitations of the survey design estimation of long-term percentile values (especially the upper percentiles) is uncertain.	Medium

APPENDIX 11A

Sample Calculation of Mean Daily Fat Intake Based on CDC (1994) Data

Sample Calculation of Mean Daily Fat Intake Based on CDC (1994) Data

$$0.34 \ x \ 2{,}095 \ kcal \ x \ X = 82 \ g{-}fat$$

$$\therefore X = 0.115 \ \frac{g{-}fat}{kcal}$$

X is the conversion factor from kcal/day to g-fat/day. An example of obtaining the grams of fat from the daily TFEI (1591 kcal/day) for children ages 3-5 and their percent TFEI from total dietary fat (33 percent) is as follows:

$$1{,}591 \ \frac{kcal}{day} \ x \ 0.33 \ x \ 0.12 \ \frac{g{-}fat}{kcal} = 63 \ \frac{g{-}fat}{day}$$

TABLE OF CONTENTS

12. INTAKE RATES FOR VARIOUS HOME PRODUCED FOOD ITEMS

12.1. BACKGROUND

Ingestion of contaminated foods is a potential pathway of exposure to toxic chemicals. Consumers of home produced food products may be of particular concern because exposure resulting from local site contamination may be higher for this subpopulation. According to a survey by the National Gardening Association (1987), a total of 34 million (or 38 percent) U.S. households participated in vegetable gardening in 1986. Table 12-1 contains demographic data on vegetable gardening in 1986 by region/section, community size, and household size.

Table 12-1. 1986 Vegetable Gardening by Demographic Factors

Demographic Factor	Percentage of total households that have gardens (%)	Number of households (million)
Total	38	34
Region/section		
East	33	7.3
New England	37	1.9
Mid-Atlantic	32	5.4
Midwest	50	11.0
East Central	50	6.6
West Central	50	4.5
South	33	9.0
Deep South	44	3.1
Rest of South	29	5.9
West	37	6.2
Rocky Mountain	53	2.3
Pacific	32	4.2
Size of community		
City	26	6.2
Suburb	33	10.2
Small town	32	3.4
Rural	61	14.0
Household size		
Single, separated, divorced, widowed	54	8.5
Married, no children	45	11.9
Married, with children	44	13.2

Source: National Gardening Association, 1987.

Table 12-2 contains information on the types of vegetables grown by home gardeners in 1986. Tomatoes, peppers, onions, cucumbers, lettuce, beans, carrots, and corn are among the vegetables grown by the largest percentage of gardeners. Home-produced foods can become contaminated in a variety of ways. Ambient pollutants in the air may be deposited on plants, adsorbed onto or absorbed by the plants, or dissolved in rainfall or irrigation waters that contact the plants. Pollutants may also be adsorbed onto plants roots from contaminated soil and water. Finally, the addition of pesticides, soil additives, and fertilizers to crops or gardens may result in contamination of food products. Meat and dairy products can become contaminated if animals consume contaminated soil, water, or feed crops. Intake rates for home-produced food products are needed to

Table 12-2. Percentage of Gardening Households Growing Different Vegetables in 1986

Vegetable	Percent
Artichokes	0.8
Asparagus	8.2
Beans	43.4
Beets	20.6
Broccoli	19.6
Brussel sprouts	5.7
Cabbage	29.6
Carrots	34.9
Cauliflower	14.0
Celery	5.4
Chard	3.5
Corn	34.4
Cucumbers	49.9
Dried peas	2.5
Dry beans	8.9
Eggplant	13.0
Herbs	9.8
Kale	3.1
Kohlrabi	3.0
Leeks	1.2
Lettuce	41.7
Melons	21.9
Okra	13.6
Onions	50.3
Oriental vegetables	2.1
Parsnips	2.2
Peanuts	1.9
Peas	29.0
Peppers	57.7
Potatoes	25.5
Pumpkins	10.2
Radishes	30.7
Rhubarb	12.2
Spinach	10.2
Summer squash	25.7
Sunflowers	8.2
Sweet potatoes	5.7
Tomato	85.4
Turnips	10.7
Winter squash	11.1

Source: National Gardening Association, 1987.

assess exposure to local contaminants present in homegrown or home caught foods. Recently, EPA analyzed data from the U.S. Department of Agriculture's (USDA) Nationwide Food Consumption Survey (NFCS) to generate distributions of intake rates for home-produced foods. The methods used and the results of these analyses are presented below.

12.2. METHODS

Nationwide Food Consumption Survey (NFCS) data were used to generate intake rates for home-produced foods. USDA conducts the NFCS every 10 years to analyze the food consumption behavior and dietary status of Americans (USDA, 1992). The most recent NFCS was conducted in 1987-88. The survey used a statistical sampling technique designed to ensure that all seasons, geographic regions of the 48 conterminous states in the U.S., and socioeconomic and demographic groups were represented (USDA, 1994). There were two components of the NFCS. The household component collected information over a seven-day period on the socioeconomic and demographic characteristics of households, and the types, amount, value, and sources of foods consumed by the household (USDA, 1994). The individual intake component collected information on food intakes of individuals within each household over a three-day period (USDA, 1993). The sample size for the 1987-88 survey was approximately 4,300 households (over 10,000 individuals). This is a decrease over the previous survey conducted in 1977-78 which sampled approximately 15,000 households (over 36,000 individuals) (USDA, 1994). The sample size was lower in the 1987-88 survey as a result of budgetary constraints and low response rate (i.e., 38 percent for the household survey and 31 percent for the individual survey) (USDA, 1993). However, NFCS data from 1987-88 were used to generate homegrown intake rates because they were the most recent data available and were believed to be more reflective of current eating patterns among the U.S. population.

The USDA data were adjusted by applying the sample weights calculated by USDA to the data set prior to analysis. The USDA sample weights were designed to "adjust for survey non-response and other vagaries of the sample selection process" (USDA, 1987-88). Also, the USDA weights are calculated "so that the weighted sample total equals the known population total, in thousands, for several characteristics thought to be correlated with eating behavior" (USDA, 1987-88).

For the purposes of this study, home-produced foods were defined as homegrown fruits and vegetables, meat and dairy products derived from consumer-raised livestock or game meat, and home caught fish. The food items/groups selected for analysis included major food groups (i.e., total fruits, total vegetables, total meats, total dairy, total fish and shellfish), individual food items for which >30 households reported eating the home-produced form of the item, fruits and vegetables categorized as exposed, protected, and roots, and various USDA fruit and vegetable subcategories (i.e., dark green vegetables, citrus fruits, etc.). Food items/groups were identified in the NFCS data base according to NFCS-defined food codes. Appendix 12A presents the codes used to determine the various food groups.

Although the individual intake component of the NFCS gives the best measure of the amount of each food item eaten by each individual in the household, it could not be used directly to measure consumption of home produced food because the individual component does not identify the source of the food item (i.e., as home produced or not). Therefore, an analytical method which incorporated data from both the household and individual survey components was developed to estimate individual home produced food intake. The USDA household data were used to determine (1) the amount of each home produced food item used during a week by household members and (2) the number of meals eaten in the household by each household member during a week. Note that the household survey reports the total amount of each food item used in the household (whether by guests or household members); the amount used by household members was derived by multiplying the total amount used in the household by the proportion of all meals served in the household (during the survey week) that were consumed by household members.

The individual survey data was used to generate average sex- and age-specific serving sizes for each food item. The age categories used in the analysis were as follows: 1 to 2 years; 3 to 5 years; 6 to 11 years; 12 to 19 years; 20 to 39 years; 40 to 69 years; and over 70 years (intake rates were not calculated for children under 1; the rationale for this is discussed below). These serving sizes were used during subsequent analyses to generate homegrown food intake rates for individual household members. Assuming that the proportion of the household quantity of each homegrown food item/group was a function of the number of meals and the mean sex- and age-specific serving size for each family member, individual intakes of home produced food were calculated for all members of the survey population using the following general equation:

$$w_i = W_f \cdot \left[\frac{m_i q_i}{\sum_{i=1}^{n} m_i q_i} \right] \qquad \text{(Eqn. 12-1)}$$

where:

- w_i = Homegrown amount of food item/group attributed to member i during the week (g/week);
- W_f = Total quantity of homegrown food item/group used by the family members (g/week);
- m_i = Number of meals of household food consumed by member i during the week (meals/week); and
- q_i = Serving size for an individual within the age and sex category of the member (g/meal).

Daily intake of a homegrown food item/group was determined by dividing the weekly value (w_i) by seven. Intake rates were indexed to the self-reported body weight of the survey respondent and reported in units of g/kg-day. Intake rates were not calculated for children under one year of age because their diet differs markedly from that of other household members, and thus the assumption that all household members share all foods would be invalid for this age group. In Section 12.5, a method for estimating per-capita homegrown intake in this age group is suggested.

For the major food groups (fruits, vegetables, meats, dairy, and fish) and individual foods consumed by at least 30 households, distributions of home produced intake among consumers were generated for the entire data set and according to the following subcategories: age groups, urbanization categories, seasons, racial classifications, regions, and responses to the questionnaire.

Consumers were defined as members of survey households who reported consumption of the food item/group of interest during the one week survey period. In addition, for the major food groups, distributions were generated for each region by season, urbanization, and responses to the questionnaire. Table 12-3 presents the codes, definitions, and a description of the data included in each of the subcategories. Intake rates were not calculated for food items/groups for which less than 30 households reported home-produced usage because the number of observations may be inadequate for generating distributions that would be representative of that segment of consumers. Fruits and vegetables were also classified as exposed, protected, or roots, as shown in Appendix 12A of this document. Exposed foods are those that are grown above ground and are likely to be contaminated by pollutants deposited on surfaces that are eaten. Protected products are those that have outer protective coatings that are typically removed before consumption. Distributions of intake were tabulated for these food classes for the same subcategories listed above. Distributions were also tabulated for the following USDA food classifications: dark green vegetables, deep yellow vegetables, other vegetables, citrus fruits, and other fruits. Finally, the percentages of total intake of the food items/groups consumed within survey households that can be attributed to home production were tabulated. The percentage of intake that was homegrown was calculated as the ratio of total intake of the homegrown food item/group by the survey population to the total intake of all forms of the food by the survey population.

As disccussed in Section 12.3, percentiles of average daily intake derived from short time intervals (e.g., 7 days) will not, in general, be reflective of long term patterns. This is especially true regarding consumption of many home grown products (e.g., fruits, vegetables), where there is often a strong seasonal component associated with their use. To try to derive, for the major food categories, the long term distribution of average daily intake rates from the short-term data available here, an approach was developed which attempted to account for seasonal variability in consumption. This approach used regional "seasonally adjusted distributions" to approximate regional long term distributions and then combined these regional adjusted distributions (in proportion to the weights for each region) to obtain a U.S. adjusted distribution which approximated the U.S. long term distribution.

The percentiles of the seasonally adjusted distribution for a given region are generated by averaging the corresponding percentiles of each of the four seasonal distributions of the region. More formally, the seasonally adjusted distribution for each region is such that its inverse cumulative distribution function is the average of the inverse cumulative distribution functions of each of the seasonal distributions of that region. The use of regional seasonally adjusted distributions to approximate regional long term distributions is based on the assumption that each individual consumes at the same regional percentile levels for each season and consumes at a constant weekly rate throughout a given season. Thus, for instance, if the 60th percentile weekly intake level in the South is 14.0 g in the summer and 7.0 g in each of the three other seasons, then an individual in the South with an average weekly intake of 14.0 g over the summer would be assumed to have an intake of 14.0 g for each week of the summer and an intake of 7.0 g for each week of the other seasons.

Note that the seasonally adjusted distributions derived above were generated using the overall

Table 12-3. Sub-category Codes and Definitions

Code	Definition	Description
		Region[a]
1	Northeast	Includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont
2	Midwest	Includes Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin
3	South	Includes Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia
4	West	Includes Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming
		Urbanization
1	Central City	Cities with populations of 50,000 or more that is the main city within the metropolitan statistical area (MSA).
2	Suburban	An area that is generally within the boundaries of an MSA, but is not within the legal limit of the central city.
3	Nonmetropolitan	An area that is not within an MSA.
		Race
1	--	White (Caucasian)
2	--	Black
3	--	Asian and Pacific Islander
4	--	Native American, Aleuts, and Eskimos
5, 8, 9	Other/NA	Don't know, no answer, some other race
		Responses to Survey Questions
Grow	Question 75	Did anyone in the household grow any vegetables or fruit for use in the household?
Raise Animals	Question 76	Did anyone in the household produce any animal products such as milk, eggs, meat, or poultry for home use in your household?
Fish/Hunt	Question 77	Did anyone in the household catch any fish or shoot game for home use?
Farm	Question 79	Did anyone in the household operate a farm or ranch?
		Season
Spring	-	April, May, June
Summer	-	July, August, September
Fall	-	October, November, December
Winter	-	January, February, March

[a] Alaska and Hawaii were not included.
Source: USDA 1987-88.

distributions, i.e., both consumers and non-consumers. However, since all the other distributions presented in this section are based on consumers only, the percentiles for the adjusted distributions have been revised to reflect the percentiles among consumers only. Given the above assumption about how each individual consumes, the percentage consuming for the seasonally adjusted distributions give an estimate of the percentage of the population consuming the specified food category at any time during the year.

The intake data presented here for consumers of home-produced foods and the total number of individuals surveyed may be used to calculate the mean and the percentiles of the distribution of home produced food consumption in the overall population (consumers and non-consumers) as follows:

Assuming that w_p is the homegrown amount of food item/group at the p^{th} percentile, N_H is the weighted number of households who are users of the homegrown food item, and N_A is the weighted number of all households surveyed; then, $(N_A - N_H)$ is the weighted number of households who reported zero homegrown consumption. There are (p/100) x N_H households below the p^{th} percentile. Therefore, w_p is the

$$100 \times \frac{\frac{p}{100} \times N_H + [N_A - N_H]}{N_A} \ percent \qquad \text{(Eqn. 12-2)}$$

of the overall distribution of homegrown food consumption. The mean in the overall population is calculated by multiplying the mean among consumers by the proportion consuming, N_H / N_A.

Table 12-4 displays the weighted numbers N_A, as well as the unweighted total survey sample sizes, for each subcategory and overall. It should be noted that the total unweighted number of observations in Table 12-4 (9,852) is somewhat lower than the number of observations reported by USDA because this study only used observations for family members for which age and body weight were specified.

As mentioned above, the intake rates derived in this section are based on the amount of household food consumption. As measured by the NFCS, the amount of food "consumed" by the household is a measure of consumption in an economic sense, i.e., a measure of the weight of food brought into the household that has been consumed (used up) in some manner. In addition to food being consumed by persons, food may be used up by spoiling, by being discarded (e.g., inedible parts), through cooking processes, etc.

USDA estimated preparation losses for various foods (USDA, 1975). For meats, a net cooking loss, which includes dripping and volatile losses, and a net post cooking loss, which involves losses from cutting, bones, excess fat, scraps and juices, were derived for a variety of cuts and cooking methods. For each meat type (e.g., beef) EPA has averaged these losses across all cuts and cooking methods to obtain a mean net cooking loss and a mean net post cooking loss; these are displayed in Table 12-5. For individual fruits and vegetables, USDA (1975) also gave cooking and post-cooking losses. These data are presented in Tables 12-6 and 12-7.

The following formulas can be used to convert the intake rates tabulated here to rates reflecting actual consumption:

$$I_A = I \times (1 - L_1) \times (1 - L_2) \qquad \text{(Eqn. 12-3)}$$

$$I_A = I \times (1 - L_P) \qquad \text{(Eqn. 12-4)}$$

where I_A is the adjusted intake rate, I the tabulated rate, L_1 the cooking loss, L_2 post-cooking loss and L_P the paring loss. For fruits, corrections based on cooking and postcooking losses only apply to fruits that are eaten in cooked forms (i.e., apples eaten as applesauce). For raw forms of the fruits, paring or preparation loss data should be used to correct for losses from removal of skin, peel, core, caps, pits, stems, and defects, or draining of liquids from canned or frozen forms. To obtain preparation losses for food categories, the preparation losses of the individual foods making up the category can be averaged.

In calculating ingestion exposure, assessors should use consistent forms in combining intake rates with contaminant concentrations. This issue has been previously discussed in the other food Chapters.

Table 12-4. Weighted and Unweighted Number of Observations for NFCS Data Used in Analysis of Food Intake

	All Regions		Northeast		Midwest		South		West	
	wgtd	unwgtd	wgtd	unwgtd	wgtd	unwgtd	wgtd	unwgtd	wgtd	unwgtd
Total	188019000	9852	41167000	2018	46395000	2592	64331000	3399	36066000	1841
Age										
< 01	2814000	156	545000	29	812000	44	889000	51	568000	32
01-02	5699000	321	1070000	56	1757000	101	1792000	105	1080000	59
03-05	8103000	461	1490000	92	2251000	133	2543000	140	1789000	95
06-11	16711000	937	3589000	185	4263000	263	5217000	284	3612000	204
12-19	20488000	1084	4445000	210	5490000	310	6720000	369	3833000	195
20-39	61606000	3058	12699000	600	15627000	823	21786000	1070	11494000	565
40-69	56718000	3039	13500000	670	13006000	740	19635000	1080	10577000	549
70 +	15880000	796	3829000	176	3189000	178	5749000	300	3113000	142
Season										
Fall	47667000	1577	9386000	277	14399000	496	13186000	439	10696000	365
Spring	46155000	3954	10538000	803	10657000	1026	16802000	1437	8158000	688
Summer	45485000	1423	9460000	275	10227000	338	17752000	562	7986000	246
Winter	48712000	2898	11783000	663	11112000	732	16591000	961	9226000	542
Urbanization										
Central City	56352000	2217	9668000	332	17397000	681	17245000	715	12042000	489
Nonmetropolitan	45023000	3001	5521000	369	14296000	1053	19100000	1197	6106000	382
Surburban	86584000	4632	25978000	1317	14702000	858	27986000	1487	17918000	970
Race										
Asian	2413000	114	333000	13	849000	37	654000	32	577000	32
Black	21746000	1116	3542000	132	2794000	126	13701000	772	1709000	86
Native American	1482000	91	38000	4	116000	6	162000	8	1166000	73
Other/NA	4787000	235	1084000	51	966000	37	1545000	86	1192000	61
White	157531000	8294	36170000	1818	41670000	2386	48269000	2501	31422000	1589
Response to Questionnaire										
Do you garden?	68152000	3744	12501000	667	22348000	1272	20518000	1136	12725000	667
Do you raise animals?	10097000	631	1178000	70	3742000	247	2603000	162	2574000	152
Do you hunt?	20216000	1148	3418000	194	6948000	411	6610000	366	3240000	177
Do you fish?	39733000	2194	5950000	321	12621000	725	13595000	756	7567000	392
Do you farm?	7329000	435	830000	42	2681000	173	2232000	130	1586000	90

Table 12-5. Percent Weight Losses from Preparation of Various Meats

	Mean Net Cooking Loss (%)[a]			Mean Net Post Cooking Loss (%)[b]		
Meat Type	Mean	Range of Means	Standard Deviation	Mean	Range of Means	Standard Deviation
Beef	27.24	11.00 to 42.00	7.08	24.17	10.00 to 46.00	9.34
Pork	28.06	1.00 to 67.00	9.71	35.86	14.00 to 52.00	11.41
Chicken	32.04	7.00 to 55.00	8.69	31.10	16.00 to 51.00	7.84
Turkey	31.91	11.00 to 57.00	6.97	28.45	8.00 to 48.00	10.07
Lamb	30.00	25.00 to 37.00	4.85	34.00	14.00 to 61.00	13.74
Veal	29.38	10.00 to 45.00	10.79	24.67	18.00 to 37.00	8.73
Fish[c]	29.91	-19.00 to 81.00	18.90	11.26	1.00 to 26.00	6.42
Shellfish[d]	32.83	1.00 to 94.00	29.50	10.00	10.00 to 10.00	0.00

[a] Includes dripping and volatile losses during cooking. Averaged over various cuts and preparation methods.
[b] Includes losses from cutting, shrinkage, excess fat, bones, scraps, and juices. Averaged over various cuts and preparation methods.
[c] Averaged over a variety of fish, to include: bass, bluefish, butterfish, cod, flounder, haddock, halibut, lake trout, makerel, perch, porgy, red snapper, rockfish, salmon, sea trout, shad, smelt, sole, spot, squid, swordfish steak, trout, and whitefish.
[d] Averaged over a variety of shellfish, to include: clams, crab, crayfish, lobster, oysters, and shrimp and shrimp dishes.

Source: USDA, 1975.

Table 12-6. Percent Weight Losses from Preparation of Various Fruits

	Mean Net Cooking Loss (%)[a]			Mean Net Post Cooking Loss (%)[b]			Mean Paring or Preparation Loss (%)[c,d]		
Type of Fruit	Mean	Range of Means	Standard Deviation	Mean	Range of Means	Standard Deviation	Mean	Range of Means	Standard
Apples	-70.9	-478 to 15	156.00	24.6	3 to 42	12.6	22.0[c]	13 to 40[c]	NA[c]
Pears	-53.7	-113 to 19	54.7	--	--	--	22.0[c]	12 to 60[c]	NA[c]
							41.0[d]	25 to 47[d]	NA[d]
Peaches	-145.0	-418 to 5	173.4	36.1	19 to 50	11.7	24.0[c]	6 to 68[c]	NA[c]
Strawberries	--	--	--	--	--	--	10.0[c]	6 to 14[c]	NA[c]
							30.0[d]	96 to 41[d]	14.9[d]
Oranges	--	--	--	--	--	--	29.0[c]	19 to 38[c]	NA[c]

[a] Includes losses from coring, peeling, stemming, trimming, draining, thawing, pitting, and defects, and gains from the addition of water and sugar. Averaged over various preparation methods.
[b] Includes losses from draining cooked forms.
[c] Includes losses from removal of skin or peel, core or pit, stems or caps, seeds and defects.
[d] Includes losses from removal of drained liquids from canned or frozen forms.

Source: USDA, 1975

Table 12-7. Percent Weight Losses from Preparation of Various Vegetables

	Mean Net Cooking Loss (%)[a]			Mean Net Post Cooking Loss (%)[b]		
Type of Vegetable	Mean	Range of Means	Standard Deviation	Mean	Range of Means	Standard Deviation
Asparagus	22.83	5 to 47	15.70	--	--	--
Beets	27.71	4 to 60	17.08	--	--	--
Broccoli	13.83	0 to 39	13.16	--	--	--
Cabbage	11.25	4 to 20	6.22	--	--	--
Carrots	19.13	2 to 41	12.23	--	--	--
Corn	25.67	-1 to 64	21.98	--	--	--
Cucumbers	17.50	5 to 40	13.57	--	--	--
Lettuce	21.63	6 to 36	11.86	--	--	--
Lima Beans	-12.20	-143 to 56	69.12	--	--	--
Okra	11.83	-10 to 40	15.52	--	--	--
Onions	4.54	-90 to 63	38.12	--	--	--
Peas, green	2.00	-147 to 62	63.48	--	--	--
Peppers	13.40	3 to 27	9.11	--	--	--
Pumpkins	19.00	8 to 30	11.00	--	--	--
Snap Beans	18.00	5 to 42	13.07	--	--	--
Tomatoes	15.13	2 to 34	9.56	--	--	--
Potatoes	-21.83	-527 to 46	120.98	21.63	1 to 33	10.86

[a] Includes losses due to paring, trimming, flowering the stalk, thawing, draining, scraping, shelling, slicing, husking, chopping, and dicing and gains from the addition of water, fat, or other ingredients. Averaged over various preparation methods.
[b] Includes losses from draining or removal of skin.

Source: USDA, 1975

12.3. RESULTS

The intake rate distributions (among consumers) for total home-produced fruits, vegetables, meats, fish and dairy products are shown, respectively, in Tables 12-8 through 12-32 (displayed at the end of Chapter 12). Also shown in these tables is the proportion of respondents consuming the item during the (one-week) survey period. Home grown vegetables were the most commonly consumed of the major food groups (18.3%), followed by fruit (7.8%), meat (4.9%), fish (2.1%), and dairy products (0.7%). The intake rates for the major food groups vary according to region, age, urbanization code, race, and response to survey questions. In general, intake rates of home produced foods are higher among populations in non-metropolitan and suburban areas and lowest in central city areas. Results of the regional analyses indicate that intake of homegrown fruits, vegetables, meat and dairy products is generally highest for individuals in the Midwest and South and lowest for those in the Northeast. Intake rates of home-caught fish were generally highest among consumers in the South. Homegrown intake was generally higher among individuals who indicated that they operate a farm, grow their own vegetables, raise animals, and catch their own fish. The results of the seasonal analyses for all regions combined indicated that, in general, homegrown fruits and vegetables were eaten at a higher rate in summer, and home caught fish was consumed at a higher rate in spring; however, seasonal intake varied based on individual regions. Seasonally adjusted intake rate distributions for the major food groups are presented in Table 12-33.

Tables 12-34 through 12-60 present distributions of intake for individual home-produced food items for households that reported consuming the homegrown form of the food during the survey period. Intake rate distributions among consumers for homegrown foods categorized as exposed fruits and vegetables, protected fruits and vegetables, and root vegetables are presented in Tables 12-61 through 12-65; the intake distributions for various USDA classifications (e.g., dark green vegetables) are presented in Tables 12-66 through 12-70. The results are presented in units of g/kg-day. Table 12-71 presents the fraction of household intake attributed to home-produced forms of the food items/groups evaluated. Thus, use of these data in calculating potential dose does not require the body weight factor to be included in the denominator of the average daily dose (ADD) equation. It should be noted that converting these intake rates into units of g/day by multiplying by a single average body weight is inappropriate, because individual intake rates were indexed to the actual body weights of the survey respondents. However, if there is a need to compare the total intake data presented here to other intake data in units of g/day, a body weight less than 70 kg (i.e., approximately 60 kg; calculated based on the number of respondents in each age category and the average body weights for these age groups, as presented in Volume I, Chapter 7) should be used because the total survey population included children as well as adults.

12.4. ADVANTAGES AND LIMITATIONS

The USDA NFCS data set is the largest publicly available source of information on food consumption habits in the United States. The advantages of using this data set are that it is expected to be representative of the U.S. population and that it provides information on a wide variety of food groups. However, the data collected by the USDA NFCS are based on short-term dietary recall and the intake distributions generated from them may not accurately reflect long-term intake patterns, particularly with respect to the tails (extremes) of the distributions. Also, the two survey components (i.e., household and individual) do not define food items/groups in a consistent manner; as a result, some errors may be introduced into these analyses because the two survey components are linked. The results presented here may also be biased by assumptions that are inherent in the analytical method utilized. The analytical method may not capture all high-end consumers within households because average serving sizes are used in calculating the proportion of homegrown food consumed by each household member. Thus, for instance, in a two-person household where one member had high intake and one had low intake, the method used here would assume that both members had an equal and moderate level of intake. In addition, the analyses assume that all family members consume a portion of the home produced food used within the household. However, not all family members may consume each home produced food item and serving sizes allocated here may not be entirely representative of the portion of household foods consumed by each family member. As was mentioned in Section 12.2, no analyses were performed for the under 1 year age group due to the above concerns. Below, in Section 12.5, a recommended approach for dealing with this age group is presented.

The preparation loss factors discussed in Section 12.2 are intended to convert intake rates based on “household consumption” to rates reflective of what individuals actually consume. However, these factors do not include losses to spoilage, feeding to pets, food thrown away, etc.

12.5. RECOMMENDATIONS

The distribution data presented in this study may be used to assess exposure to contaminants in foods grown, raised, or caught at a specific site. Table 12-72 presents the confidence ratings for homegrown food intake. The recommended values for mean intake rates among consumers for the various home produced foods can be taken from the tables presented here; these can be converted to per capita rates by multiplying by the fraction consuming. The data presented here for consumers of home-produced foods represent average daily intake rates of food items/groups over the seven-day survey period and do not account for variations in eating habits during the rest of the year; thus the percentiles presented here (except the seasonally adjusted) are only valid when considering exposures over time periods of about one week. Similarly, the figures for percentage consuming are also only valid over a one week time period. Since the tabulated percentiles reflect the distribution among consumers only, Eqn. 12-2 must be used to convert the percentiles shown here to ones valid for the general population.

In contrast, the seasonally adjusted percentiles are designed to give percentiles of the long term distribution of average daily intake and the percentage consuming shown with this distribution is designed to estimate the percent of the population consuming at any time during a year. However, because the assumptions mentioned in Section 12.2 can not be verified to hold, these upper percentiles must be assigned a low confidence rating. Eqn. 12-2 may also be used with this distribution to convert percentiles among consumers to percentiles for the general population.

For all the rates tabulated here, preparation loss factors should be applied where appropriate. The form of the food used to estimate intake should be consistent with the form used to measure contaminant concentration.

As described above, the tables do not display rates for children under 1 year of age. For this age group, it is recommended that per-capita homegrown consumption rates be estimated using the following approach. First, for each specific home produced food of interest, the ratio of per capita intake for children under 1 year compared to that of children 1 to 2 years is calculated using the USDA CSFII 1989-1991 results displayed in Volume II, Chapters 9 and 11. Note these results are based on individual food intakes; however, they consider all sources of food, not just home produced. Second, the per-capita intake rate in the 1 to 2 year age group of the home produced food of interest is calculated as described above by multiplying the fraction consuming by the mean intake rate among consumers (both these numbers are displayed in the tables). Finally, the per capita homegrown intake rate in children under 1 year of the food of interest is estimated by multiplying the homegrown per-capita intake rate in the 1 to 2 year age group by the above ratio of intakes in the under 1 year age group as compared to the 1 to 2 year age group.

The AIHC Sourcebook (AIHC, 1994) used data presented in the 1989 version of the Exposure Factors Handbook which reported data from the USDA 1977-78 NFCS. In this Handbook, new analyses of more recent data from USDA were conducted. Numbers, however, cannot be directly compared with previous values since the results from the new analyses are presented on a body weight basis.

12.6. REFERENCES FOR CHAPTER 12

American Industrial Health Council (AIHC) (1994) Exposure factors sourcebook. AIHC, Washington, DC.

National Gardening Association. (1987) National gardening survey: 1986-1987. Burlington, Vermont: The National Gardening Association, Inc.

USDA. (1975) Food yields summarized by different stages of preparation. Agriculture Handbook No. 102. U.S. Department of Agriculture, Agricultural Research Service, Washington, DC.

USDA. (1987-88) Dataset: Nationwide Food Consumption Survey 1987/88 Household Food Use. U.S. Department of Agriculture. Washington, D.C. 1987/88 NFCS Database.

USDA. (1992) Changes in food consumption and expenditures in American households during the 1980's. U.S. Department of Agriculture. Washington, D.C. Statistical Bulletin No. 849.

USDA. (1993) Food and nutrient intakes by individuals in the United States, 1 Day, 1987-88. Nationwide Food Consumption Survey 1987-88, NFCS Report No. 87-I-1.

USDA. (1994) Food consumption and dietary levels of households in the United States, 1987-88. U.S. Department of Agriculture, Agricultural Research Service. Report No. 87-H-1.

Chapter 12 Intake Rates for Various Home Produced Food Items

Chapter 12 Intake Rates for Various Home Produced Food Items (continued)

Table 12-1. 1986 Vegetable Gardening by Demographic Factors

Demographic Factor	Percentage of total households that have gardens (%)	Number of households (million)
Total	38	34
Region/section		
East	33	7.3
New England	37	1.9
Mid-Atlantic	32	5.4
Midwest	50	11.0
East Central	50	6.6
West Central	50	4.5
South	33	9.0
Deep South	44	3.1
Rest of South	29	5.9
West	37	6.2
Rocky Mountain	53	2.3
Pacific	32	4.2
Size of community		
City	26	6.2
Suburb	33	10.2
Small town	32	3.4
Rural	61	14.0
Household size		
Single, separated, divorced, widowed	54	8.5
Married, no children	45	11.9
Married, with children	44	13.2

Source: National Gardening Association, 1987.

Table 12-2. Percentage of Gardening Households Growing Different Vegetables in 1986

Vegetable	Percent
Artichokes	0.8
Asparagus	8.2
Beans	43.4
Beets	20.6
Broccoli	19.6
Brussel sprouts	5.7
Cabbage	29.6
Carrots	34.9
Cauliflower	14.0
Celery	5.4
Chard	3.5
Corn	34.4
Cucumbers	49.9
Dried peas	2.5
Dry beans	8.9
Eggplant	13.0
Herbs	9.8
Kale	3.1
Kohlrabi	3.0
Leeks	1.2
Lettuce	41.7
Melons	21.9
Okra	13.6
Onions	50.3
Oriental vegetables	2.1
Parsnips	2.2
Peanuts	1.9
Peas	29.0
Peppers	57.7
Potatoes	25.5
Pumpkins	10.2
Radishes	30.7
Rhubarb	12.2
Spinach	10.2
Summer squash	25.7
Sunflowers	8.2
Sweet potatoes	5.7
Tomato	85.4
Turnips	10.7
Winter squash	11.1

Source: National Gardening Association, 1987.

Table 12-3. Sub-category Codes and Definitions

Code	Definition	Description
Region[a]		
1	Northeast	Includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont
2	Midwest	Includes Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin
3	South	Includes Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia
4	West	Includes Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming
Urbanization		
1	Central City	Cities with populations of 50,000 or more that is the main city within the metropolitan statistical area (MSA).
2	Suburban	An area that is generally within the boundaries of an MSA, but is not within the legal limit of the central city.
3	Nonmetropolitan	An area that is not within an MSA.
Race		
1	--	White (Caucasian)
2	--	Black
3	--	Asian and Pacific Islander
4	--	Native American, Aleuts, and Eskimos
5, 8, 9	Other/NA	Don't know, no answer, some other race
Responses to Survey Questions		
Grow	Question 75	Did anyone in the household grow any vegetables or fruit for use in the household?
Raise Animals	Question 76	Did anyone in the household produce any animal products such as milk, eggs, meat, or poultry for home use in your household?
Fish/Hunt	Question 77	Did anyone in the household catch any fish or shoot game for home use?
Farm	Question 79	Did anyone in the household operate a farm or ranch?
Season		
Spring	-	April, May, June
Summer	-	July, August, September
Fall	-	October, November, December
Winter	-	January, February, March

[a] Alaska and Hawaii were not included.
Source: USDA 1987-88.

Table 12-4. Weighted and Unweighted Number of Observations for NFCS Data Used in Analysis of Food Intake

	All Regions		Northeast		Midwest		South		West	
	wgtd	unwgtd	wgtd	unwgtd	wgtd	unwgtd	wgtd	unwgtd	wgtd	unwgtd
Total	188019000	9852	41167000	2018	46395000	2592	64331000	3399	36066000	1841
Age										
< 01	2814000	156	545000	29	812000	44	889000	51	568000	32
01-02	5699000	321	1070000	56	1757000	101	1792000	105	1080000	59
03-05	8103000	461	1490000	92	2251000	133	2543000	140	1789000	95
06-11	16711000	937	3589000	185	4263000	263	5217000	284	3612000	204
12-19	20488000	1084	4445000	210	5490000	310	6720000	369	3833000	195
20-39	61606000	3058	12699000	600	15627000	823	21786000	1070	11494000	565
40-69	56718000	3039	13500000	670	13006000	740	19635000	1080	10577000	549
70 +	15880000	796	3829000	176	3189000	178	5749000	300	3113000	142
Season										
Fall	47667000	1577	9386000	277	14399000	496	13186000	439	10696000	365
Spring	46155000	3954	10538000	803	10657000	1026	16802000	1437	8158000	688
Summer	45485000	1423	9460000	275	10227000	338	17752000	562	7986000	246
Winter	48712000	2898	11783000	663	11112000	732	16591000	961	9226000	542
Urbanization										
Central City	56352000	2217	9668000	332	17397000	681	17245000	715	12042000	489
Nonmetropolitan	45023000	3001	5521000	369	14296000	1053	19100000	1197	6106000	382
Surburban	86584000	4632	25978000	1317	14702000	858	27986000	1487	17918000	970
Race										
Asian	2413000	114	333000	13	849000	37	654000	32	577000	32
Black	21746000	1116	3542000	132	2794000	126	13701000	772	1709000	86
Native American	1482000	91	38000	4	116000	6	162000	8	1166000	73
Other/NA	4787000	235	1084000	51	966000	37	1545000	86	1192000	61
White	157531000	8294	36170000	1818	41670000	2386	48269000	2501	31422000	1589
Response to Questionnaire										
Do you garden?	68152000	3744	12501000	667	22348000	1272	20518000	1136	12725000	667
Do you raise animals?	10097000	631	1178000	70	3742000	247	2603000	162	2574000	152
Do you hunt?	20216000	1148	3418000	194	6948000	411	6610000	366	3240000	177
Do you fish?	39733000	2194	5950000	321	12621000	725	13595000	756	7567000	392
Do you farm?	7329000	435	830000	42	2681000	173	2232000	130	1586000	90

Table 12-5. Percent Weight Losses from Preparation of Various Meats

Meat Type	Mean Net Cooking Loss (%)[a] Mean	Range of Means	Standard Deviation	Mean Net Post Cooking Loss (%)[b] Mean	Range of Means	Standard Deviation
Beef	27.24	11.00 to 42.00	7.08	24.17	10.00 to 46.00	9.34
Pork	28.06	1.00 to 67.00	9.71	35.86	14.00 to 52.00	11.41
Chicken	32.04	7.00 to 55.00	8.69	31.10	16.00 to 51.00	7.84
Turkey	31.91	11.00 to 57.00	6.97	28.45	8.00 to 48.00	10.07
Lamb	30.00	25.00 to 37.00	4.85	34.00	14.00 to 61.00	13.74
Veal	29.38	10.00 to 45.00	10.79	24.67	18.00 to 37.00	8.73
Fish[c]	29.91	-19.00 to 81.00	18.90	11.26	1.00 to 26.00	6.42
Shellfish[d]	32.83	1.00 to 94.00	29.50	10.00	10.00 to 10.00	0.00

[a] Includes dripping and volatile losses during cooking. Averaged over various cuts and preparation methods.

[b] Includes losses from cutting, shrinkage, excess fat, bones, scraps, and juices. Averaged over various cuts and preparation methods.

[c] Averaged over a variety of fish, to include: bass, bluefish, butterfish, cod, flounder, haddock, halibut, lake trout, makerel, perch, porgy, red snapper, rockfish, salmon, sea trout, shad, smelt, sole, spot, squid, swordfish steak, trout, and whitefish.

[d] Averaged over a variety of shellfish, to include: clams, crab, crayfish, lobster, oysters, and shrimp and shrimp dishes.

Source: USDA, 1975.

Table 12-6. Percent Weight Losses from Preparation of Various Fruits

Type of Fruit	Mean Net Cooking Loss (%)[a] Mean	Range of Means	Standard Deviation	Mean Net Post Cooking Loss (%)[b] Mean	Range of Means	Standard Deviation	Mean Paring or Preparation Loss (%)[c,d] Mean	Range of Means	Standard
Apples	-70.9	-478 to 15	156.00	24.6	3 to 42	12.6	22.0[c]	13 to 40[c]	NA[c]
Pears	-53.7	-113 to 19	54.7	--	--	--	22.0[c]	12 to 60[c]	NA[c]
							41.0[d]	25 to 47[d]	NA[d]
Peaches	-145.0	-418 to 5	173.4	36.1	19 to 50	11.7	24.0[c]	6 to 68[c]	NA[c]
Strawberries	--	--	--	--	--	--	10.0[c]	6 to 14[c]	NA[c]
							30.0[d]	96 to 41[d]	14.9[d]
Oranges	--	--	--	--	--	--	29.0[c]	19 to 38[c]	NA[c]

[a] Includes losses from coring, peeling, stemming, trimming, draining, thawing, pitting, and defects, and gains from the addition of water and sugar. Averaged over various preparation methods.
[b] Includes losses from draining cooked forms.
[c] Includes losses from removal of skin or peel, core or pit, stems or caps, seeds and defects.
[d] Includes losses from removal of drained liquids from canned or frozen forms.

Source: USDA, 1975

Table 12-7. Percent Weight Losses from Preparation of Various Vegetables

	Mean Net Cooking Loss (%)[a]			Mean Net Post Cooking Loss (%)[b]		
Type of Vegetable	Mean	Range of Means	Standard Deviation	Mean	Range of Means	Standard Deviation
Asparagus	22.83	5 to 47	15.70	--	--	--
Beets	27.71	4 to 60	17.08	--	--	--
Broccoli	13.83	0 to 39	13.16	--	--	--
Cabbage	11.25	4 to 20	6.22	--	--	--
Carrots	19.13	2 to 41	12.23	--	--	--
Corn	25.67	-1 to 64	21.98	--	--	--
Cucumbers	17.50	5 to 40	13.57	--	--	--
Lettuce	21.63	6 to 36	11.86	--	--	--
Lima Beans	-12.20	-143 to 56	69.12	--	--	--
Okra	11.83	-10 to 40	15.52	--	--	--
Onions	4.54	-90 to 63	38.12	--	--	--
Peas, green	2.00	-147 to 62	63.48	--	--	--
Peppers	13.40	3 to 27	9.11	--	--	--
Pumpkins	19.00	8 to 30	11.00	--	--	--
Snap Beans	18.00	5 to 42	13.07	--	--	--
Tomatoes	15.13	2 to 34	9.56	--	--	--
Potatoes	-21.83	-527 to 46	120.98	21.63	1 to 33	10.86

[a] Includes losses due to paring, trimming, flowering the stalk, thawing, draining, scraping, shelling, slicing, husking, chopping, and dicing and gains from the addition of water, fat, or other ingredients. Averaged over various preparation methods.

[b] Includes losses from draining or removal of skin.

Source: USDA, 1975

Table 12-8. Intake of Homegrown Fruits (g/kg-day) - All Regions Combined

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	14744000	817	7.84	2.68E+00	1.89E-01	6.26E-02	1.68E-01	2.78E-01	4.97E-01	1.07E+00	2.37E+00	5.97E+00	1.11E+01	2.40E+01	6.06E+01
Age Group															
01-02	360000	23	6.32	8.74E+00	3.10E+00	9.59E-01	1.09E+00	1.30E+00	1.64E+00	3.48E+00	7.98E+00	1.93E+01	6.06E+01	6.06E+01	6.06E+01
03-05	550000	34	6.79	4.07E+00	1.48E+00	1.00E-02	1.00E-02	3.62E-01	9.77E-01	1.92E+00	2.73E+00	6.02E+00	8.91E+00	4.83E+01	4.83E+01
06-11	1044000	75	6.25	3.59E+00	6.76E-01	1.00E-02	1.91E-01	4.02E-01	6.97E-01	1.31E+00	3.08E+00	1.18E+01	1.58E+01	3.22E+01	3.22E+01
12-19	1189000	67	5.80	1.94E+00	3.66E-01	8.74E-02	1.27E-01	2.67E-01	4.41E-01	6.61E-01	2.35E+00	6.76E+00	8.34E+00	1.85E+01	1.85E+01
20-39	3163000	164	5.13	1.95E+00	3.33E-01	8.14E-02	1.28E-01	2.04E-01	3.74E-01	7.03E-01	1.77E+00	4.17E+00	6.84E+00	1.61E+01	3.70E+01
40-69	5633000	309	9.93	2.66E+00	3.04E-01	6.26E-02	1.91E-01	2.86E-01	4.69E-01	1.03E+00	2.33E+00	5.81E+00	1.30E+01	2.38E+01	5.33E+01
70 +	2620000	134	16.50	2.25E+00	2.34E-01	4.41E-02	2.24E-01	3.80E-01	6.11E-01	1.18E+00	2.35E+00	5.21E+00	8.69E+00	1.17E+01	1.53E+01
Season															
Fall	3137000	108	6.58	1.57E+00	1.59E-01	2.63E-01	3.04E-01	3.90E-01	5.70E-01	1.04E+00	1.92E+00	3.48E+00	4.97E+00	1.06E+01	1.06E+01
Spring	2963000	301	6.42	1.58E+00	1.37E-01	8.89E-02	1.98E-01	2.54E-01	4.23E-01	8.57E-01	1.70E+00	4.07E+00	5.10E+00	8.12E+00	3.17E+01
Summer	4356000	145	9.58	3.86E+00	6.40E-01	1.00E-02	9.18E-02	1.56E-01	4.45E-01	1.26E+00	3.31E+00	1.09E+01	1.46E+01	5.33E+01	6.06E+01
Winter	4288000	263	8.80	3.08E+00	3.41E-01	4.41E-02	1.72E-01	2.69E-01	5.56E-01	1.15E+00	2.61E+00	8.04E+00	1.53E+01	2.49E+01	4.83E+01
Urbanization															
Central City	3668000	143	6.51	2.31E+00	2.64E-01	4.41E-02	1.82E-01	3.33E-01	5.67E-01	1.08E+00	2.46E+00	5.34E+00	1.05E+01	1.43E+01	1.93E+01
Nonmetropolitan	4118000	278	9.15	2.41E+00	3.09E-01	6.26E-02	1.27E-01	2.32E-01	4.50E-01	1.15E+00	2.42E+00	4.46E+00	8.34E+00	2.40E+01	5.33E+01
Suburban	6898000	394	7.97	3.07E+00	3.22E-01	1.25E-01	2.30E-01	2.95E-01	4.91E-01	9.93E-01	2.33E+00	7.26E+00	1.52E+01	3.70E+01	6.06E+01
Race															
Black	450000	20	2.07	1.87E+00	8.53E-01	1.32E-01	2.84E-01	4.55E-01	6.08E-01	1.13E+00	1.53E+00	2.29E+00	2.29E+00	1.93E+01	1.93E+01
White	14185000	793	9.00	2.73E+00	1.94E-01	7.22E-02	1.82E-01	2.82E-01	5.10E-01	1.07E+00	2.46E+00	6.10E+00	1.17E+01	2.40E+01	6.06E+01
Questionnaire Response															
Households who garden	12742000	709	18.70	2.79E+00	2.10E-01	5.60E-02	1.84E-01	2.87E-01	5.30E-01	1.12E+00	2.50E+00	6.10E+00	1.18E+01	2.49E+01	6.06E+01
Households who farm	1917000	112	26.16	2.58E+00	2.59E-01	7.22E-02	2.76E-01	4.13E-01	7.53E-01	1.61E+00	3.62E+00	5.97E+00	7.82E+00	1.58E+01	1.58E+01

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-9. Intake of Homegrown Fruits (g/kg-day) - Northeast

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1279000	72	3.11	9.29E-01	2.20E-01	7.91E-02	8.48E-02	1.61E-01	3.11E-01	4.85E-01	7.82E-01	1.29E+00	2.16E+00	1.17E+01	1.17E+01
Season															
Fall	260000	8	2.77	*	*	*	*	*	*	*	*	*	*	*	*
Spring	352000	31	3.34	8.80E-01	2.32E-01	8.74E-02	1.61E-01	1.68E-01	2.87E-01	4.85E-01	8.79E-01	1.83E+00	2.16E+00	7.13E+00	7.13E+00
Summer	271000	9	2.86	*	*	*	*	*	*	*	*	*	*	*	*
Winter	396000	24	3.36	7.10E-01	1.13E-01	1.84E-01	2.07E-01	2.30E-01	2.93E-01	5.42E-01	8.81E-01	1.38E+00	1.79E+00	2.75E+00	2.75E+00
Urbanization															
Central City	50000	3	0.52	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	176000	10	3.19	*	*	*	*	*	*	*	*	*	*	*	*
Suburban	1053000	59	4.05	1.05E+00	2.63E-01	1.84E-01	2.30E-01	2.93E-01	4.37E-01	5.43E-01	8.12E-01	1.29E+00	2.75E+00	1.17E+01	1.17E+01
Questionnaire Response															
Households who garden	983000	59	7.86	1.04E+00	2.64E-01	8.74E-02	1.82E-01	2.13E-01	3.75E-01	5.43E-01	8.81E-01	1.38E+00	2.75E+00	1.17E+01	1.17E+01
Households who farm	132000	4	15.90	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-10. Intake of Homegrown Fruits (g/kg-day) - Midwest

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	4683000	302	10.09	3.01E+00	4.13E-01	4.41E-02	1.25E-01	2.35E-01	4.68E-01	1.03E+00	2.31E+00	6.76E+00	1.39E+01	5.33E+01	6.06E+
Season															
Fall	1138000	43	7.90	1.54E+00	1.86E-01	2.63E-01	3.04E-01	4.74E-01	6.11E-01	1.07E+00	1.92E+00	3.48E+00	4.34E+00	5.33E+00	5.33E+
Spring	1154000	133	10.83	1.69E+00	2.76E-01	8.89E-02	2.09E-01	2.62E-01	4.23E-01	9.23E-01	1.72E+00	2.89E+00	4.47E+00	1.60E+01	3.17E+
Summer	1299000	44	12.70	7.03E+00	1.85E+00	6.26E-02	9.18E-02	1.25E-01	4.28E-01	1.55E+00	8.34E+00	1.61E+01	3.70E+01	6.06E+01	6.06E+
Winter	1092000	82	9.83	1.18E+00	1.80E-01	2.57E-02	5.60E-02	1.46E-01	3.62E-01	6.09E-01	1.42E+00	2.61E+00	3.73E+00	1.09E+01	1.09E+
Urbanization															
Central City	1058000	42	6.08	1.84E+00	3.93E-01	4.15E-02	1.01E-01	2.63E-01	5.21E-01	1.07E+00	1.90E+00	2.82E+00	9.74E+00	1.09E+01	1.09E+
Nonmetropolitan	1920000	147	13.43	2.52E+00	5.43E-01	5.60E-02	1.08E-01	1.46E-01	3.96E-01	1.03E+00	2.07E+00	4.43E+00	6.84E+00	5.33E+01	5.33E+
Suburban	1705000	113	11.60	4.29E+00	8.72E-01	9.18E-02	2.04E-01	3.10E-01	4.81E-01	7.64E-01	3.01E+00	1.39E+01	1.80E+01	6.06E+01	6.06E+
Response to Questionnaire															
Households who garden	4060000	267	18.17	3.27E+00	4.69E-01	4.41E-02	1.01E-01	2.04E-01	4.48E-01	1.07E+00	2.37E+00	7.15E+00	1.46E+01	5.33E+01	6.06E+
Households who farm	694000	57	25.89	2.59E+00	3.01E-01	5.60E-02	1.91E-01	4.08E-01	1.26E+00	1.63E+00	3.89E+00	6.76E+00	8.34E+00	1.11E+01	1.11E+

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-11. Intake of Homegrown Fruits (g/kg-day) - South

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	4148000	208	6.45	2.97E+00	3.00E-01	1.12E-01	2.42E-01	3.55E-01	5.97E-01	1.35E+00	3.01E+00	8.18E+00	1.41E+01	2.38E+01	2.40E+01
Season															
Fall	896000	29	6.80	1.99E+00	4.39E-01	3.92E-01	4.27E-01	4.46E-01	6.50E-01	1.13E+00	1.96E+00	4.97E+00	8.18E+00	1.06E+01	1.06E+01
Spring	620000	59	3.69	2.05E+00	2.55E-01	1.55E-01	2.82E-01	3.11E-01	4.50E-01	1.06E+00	4.09E+00	5.01E+00	6.58E+00	7.05E+00	7.05E+00
Summer	1328000	46	7.48	2.84E+00	6.50E-01	8.14E-02	1.56E-01	2.67E-01	4.41E-01	1.31E+00	2.83E+00	6.10E+00	1.43E+01	2.40E+01	2.40E+01
Winter	1304000	74	7.86	4.21E+00	6.51E-01	1.12E-01	2.36E-01	3.82E-01	8.92E-01	1.88E+00	3.71E+00	1.41E+01	1.97E+01	2.38E+01	2.38E+01
Urbanization															
Central City	1066000	39	6.18	3.33E+00	5.39E-01	2.36E-01	3.92E-01	4.55E-01	8.34E-01	2.55E+00	4.77E+00	8.18E+00	1.06E+01	1.43E+01	1.43E+01
Nonmetropolitan	1548000	89	8.10	2.56E+00	3.87E-01	8.14E-02	2.67E-01	3.38E-01	6.12E-01	1.40E+00	2.83E+00	5.97E+00	1.04E+01	2.40E+01	2.40E+01
Suburban	1534000	80	5.48	3.14E+00	6.02E-01	1.12E-01	1.56E-01	2.84E-01	5.08E-01	1.10E+00	2.29E+00	1.18E+01	1.55E+01	2.38E+01	2.38E+01
Response to Questionnaire															
Households who garden	3469000	174	16.91	2.82E+00	2.94E-01	1.56E-01	2.84E-01	3.84E-01	6.50E-01	1.39E+00	2.94E+00	6.10E+00	1.41E+01	2.11E+01	2.40E+01
Households who farm	296000	16	13.26	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulatins for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-12. Intake of Homegrown Fruits (g/kg-day) - West

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	4574000	233	12.68	2.62E+00	3.07E-01	1.50E-01	2.75E-01	3.33E-01	6.17E-01	1.20E+00	2.42E+00	5.39E+00	1.09E+01	2.49E+01	4.83E+01
Season															
Fall	843000	28	7.88	1.47E+00	2.49E-01	2.91E-01	2.91E-01	2.95E-01	4.83E-01	1.04E+00	2.15E+00	2.99E+00	4.65E+00	5.39E+00	5.39E+00
Spring	837000	78	10.26	1.37E+00	1.59E-01	1.73E-01	1.96E-01	2.51E-01	5.10E-01	9.81E-01	1.61E+00	2.95E+00	5.29E+00	6.68E+00	7.02E+00
Summer	1398000	44	17.51	2.47E+00	4.72E-01	1.86E-01	2.75E-01	4.04E-01	6.17E-01	1.28E+00	3.14E+00	7.26E+00	1.09E+01	1.30E+01	1.30E+01
Winter	1496000	83	16.22	4.10E+00	7.91E-01	7.14E-02	2.96E-01	3.33E-01	7.74E-01	1.51E+00	3.74E+00	1.11E+01	1.85E+01	4.83E+01	4.83E+01
Urbanization															
Central City	1494000	59	12.41	1.99E+00	4.24E-01	7.14E-02	2.35E-01	3.42E-01	5.26E-01	8.63E-01	2.04E+00	4.63E+00	9.52E+00	1.93E+01	1.93E+01
Nonmetropolitan	474000	32	7.76	2.24E+00	5.25E-01	1.84E-01	2.76E-01	4.24E-01	6.25E-01	7.68E-01	2.64E+00	4.25E+00	1.09E+01	1.09E+01	1.09E+01
Suburban	2606000	142	14.54	3.04E+00	4.63E-01	1.83E-01	2.75E-01	3.14E-01	7.10E-01	1.39E+00	3.14E+00	5.81E+00	1.03E+01	3.22E+01	4.83E+01
Response to Questionnaire															
Households who garden	4170000	207	32.77	2.76E+00	3.39E-01	1.00E-01	2.75E-01	3.14E-01	6.29E-01	1.20E+00	2.54E+00	5.81E+00	1.09E+01	2.49E+01	4.83E+01
Households who farm	795000	35	50.13	1.85E+00	2.59E-01	2.75E-01	2.76E-01	5.98E-01	7.10E-01	1.26E+00	2.50E+00	4.63E+00	5.00E+00	6.81E+00	6.81E+00

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-13. Intake of Homegrown Vegetables (g/kg-day) - All Regions Combined

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	34392000	1855	18.29	2.08E+00	6.76E-02	4.79E-03	1.10E-01	1.80E-01	4.47E-01	1.11E+00	2.47E+00	5.20E+00	7.54E+00	1.55E+01	2.70E+01
Age															
01-02	951000	53	16.69	5.20E+00	8.47E-01	2.32E-02	2.45E-01	3.82E-01	1.23E+00	3.27E+00	5.83E+00	1.31E+01	1.96E+01	2.70E+01	2.70E+01
03-05	1235000	76	15.24	2.46E+00	2.79E-01	0.00E+00	4.94E-02	3.94E-01	7.13E-01	1.25E+00	3.91E+00	6.35E+00	7.74E+00	1.06E+01	1.28E+01
06-11	3024000	171	18.10	2.02E+00	2.54E-01	5.95E-03	1.00E-01	1.60E-01	4.00E-01	8.86E-01	2.21E+00	4.64E+00	6.16E+00	1.76E+01	2.36E+01
12-19	3293000	183	16.07	1.48E+00	1.35E-01	0.00E+00	6.46E-02	1.45E-01	3.22E-01	8.09E-01	1.83E+00	3.71E+00	6.03E+00	7.71E+00	9.04E+00
20-39	8593000	437	13.95	1.47E+00	9.59E-02	1.69E-02	7.77E-02	1.57E-01	2.73E-01	7.61E-01	1.91E+00	3.44E+00	4.92E+00	1.05E+01	2.06E+01
40-69	12828000	700	22.62	2.07E+00	1.02E-01	5.13E-03	1.19E-01	2.14E-01	5.26E-01	1.18E+00	2.47E+00	5.12E+00	6.94E+00	1.49E+01	2.29E+01
70 +	4002000	211	25.20	2.51E+00	1.94E-01	5.21E-03	1.51E-01	2.39E-01	5.81E-01	1.37E+00	3.69E+00	6.35E+00	8.20E+00	1.25E+01	1.55E+01
Seasons															
Fall	11026000	394	23.13	1.88E+00	1.28E-01	4.98E-02	1.13E-01	1.80E-01	4.13E-01	9.83E-01	2.11E+00	4.88E+00	6.94E+00	1.25E+01	1.89E+01
Spring	6540000	661	14.17	1.36E+00	7.23E-02	2.44E-03	4.47E-02	1.35E-01	3.21E-01	7.04E-01	1.63E+00	3.37E+00	5.21E+00	8.35E+00	2.36E+01
Summer	11081000	375	24.36	2.86E+00	1.93E-01	6.93E-02	1.57E-01	2.24E-01	7.12E-01	1.62E+00	3.44E+00	6.99E+00	9.75E+00	1.87E+01	2.70E+01
Winter	5745000	425	11.79	1.79E+00	1.14E-01	3.73E-03	4.49E-02	1.56E-01	4.69E-01	1.05E+00	2.27E+00	3.85E+00	6.01E+00	1.06E+01	2.06E+01
Urbanizations															
Central City	6183000	228	10.97	1.40E+00	1.23E-01	1.01E-02	6.59E-02	1.50E-01	3.00E-01	7.50E-01	1.67E+00	3.83E+00	4.67E+00	9.96E+00	1.66E+01
Nonmetropolitan	13808000	878	30.67	2.68E+00	1.19E-01	2.12E-02	1.58E-01	2.58E-01	5.99E-01	1.45E+00	3.27E+00	6.35E+00	9.33E+00	1.75E+01	2.70E+01
Suburban	14341000	747	16.56	1.82E+00	9.12E-02	3.34E-03	1.10E-01	1.63E-01	3.94E-01	9.63E-01	2.18E+00	4.32E+00	6.78E+00	1.25E+01	2.06E+01
Race															
Black	1872000	111	8.61	1.78E+00	2.33E-01	0.00E+00	7.77E-02	1.39E-01	4.38E-01	9.32E-01	2.06E+00	4.68E+00	5.70E+00	8.20E+00	1.89E+01
White	31917000	1714	20.26	2.10E+00	7.09E-02	7.34E-03	1.13E-01	1.84E-01	4.54E-01	1.12E+00	2.48E+00	5.18E+00	7.68E+00	1.55E+01	2.70E+01
Response to Questionnaire															
Households who garden	30217000	1643	44.34	2.17E+00	7.09E-02	5.21E-03	1.11E-01	1.85E-01	4.84E-01	1.18E+00	2.68E+00	5.35E+00	7.72E+00	1.55E+01	2.36E+01
Households who farm	4319000	262	58.93	3.29E+00	2.51E-01	0.00E+00	1.61E-01	2.92E-01	8.46E-01	1.67E+00	3.61E+00	8.88E+00	1.18E+01	1.76E+01	2.36E+01

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-14. Intake of Homegrown Vegetables (g/kg-day) - Northeast

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	4883000	236	11.86	1.78E+00	1.68E-01	2.18E-03	8.27E-02	1.43E-01	2.80E-01	7.47E-01	1.89E+00	6.03E+00	7.82E+00	1.27E+01	1.49E+01
Seasons															
Fall	1396000	41	14.87	1.49E+00	4.06E-01	8.27E-02	1.34E-01	1.74E-01	2.69E-01	5.81E-01	1.17E+00	6.64E+00	9.97E+00	1.02E+01	1.02E+01
Spring	1204000	102	11.43	8.18E-01	1.07E-01	0.00E+00	2.89E-03	4.47E-02	1.72E-01	4.55E-01	9.52E-01	2.26E+00	3.11E+00	6.52E+00	6.78E+00
Summer	1544000	48	16.32	2.83E+00	4.67E-01	1.11E-01	1.45E-01	1.59E-01	7.38E-01	1.29E+00	3.63E+00	7.82E+00	9.75E+00	1.49E+01	1.49E+01
Winter	739000	45	6.27	1.67E+00	2.74E-01	3.23E-03	4.23E-03	9.15E-02	2.56E-01	1.25E+00	2.77E+00	3.63E+00	6.10E+00	8.44E+00	8.44E+00
Urbanizations															
Central City	380000	14	3.93	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	787000	48	14.25	3.05E+00	5.41E-01	0.00E+00	4.68E-02	1.14E-01	2.02E-01	2.18E+00	4.61E+00	9.04E+00	1.27E+01	1.49E+01	1.49E+01
Suburban	3716000	174	14.30	1.59E+00	1.74E-01	2.44E-03	8.27E-02	1.42E-01	2.75E-01	7.18E-01	1.64E+00	4.82E+00	6.80E+00	1.02E+01	1.02E+01
Response to Questionnaire															
Households who garden	4381000	211	35.05	1.92E+00	1.84E-01	2.18E-03	8.27E-02	1.42E-01	3.10E-01	8.83E-01	2.18E+00	6.16E+00	7.82E+00	1.27E+01	1.49E+01
Households who farm	352000	19	42.41	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-15. Intake of Homegrown Vegetables (g/kg-day) - Midwest

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	12160000	699	26.21	2.26E+00	1.20E-01	1.59E-02	7.77E-02	1.80E-01	4.88E-01	1.15E+00	2.58E+00	5.64E+00	7.74E+00	1.75E+01	2.36E+01
Seasons															
Fall	4914000	180	34.13	1.84E+00	1.76E-01	1.01E-02	6.51E-02	1.60E-01	4.16E-01	1.03E+00	2.10E+00	5.27E+00	6.88E+00	1.31E+01	1.31E+01
Spring	2048000	246	19.22	1.65E+00	1.49E-01	6.04E-02	1.53E-01	2.21E-01	4.59E-01	9.13E-01	1.72E+00	4.49E+00	5.83E+00	1.28E+01	2.36E+01
Summer	3319000	115	32.45	3.38E+00	3.87E-01	1.05E-01	1.62E-01	3.02E-01	8.47E-01	2.07E+00	3.94E+00	7.72E+00	1.40E+01	1.96E+01	2.29E+01
Winter	1879000	158	16.91	2.05E+00	2.64E-01	2.41E-03	2.14E-02	6.59E-02	3.62E-01	8.77E-01	2.13E+00	5.32E+00	7.83E+00	1.67E+01	2.06E+01
Urbanizations															
Central City	3177000	113	18.26	1.36E+00	1.91E-01	0.00E+00	6.05E-02	1.10E-01	2.45E-01	7.13E-01	1.67E+00	3.94E+00	5.50E+00	9.96E+00	1.66E+01
Nonmetropolitan	5344000	379	37.38	2.73E+00	1.86E-01	2.12E-02	1.13E-01	2.61E-01	5.98E-01	1.31E+00	3.15E+00	7.19E+00	1.06E+01	1.75E+01	2.36E+01
Suburban	3639000	207	24.75	2.35E+00	2.16E-01	3.26E-02	1.54E-01	2.22E-01	6.36E-01	1.39E+00	2.75E+00	4.87E+00	7.18E+00	1.96E+01	2.06E+01
Response to Questionnaire															
Households who garden	10927000	632	48.89	2.33E+00	1.27E-01	1.59E-02	1.04E-01	1.76E-01	5.03E-01	1.18E+00	2.74E+00	5.81E+00	7.75E+00	1.67E+01	2.36E+01
Households who farm	1401000	104	52.26	3.97E+00	4.31E-01	1.40E-01	3.35E-01	5.51E-01	8.67E-01	2.18E+00	5.24E+00	1.06E+01	1.44E+01	1.75E+01	2.36E+01

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-16. Intake of Homegrown Vegetables (g/kg-day) - South

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	11254000	618	17.49	2.19E+00	1.21E-01	2.92E-02	1.60E-01	2.41E-01	5.63E-01	1.24E+00	2.69E+00	4.92E+00	7.43E+00	1.70E+01	2.70E+01
Seasons															
Fall	2875000	101	21.80	2.07E+00	2.82E-01	9.59E-02	1.13E-01	1.91E-01	5.24E-01	1.14E+00	2.69E+00	4.48E+00	6.02E+00	1.55E+01	1.89E+01
Spring	2096000	214	12.47	1.55E+00	1.13E-01	1.41E-02	9.21E-02	2.61E-01	5.33E-01	9.35E-01	2.07E+00	3.58E+00	4.81E+00	8.35E+00	1.03E+01
Summer	4273000	151	24.07	2.73E+00	3.16E-01	1.10E-01	1.72E-01	2.50E-01	6.15E-01	1.54E+00	3.15E+00	5.99E+00	9.70E+00	2.36E+01	2.70E+01
Winter	2010000	152	12.12	1.88E+00	1.37E-01	3.03E-03	1.63E-01	3.53E-01	6.40E-01	1.37E+00	2.69E+00	3.79E+00	5.35E+00	7.47E+00	8.36E+00
Urbanizations															
Central City	1144000	45	6.63	1.10E+00	1.62E-01	1.10E-02	9.59E-02	1.50E-01	2.63E-01	6.15E-01	1.37E+00	2.79E+00	3.70E+00	4.21E+00	4.58E+00
Nonmetropolitan	6565000	386	34.37	2.78E+00	1.84E-01	5.08E-02	2.23E-01	3.50E-01	7.12E-01	1.66E+00	3.31E+00	5.99E+00	9.56E+00	1.89E+01	2.70E+01
Suburban	3545000	187	12.67	1.44E+00	1.13E-01	0.00E+00	1.13E-01	1.99E-01	3.96E-01	9.33E-01	1.72E+00	3.61E+00	5.26E+00	8.20E+00	8.20E+00
Response to Questionnaire															
Households who garden	9447000	522	46.04	2.27E+00	1.22E-01	3.46E-02	1.61E-01	2.62E-01	6.10E-01	1.37E+00	3.02E+00	5.18E+00	7.43E+00	1.55E+01	2.36E+01
Households who farm	1609000	91	72.09	3.34E+00	4.57E-01	0.00E+00	1.32E-01	2.33E-01	1.03E+00	1.72E+00	3.15E+00	9.56E+00	1.18E+01	2.36E+01	2.36E+01

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-17. Intake of Homegrown Vegetables (g/kg-day) - West

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	6035000	300	16.73	1.81E+00	1.38E-01	7.35E-03	9.85E-02	1.66E-01	3.79E-01	9.01E-01	2.21E+00	4.64E+00	6.21E+00	1.14E+01	1.55E+01
Seasons															
Fall	1841000	72	17.21	2.01E+00	2.93E-01	9.83E-02	1.50E-01	2.04E-01	4.81E-01	1.21E+00	2.21E+00	4.85E+00	7.72E+00	1.25E+01	1.25E+01
Spring	1192000	99	14.61	1.06E+00	1.74E-01	3.31E-03	7.35E-03	4.66E-02	1.95E-01	3.56E-01	9.08E-01	3.37E+00	5.54E+00	8.60E+00	8.60E+00
Summer	1885000	59	23.60	2.39E+00	3.71E-01	6.93E-02	1.04E-01	2.46E-01	5.45E-01	1.37E+00	3.23E+00	4.67E+00	8.36E+00	1.55E+01	1.55E+01
Winter	1117000	70	12.11	1.28E+00	1.72E-01	1.29E-02	1.52E-01	1.99E-01	4.83E-01	7.65E-01	1.43E+00	2.81E+00	5.12E+00	7.57E+00	7.98E+00
Urbanizations															
Central City	1482000	56	12.31	1.80E+00	2.76E-01	2.58E-02	7.39E-02	1.57E-01	4.81E-01	1.10E+00	2.95E+00	4.64E+00	4.85E+00	1.14E+01	1.14E+01
Nonmetropolitan	1112000	65	18.21	1.52E+00	2.24E-01	3.42E-03	9.80E-03	2.04E-01	2.69E-01	6.75E-01	2.13E+00	4.13E+00	5.12E+00	8.16E+00	8.16E+00
Suburban	3441000	179	19.20	1.90E+00	1.98E-01	1.29E-02	1.04E-01	1.52E-01	3.94E-01	9.32E-01	2.20E+00	4.63E+00	7.98E+00	1.25E+01	1.55E+01
Response to Questionnaire															
Households who garden	5402000	276	42.45	1.91E+00	1.04E-03	8.53E-03	1.04E-01	1.66E-01	4.33E-01	1.07E+00	2.37E+00	4.67E+00	6.21E+00	1.25E+01	1.55E+01
Households who farm	957000	48	60.34	2.73E+00	3.32E-03	1.17E-01	4.14E-01	4.69E-01	7.65E-01	1.42E+00	3.27E+00	6.94E+00	1.09E+01	1.55E+01	1.55E+01

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-18. Intake of Home Produced Meats (g/kg-day) - All Regions Combined

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	9257000	569	4.92	2.21E+00	1.07E-01	1.21E-01	2.37E-01	3.74E-01	6.60E-01	1.39E+00	2.89E+00	4.89E+00	6.78E+00	1.40E+01	2.32E+01
Age															
01-02	276000	22	4.84	3.65E+00	6.10E-01	3.85E-01	9.49E-01	9.49E-01	1.19E+00	2.66E+00	4.72E+00	8.68E+00	1.00E+01	1.15E+01	1.15E+01
03-05	396000	26	4.89	3.61E+00	5.09E-01	8.01E-01	8.01E-01	1.51E+00	2.17E+00	2.82E+00	3.72E+00	7.84E+00	9.13E+00	1.30E+01	1.30E+01
06-11	1064000	65	6.37	3.65E+00	4.51E-01	3.72E-01	6.52E-01	7.21E-01	1.28E+00	2.09E+00	4.71E+00	8.00E+00	1.40E+01	1.53E+01	1.53E+01
12-19	1272000	78	6.21	1.70E+00	1.68E-01	1.90E-01	3.20E-01	4.70E-01	6.23E-01	1.23E+00	2.35E+00	3.66E+00	4.34E+00	6.78E+00	7.51E+00
20-39	2732000	158	4.43	1.82E+00	1.53E-01	1.23E-01	1.85E-01	2.95E-01	5.28E-01	1.11E+00	2.65E+00	4.52E+00	6.23E+00	9.17E+00	1.09E+01
40-69	2872000	179	5.06	1.72E+00	1.11E-01	1.81E-02	2.12E-01	3.43E-01	5.84E-01	1.17E+00	2.38E+00	3.67E+00	5.16E+00	5.90E+00	7.46E+00
70 +	441000	28	2.78	1.39E+00	2.34E-01	9.26E-02	9.26E-02	1.25E-01	5.47E-01	1.01E+00	1.81E+00	2.82E+00	3.48E+00	7.41E+00	7.41E+00
Seasons															
Fall	2852000	107	5.98	1.57E+00	1.39E-01	1.23E-01	2.10E-01	3.52E-01	5.21E-01	1.11E+00	2.27E+00	3.19E+00	4.41E+00	6.78E+00	7.84E+00
Spring	1726000	197	3.74	2.37E+00	1.52E-01	2.44E-01	3.20E-01	4.46E-01	7.76E-01	1.69E+00	3.48E+00	5.00E+00	6.67E+00	1.01E+01	1.30E+01
Summer	2368000	89	5.21	3.10E+00	3.82E-01	1.81E-02	1.85E-01	4.06E-01	8.52E-01	1.77E+00	4.34E+00	7.01E+00	1.05E+01	2.23E+01	2.23E+01
Winter	2311000	176	4.74	1.98E+00	1.74E-01	1.35E-01	2.37E-01	3.67E-01	6.48E-01	1.33E+00	2.43E+00	3.96E+00	6.40E+00	1.09E+01	2.32E+01
Urbanizations															
Central City	736000	28	1.31	1.15E+00	1.83E-01	1.82E-01	1.85E-01	2.10E-01	4.42E-01	7.21E-01	1.58E+00	2.69E+00	3.40E+00	3.64E+00	3.64E+00
Nonmetropolitan	4932000	315	10.95	2.70E+00	1.76E-01	1.23E-01	2.63E-01	4.06E-01	7.49E-01	1.63E+00	3.41E+00	6.06E+00	8.47E+00	1.53E+01	2.32E+01
Suburban	3589000	226	4.15	1.77E+00	1.03E-01	2.90E-02	2.87E-01	3.67E-01	6.80E-01	1.33E+00	2.49E+00	3.66E+00	4.71E+00	7.20E+00	1.01E+01
Race															
Black	128000	6	0.59	*		*	*	*	*	*	*	*	*	*	*
White	8995000	556	5.71	2.26E+00	1.09E-01	9.26E-02	2.57E-01	3.86E-01	6.80E-01	1.41E+00	2.91E+00	5.00E+00	7.01E+00	1.40E+01	2.32E+01
Response to Questionnaire															
Households who raise animals	5256000	343	52.06	2.80E+00	1.45E-01	2.12E-01	3.86E-01	6.23E-01	1.03E+00	1.94E+00	3.49E+00	5.90E+00	7.84E+00	1.40E+01	2.32E+01
Households who farm	3842000	243	52.42	2.86E+00	1.85E-01	1.97E-01	4.45E-01	5.98E-01	8.94E-01	1.84E+00	3.64E+00	6.09E+00	8.00E+00	1.40E+01	2.32E+01

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-19. Intake of Home Produced Meats (g/kg-day) - Northeast

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1113000	52	2.70	1.46E+00	2.10E-01	2.92E-01	3.40E-01	3.52E-01	6.44E-01	8.94E-01	1.87E+00	2.68E+00	2.89E+00	1.09E+01	1.09E+01
Seasons															
Fall	569000	18	6.06	*	*	*	*	*	*	*	*	*	*	*	*
Spring	66000	8	0.63	*	*	*	*	*	*	*	*	*	*	*	*
Summer	176000	6	1.86	*	*	*	*	*	*	*	*	*	*	*	*
Winter	302000	20	2.56	2.02E+00	5.56E-01	2.92E-01	3.14E-01	4.30E-01	6.19E-01	1.11E+00	2.38E+00	2.93E+00	7.46E+00	1.09E+01	1.09E+01
Urbanizations															
Central City	0	0	0.00												
Nonmetropolitan	391000	17	7.08	*	*	*	*	*	*	*	*	*	*	*	*
Suburban	722000	35	2.78	1.49E+00	1.53E-01	2.92E-01	3.52E-01	4.30E-01	6.80E-01	1.39E+00	2.34E+00	2.68E+00	2.89E+00	3.61E+00	3.61E+00
Response to Questionnaire															
Households who raise animals	509000	25	43.21	2.03E+00	3.85E-01	6.19E-01	6.46E-01	6.46E-01	8.78E-01	1.62E+00	2.38E+00	2.93E+00	7.46E+00	1.09E+01	1.09E+01
Households who farm	373000	15	44.94	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations
NOTE: SE = standard error
P = percentile of the distribution
Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-20. Intake of Home Produced Meats (g/kg-day) - Midwest

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	3974000	266	8.57	2.55E+00	1.81E-01	1.25E-01	2.57E-01	3.85E-01	6.60E-01	1.40E+00	3.39E+00	5.75E+00	7.20E+00	1.53E+01	2.23E+01
Seasons															
Fall	1261000	49	8.76	1.76E+00	2.31E-01	2.10E-01	2.57E-01	3.72E-01	4.95E-01	1.19E+00	2.66E+00	3.49E+00	6.06E+00	6.78E+00	6.78E+00
Spring	940000	116	8.82	2.58E+00	2.24E-01	2.44E-01	3.11E-01	4.08E-01	7.33E-01	1.98E+00	3.67E+00	5.14E+00	7.79E+00	1.15E+01	1.30E+01
Summer	930000	38	9.09	4.10E+00	7.45E-01	9.26E-02	1.25E-01	5.78E-01	8.93E-01	2.87E+00	5.42E+00	8.93E+00	1.53E+01	2.23E+01	2.23E+01
Winter	843000	63	7.59	2.00E+00	2.41E-01	1.21E-01	2.37E-01	3.28E-01	6.48E-01	1.36E+00	2.69E+00	4.11E+00	5.30E+00	8.10E+00	1.22E+01
Urbanizations															
Central City	460000	18	2.64	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	2477000	175	17.33	3.15E+00	2.58E-01	9.26E-02	2.95E-01	4.25E-01	8.16E-01	2.38E+00	4.34E+00	6.15E+00	9.17E+00	1.53E+01	2.23E+01
Suburban	1037000	73	7.05	1.75E+00	1.99E-01	2.87E-01	3.65E-01	4.08E-01	6.60E-01	1.11E+00	2.03E+00	4.16E+00	5.39E+00	7.20E+00	1.01E+01
Response to Questionnaire															
Households who raise animals	2165000	165	57.86	3.20E+00	2.23E-01	2.56E-01	3.86E-01	5.78E-01	1.07E+00	2.56E+00	4.42E+00	6.06E+00	9.13E+00	1.53E+01	1.53E+01
Households who farm	1483000	108	55.32	3.32E+00	2.91E-01	3.65E-01	5.43E-01	5.89E-01	1.07E+00	2.75E+00	4.71E+00	6.78E+00	9.17E+00	1.53E+01	1.53E+01

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-21. Intake of Home Produced Meats (g/kg-day) - South

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	2355000	146	3.66	2.24E+00	1.94E-01	1.81E-02	1.56E-01	2.97E-01	7.21E-01	1.53E+00	3.07E+00	5.07E+00	6.71E+00	1.40E+01	1.40E+01
Seasons															
Fall	758000	28	5.75	1.81E+00	2.87E-01	1.23E-01	1.56E-01	1.90E-01	8.19E-01	1.53E+00	2.38E+00	3.19E+00	4.41E+00	7.84E+00	7.84E+00
Spring	511000	53	3.04	2.33E+00	2.66E-01	1.93E-01	2.97E-01	4.99E-01	7.52E-01	1.80E+00	2.82E+00	5.16E+00	6.71E+00	7.51E+00	7.51E+00
Summer	522000	18	2.94	*	*	*	*	*	*	*	*	*	*	*	*
Winter	564000	47	3.40	1.80E+00	2.45E-01	3.70E-02	1.97E-01	2.51E-01	7.16E-01	1.40E+00	2.17E+00	3.55E+00	4.58E+00	8.47E+00	8.47E+00
Urbanizations															
Central City	40000	1	0.23	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	1687000	97	8.83	2.45E+00	2.59E-01	1.23E-01	1.90E-01	4.02E-01	7.77E-01	1.61E+00	3.19E+00	6.09E+00	7.84E+00	1.40E+01	1.40E+01
Suburban	628000	48	2.24	1.79E+00	2.30E-01	1.81E-02	2.90E-02	3.70E-02	6.28E-01	1.40E+00	2.31E+00	4.56E+00	4.61E+00	6.40E+00	6.40E+00
Response to Questionnaire															
Households who raise animals	1222000	74	46.95	3.16E+00	3.16E-01	2.63E-01	6.67E-01	8.35E-01	1.34E+00	2.11E+00	3.79E+00	6.67E+00	8.47E+00	1.40E+01	1.40E+01
Households who farm	1228000	72	55.02	2.85E+00	3.24E-01	1.95E-01	4.99E-01	5.98E-01	1.01E+00	1.93E+00	3.48E+00	6.23E+00	8.47E+00	1.40E+01	1.40E+01

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-22. Intake of Home Produced Meats (g/kg-day) - West

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1815000	105	5.03	1.89E+00	2.12E-01	1.52E-01	2.25E-01	3.90E-01	6.58E-01	1.42E+00	2.49E+00	3.66E+00	4.71E+00	8.00E+00	2.32E+01
Seasons															
Fall	264000	12	2.47	*	*	*	*	*	*	*	*	*	*	*	*
Spring	209000	20	2.56	1.86E+00	2.27E-01	2.99E-01	4.25E-01	8.70E-01	1.22E+00	1.56E+00	2.43E+00	3.48E+00	4.20E+00	4.20E+00	4.20E+00
Summer	740000	27	9.27	2.20E+00	3.18E-01	1.85E-01	4.06E-01	5.35E-01	1.07E+00	1.69E+00	3.27E+00	4.44E+00	4.71E+00	8.00E+00	8.00E+00
Winter	602000	46	6.53	2.11E+00	4.55E-01	1.35E-01	3.56E-01	4.28E-01	6.72E-01	1.19E+00	2.35E+00	3.64E+00	7.02E+00	2.32E+01	2.32E+01
Urbanizations															
Central City	236000	9	1.96	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	377000	26	6.17	2.10E+00	7.00E-01	3.30E-01	3.30E-01	4.06E-01	6.72E-01	1.19E+00	1.77E+00	3.72E+00	4.97E+00	2.32E+01	2.32E+01
Suburban	1202000	70	6.71	1.95E+00	1.99E-01	1.52E-01	2.25E-01	3.67E-01	7.80E-01	1.52E+00	2.71E+00	4.20E+00	4.71E+00	8.00E+00	8.00E+00
Response to Questionnaire															
Households who raise animals	1360000	79	52.84	2.12E+00	2.65E-01	1.52E-01	2.25E-01	3.90E-01	8.15E-01	1.56E+00	2.71E+00	4.20E+00	4.97E+00	8.00E+00	2.32E+01
Households who farm	758000	48	47.79	2.41E+00	4.26E-01	1.35E-01	3.30E-01	4.67E-01	7.85E-01	1.55E+00	2.91E+00	4.71E+00	7.02E+00	2.32E+01	2.32E+01

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-23. Intake of Home Caught fish (g/kg-day) - All Regions Combined

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	3914000	239	2.08	2.07E+00	2.38E-01	8.16E-02	9.11E-02	1.95E-01	2.28E-01	4.31E-01	9.97E-01	2.17E+00	4.68E+00	7.83E+00	1.55E+
Age															
01-02	82000	6	1.44	*	*	*	*	*	*	*	*	*	*	*	*
03-05	142000	11	1.75	*	*	*	*	*	*	*	*	*	*	*	*
06-11	382000	29	2.29	2.78E+00	8.40E-01	1.60E-01	1.60E-01	1.84E-01	2.28E-01	5.47E-01	1.03E+00	3.67E+00	7.05E+00	7.85E+00	2.53E+
12-19	346000	21	1.69	1.52E+00	4.07E-01	1.95E-01	1.95E-01	1.95E-01	1.95E-01	3.11E-01	9.84E-01	1.79E+00	4.68E+00	6.67E+00	8.44E+
20-39	962000	59	1.56	1.91E+00	3.34E-01	8.16E-02	8.16E-02	9.11E-02	1.18E-01	4.43E-01	1.06E+00	2.18E+00	4.46E+00	9.57E+00	1.30E+
40-69	1524000	86	2.69	1.79E+00	2.56E-01	9.47E-02	9.47E-02	2.10E-01	2.75E-01	3.45E-01	9.85E-01	1.99E+00	4.43E+00	6.56E+00	1.08E+
70 +	450000	24	2.83	1.22E+00	2.30E-01	9.88E-02	9.88E-02	2.33E-01	2.33E-01	5.68E-01	7.64E-01	1.56E+00	3.73E+00	3.73E+00	5.12E+
Season															
Fall	1220000	45	2.56	1.31E+00	2.16E-01	1.84E-01	1.84E-01	1.96E-01	2.10E-01	3.18E-01	9.16E-01	1.79E+00	2.64E+00	3.73E+00	6.56E+
Spring	1112000	114	2.41	3.08E+00	5.55E-01	9.88E-02	1.16E-01	3.08E-01	3.40E-01	5.59E-01	1.27E+00	2.64E+00	6.68E+00	1.08E+01	3.73E+
Summer	911000	29	2.00	1.88E+00	4.24E-01	8.16E-02	8.16E-02	9.11E-02	2.04E-01	3.01E-01	7.64E-01	3.19E+00	4.43E+00	5.65E+00	9.57E+
Winter	671000	51	1.38	2.05E+00	3.68E-01	9.47E-02	9.47E-02	1.11E-01	1.60E-01	5.10E-01	1.06E+00	2.09E+00	5.89E+00	7.85E+00	1.31E+
Urbanization															
Central City	999000	46	1.77	1.79E+00	3.40E-01	9.47E-02	9.47E-02	1.60E-01	2.84E-01	6.08E-01	1.07E+00	1.85E+00	3.73E+00	9.57E+00	9.57E+
Nonmetropolitan	1174000	94	2.61	3.15E+00	5.74E-01	9.88E-02	1.16E-01	3.10E-01	3.62E-01	5.68E-01	1.88E+00	3.86E+00	6.52E+00	7.83E+00	3.73E+
Suburban	1741000	99	2.01	1.50E+00	2.30E-01	8.16E-02	8.16E-02	1.84E-01	2.01E-01	2.86E-01	5.87E-01	1.38E+00	4.37E+00	7.05E+00	1.08E+
Race															
Black	593000	41	2.73	1.81E+00	3.74E-01	1.84E-01	1.84E-01	2.01E-01	2.86E-01	3.18E-01	9.84E-01	2.17E+00	4.68E+00	9.57E+00	9.57E+
White	3228000	188	2.05	2.07E+00	2.81E-01	8.16E-02	8.16E-02	1.60E-01	2.27E-01	3.93E-01	9.97E-01	2.16E+00	4.99E+00	6.68E+00	1.61E+
Response to Questionnaire															
Households who fish	3553000	220	8.94	2.22E+00	2.58E-01	8.16E-02	8.16E-02	1.84E-01	2.27E-01	4.66E-01	1.09E+00	2.23E+00	5.61E+00	7.85E+00	1.61E+

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-24. Intake of Home Caught Fish (g/kg-day) - Northeast

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	334000	12	0.81	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	135000	4	1.44	*	*	*	*	*	*	*	*	*	*	*	*
Spring	14000	2	0.13	*	*	*	*	*	*	*	*	*	*	*	*
Summer	132000	3	1.40	*	*	*	*	*	*	*	*	*	*	*	*
Winter	53000	3	0.45	*	*	*	*	*	*	*	*	*	*	*	*
Urbanization															
Central City		0													
Nonmetropolitan	42000	4	0.76	*	*	*	*	*	*	*	*	*	*	*	*
Suburban	292000	8	1.12	*	*	*	*	*	*	*	*	*	*	*	*
Response to Questionnaire															
Households who fish	334000	12	5.61	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-25. Intake of Home Caught Fish (g/kg-day) - Midwest

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1113000	71	2.40	2.13E+00	4.19E-01	8.16E-02	8.16E-02	1.96E-01	2.27E-01	4.71E-01	1.03E+00	1.95E+00	6.10E+00	6.56E+00	1.61E+01
Season															
Fall	362000	13	2.51	*	*	*	*	*	*	*	*	*	*	*	*
Spring	224000	27	2.10	3.45E+00	1.22E+00	1.16E-01	1.16E-01	1.18E-01	3.10E-01	4.87E-01	8.21E-01	1.67E+00	1.55E+01	1.61E+01	2.53E+01
Summer	264000	8	2.58	*	*	*	*	*	*	*	*	*	*	*	*
Winter	263000	23	2.37	2.38E+00	5.33E-01	5.10E-01	5.10E-01	5.10E-01	5.48E-01	1.03E+00	1.56E+00	2.13E+00	5.89E+00	6.10E+00	1.31E+01
Urbanization															
Central City	190000	9	1.09	*		*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	501000	40	3.50	3.42E+00	7.17E-01	1.16E-01	1.16E-01	3.30E-01	4.66E-01	5.33E-01	1.88E+00	5.65E+00	6.56E+00	1.31E+01	2.53E+01
Suburban	422000	22	2.87	9.09E-01	1.81E-01	8.16E-02	8.16E-02	8.16E-02	1.96E-01	3.01E-01	5.48E-01	1.28E+00	2.09E+00	2.78E+00	3.73E+00
Response to Questionnaire															
Households who fish	956000	60	7.57	2.35E+00	4.85E-01	8.16E-02	8.16E-02	1.18E-01	2.27E-01	4.66E-01	1.12E+00	2.16E+00	6.52E+00	6.56E+00	2.53E+01

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-26. Intake of Home Caught Fish (g/kg-day) - South

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1440000	101	2.24	2.74E+00	4.76E-01	9.47E-02	9.47E-02	2.04E-01	2.86E-01	5.07E-01	1.48E+00	3.37E+00	5.61E+00	8.44E+00	3.73E+01
Season															
Fall	274000	11	2.08	*	*	*	*	*	*	*	*	*	*	*	*
Spring	538000	58	3.20	4.00E+00	9.42E-01	3.08E-01	3.08E-01	3.87E-01	4.46E-01	8.74E-01	1.94E+00	3.71E+00	8.33E+00	1.30E+01	4.52E+01
Summer	376000	14	2.12	*	*	*	*	*	*	*	*	*	*	*	*
Winter	252000	18	1.52	*	*	*	*	*	*	*	*	*	*	*	*
Urbanization															
Central City	281000	16	1.63	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	550000	41	2.88	3.33E+00	1.06E+00	2.85E-01	2.85E-01	3.38E-01	5.07E-01	1.12E+00	1.94E+00	3.19E+00	4.43E+00	6.67E+00	4.52E+01
Suburban	609000	44	2.18	2.73E+00	4.98E-01	2.04E-01	2.04E-01	2.75E-01	2.86E-01	4.26E-01	1.08E+00	4.37E+00	8.33E+00	1.04E+01	1.30E+01
Response to Questionnaire															
Households who fish	1280000	95	9.42	3.00E+00	5.14E-01	9.47E-02	9.47E-02	2.04E-01	2.80E-01	7.06E-01	1.93E+00	3.67E+00	6.68E+00	8.44E+00	3.73E+01

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standrad error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-27. Intake of Home Caught Fish (g/kg-day) - West

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1027000	55	2.85	1.57E+00	2.72E-01	9.88E-02	1.60E-01	2.01E-01	2.38E-01	4.43E-01	8.38E-01	1.79E+00	3.73E+00	5.67E+00	9.57E+00
Season															
Fall	449000	17	4.20	*	*	*	*	*	*	*	*	*	*	*	*
Spring	336000	27	4.12	1.35E+00	2.94E-01	9.88E-02	9.88E-02	2.38E-01	3.27E-01	4.43E-01	6.08E-01	1.68E+00	4.68E+00	5.61E+00	5.67E+00
Summer	139000	4	1.74	*	*	*	*	*	*	*	*	*	*	*	*
Winter	103000	7	1.12	*	*	*	*	*	*	*	*	*	*	*	*
Urbanization															
Central City	528000	21	4.38	2.03E+00	5.25E-01	3.27E-01	3.27E-01	4.33E-01	5.29E-01	7.12E-01	1.45E+00	1.85E+00	3.73E+00	9.57E+00	9.57E+00
Nonmetropolitan	81000	9	1.33	*	*	*	*	*	*	*	*	*	*	*	*
Suburban	418000	25	2.33	1.09E+00	2.49E-01	1.84E-01	1.84E-01	2.01E-01	2.10E-01	3.08E-01	5.87E-01	1.21E+00	2.90E+00	4.68E+00	5.61E+00
Response to Questionnaire														*	
Households who fish	983000	53	12.99	1.63E+00	2.81E-01	9.88E-02	1.60E-01	2.01E-01	2.18E-01	5.47E-01	9.64E-01	1.79E+00	3.73E+00	5.67E+00	9.57E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-28. Intake of Home Produced Dairy (g/kg-day) - All Regions

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1409000	89	0.75	1.40E+01	1.62E+00	1.80E-01	4.46E-01	5.08E-01	3.18E+00	1.02E+01	1.95E+01	3.42E+01	4.40E+01	7.26E+01	1.11E+02
Age															
01-02	79000	6	1.39	*	*	*	*	*	*	*	*	*	*	*	*
03-05	57000	5	0.70	*	*	*	*	*	*	*	*	*	*	*	*
06-11	264000	16	1.58	*	*	*	*	*	*	*	*	*	*	*	*
12-19	84000	5	0.41	*	*	*	*	*	*	*	*	*	*	*	*
20-39	612000	36	0.99	7.41E+00	1.02E+00	2.05E-01	3.96E-01	4.46E-01	1.89E+00	6.46E+00	1.21E+01	1.54E+01	1.95E+01	2.30E+01	2.30E+01
40-69	216000	16	0.38	*	*	*	*	*	*	*	*	*	*	*	*
70 +	77000	3	0.48	*	*	*	*	*	*	*	*	*	*	*	*
Seasons															
Fall	211000	7	0.44	*	*	*	*	*	*	*	*	*	*	*	*
Spring	253000	27	0.55	1.78E+01	4.27E+00	6.28E-01	6.54E-01	6.72E-01	5.06E+00	1.22E+01	1.95E+01	5.09E+01	8.01E+01	1.11E+02	1.11E+02
Summer	549000	22	1.21	1.53E+01	2.73E+00	4.46E-01	4.46E-01	5.08E-01	5.36E+00	1.06E+01	2.51E+01	3.49E+01	3.67E+01	4.68E+01	4.68E+01
Winter	396000	33	0.81	8.08E+00	1.99E+00	1.80E-01	2.05E-01	2.80E-01	7.36E-01	5.47E+00	1.15E+01	1.98E+01	2.04E+01	7.26E+01	7.26E+01
Urbanizations															
Central City	115000	7	0.20	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	988000	59	2.19	1.68E+01	2.10E+00	4.79E-01	9.58E-01	1.89E+00	6.74E+00	1.08E+01	2.04E+01	3.49E+01	4.40E+01	8.01E+01	1.11E+02
Suburban	306000	23	0.35	9.86E+00	2.38E+00	3.96E-01	3.96E-01	4.46E-01	5.71E-01	5.36E+00	1.31E+01	2.81E+01	2.89E+01	5.09E+01	5.09E+01
Race															
Black	0	0	0.00												
White	1382000	86	0.88	1.43E+01	1.65E+00	1.80E-01	4.46E-01	5.08E-01	3.82E+00	1.03E+01	1.95E+01	3.42E+01	4.40E+01	8.01E+01	1.11E+02
Response to Questionnaire															
Households who raise animals	1228000	80	12.16	1.59E+01	1.73E+00	1.80E-01	3.96E-01	1.89E+00	6.13E+00	1.08E+01	1.96E+01	3.49E+01	4.40E+01	8.01E+01	1.11E+02
Households who farm	1020000	63	13.92	1.71E+01	1.99E+00	3.96E-01	7.36E-01	3.18E+00	9.06E+00	1.21E+01	2.04E+01	3.49E+01	4.40E+01	8.01E+01	1.11E+02

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-29. Intake of Home Produced Dairy (g/kg-day) - Northeast

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	312000	16	0.76	*	*	*	*	*	*	*	*	*	*	*	*
Seasons															
Fall	48000	2	0.51	*	*	*	*	*	*	*	*	*	*	*	*
Spring	36000	4	0.34	*	*	*	*	*	*	*	*	*	*	*	*
Summer	116000	4	1.23	*	*	*	*	*	*	*	*	*	*	*	*
Winter	112000	6	0.95	*	*	*	*	*	*	*	*	*	*	*	*
Urbanizations															
Central City	0	0	0.00												
Nonmetropolitan	240000	10	4.35	*	*	*	*	*	*	*	*	*	*	*	*
Suburban	72000	6	0.28	*	*	*	*	*	*	*	*	*	*	*	*
Response to Questionnaire															
Households who raise animals	312000	16	26.49	*	*	*	*	*	*	*	*	*	*	*	*
Households who farm	312000	16	37.59	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-30. Intake of Home Produced Dairy (g/kg-day) - Midwest

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	594000	36	1.28	1.86E+01	3.15E+00	4.46E-01	4.46E-01	1.97E+00	8.27E+00	1.24E+01	2.30E+01	4.40E+01	4.68E+01	1.11E+02	1.11E+02
Seasons															
Fall	163000	5	1.13	*	*	*	*	*	*	*	*	*	*	*	*
Spring	94000	12	0.88	*	*	*	*	*	*	*	*	*	*	*	*
Summer	252000	11	2.46	*	*	*	*	*	*	*	*	*	*	*	*
Winter	85000	8	0.76	*	*	*	*	*	*	*	*	*	*	*	*
Urbanizations															
Central City	43000	1	0.25	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	463000	31	3.24	2.33E+01	3.40E+00	4.25E+00	8.27E+00	9.06E+00	1.21E+01	1.60E+01	3.14E+01	4.40E+01	4.68E+01	1.11E+02	1.11E+02
Suburban	88000	4	0.60	*	*	*	*	*	*	*	*	*	*	*	*
Response to Questionnaire															
Households who raise animals	490000	32	13.09	2.23E+01	3.33E+00	4.25E+00	5.36E+00	8.27E+00	1.08E+01	1.54E+01	3.14E+01	4.40E+01	4.68E+01	1.11E+02	1.11E+02
Households who farm	490000	32	18.28	2.23E+01	3.33E+00	4.25E+00	5.36E+00	8.27E+00	1.08E+01	1.54E+01	3.14E+01	4.40E+01	4.68E+01	1.11E+02	1.11E+02

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-31. Intake of Home Produced Dairy (g/kg-day) - South

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	242000	17	0.38	*	*	*	*	*	*	*	*	*	*	*	*
Seasons															
Fall	0	0	0.00												
Spring	27000	3	0.16	*	*	*	*	*	*	*	*	*	*	*	*
Summer	131000	5	0.74	*	*	*	*	*	*	*	*	*	*	*	*
Winter	84000	9	0.51	*	*	*	*	*	*	*	*	*	*	*	*
Urbanizations															
Central City	27000	3	0.16	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	215000	14	1.13	*	*	*	*	*	*	*	*	*	*	*	*
Suburban	0	0	0.00												
Response to Questionnaire															
Households who raise animals	215000	14	8.26	*	*	*	*	*	*	*	*	*	*	*	*
Households who farm	148000	8	6.63	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-32. Intake of Home Produced Dairy (g/kg-day) - West

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	261000	20	0.72	1.00E+01	2.75E+00	1.80E-01	1.80E-01	2.05E-01	5.08E-01	6.10E+00	1.33E+01	2.81E+01	2.89E+01	5.09E+01	5.09E+01
Seasons															
Fall	0	0	0.00												
Spring	96000	8	1.18	*	*	*	*	*	*	*	*	*	*	*	*
Summer	50000	2	0.63	*	*	*	*	*	*	*	*	*	*	*	*
Winter	115000	10	1.25	*	*	*	*	*	*	*	*	*	*	*	*
Urbanizations															
Central City	45000	3	0.37	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	70000	4	1.15	*	*	*	*	*	*	*	*	*	*	*	*
Suburban	146000	13	0.81	*	*	*	*	*	*	*	*	*	*	*	*
Response to Questionnaire															
Households who raise animals	211000	18	8.20	*	*	*	*	*	*	*	*	*	*	*	*
Households who farm	70000	7	4.41	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-33. Seasonally Adjusted Homegrown Intake (g/kg-day)											
Population Group	Percent Consuming	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total Vegetables											
Northeast	16.50	1.16E-03	1.59E-02	3.56E-02	1.99E-01	4.55E-01	1.37E+00	3.32E+00	5.70E+00	8.78E+00	1.01E+01
Midwest	33.25	3.69E-03	4.11E-02	8.26E-02	2.91E-01	8.11E-01	1.96E+00	4.40E+00	7.41E+00	1.31E+00	2.01E+01
South	24.00	4.78E-03	3.24E-02	5.58E-02	2.05E-01	6.10E-01	1.86E+00	3.95E+00	5.63E+00	1.20E+01	1.62E+01
West	23.75	1.80E-03	1.91E-02	3.83E-02	1.14E-01	4.92E-01	1.46E+00	2.99E+00	5.04E+00	8.91E+00	1.12E+01
All Regions	24.60	5.00E-03	2.90E-02	5.90E-02	2.19E-01	6.38E-01	1.80E+00	4.00E+00	6.08E+00	1.17E+01	2.01E+01
Total Fruit											
Northeast	3.50	3.96E-03	1.97E-02	4.76E-02	1.73E-01	3.61E-01	6.55E-01	1.48E+00	3.00E+00	5.10E+00	5.63E+00
Midwest	12.75	1.22E-03	7.01E-03	1.46E-02	1.36E-01	7.87E-01	2.98E+00	5.79E+00	9.52E+00	2.22E+01	2.71E+01
South	8.00	6.13E-03	3.23E-02	1.09E-01	3.84E-01	9.47E-01	2.10E+00	6.70+00	1.02E+01	1.49E+01	1.64E+01
West	17.75	5.50E-04	5.66E-02	8.82E-02	2.87E-01	6.88E-01	1.81E+00	4.75E+00	8.54E+00	1.45E+01	1.84E+01
All Regions	10.10	2.00E-03	1.90E-02	6.20E-02	2.50E-01	7.52E-01	2.35E+00	5.61E+00	9.12E+00	1.76E+01	2.71E+01
Total Meat											
Northeast	6.25	3.78E-03	3.01E-02	7.94E-02	1.25E-01	2.11E-01	7.00E-01	1.56E+00	1.91E+00	4.09E+00	4.80E+00
Midwest	9.25	1.77E-03	3.68E-02	2.21E-01	5.25E-02	1.61E+00	3.41E+00	5.25E+00	7.45E+00	1.19E+01	1.36E+01
South	5.75	6.12E-03	2.88E-02	5.02E-02	1.86E-01	5.30E-01	1.84E+00	3.78E+00	4.95E+00	8.45E+00	9.45E+00
West	9.50	7.24E-04	2.83E-02	9.56E-02	2.35E-01	5.64E-01	1.30E+00	2.29E+00	3.38E+00	7.20E+00	9.10E+00
All Regions	7.40	3.20E-03	3.90E-02	9.20E-02	2.20E-01	6.55E-01	1.96E+00	4.05E+00	5.17E+00	9.40E+00	1.36E+01

Table 12-34. Intake of Homegrown Apples (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	5306000	272	2.82	1.19E+00	7.58E-02	8.34E-02	2.30E-01	2.84E-01	4.50E-01	8.17E-01	1.47E+00	2.38E+00	3.40E+00	5.42E+00	1.01E+01
Age															
01-02	199000	12	3.49	*	*	*	*	*	*	*	*	*	*	*	*
03-05	291000	16	3.59	*	*	*	*	*	*	*	*	*	*	*	*
06-11	402000	25	2.41	1.28E+00	1.88E-01	4.72E-01	4.72E-01	5.63E-01	7.40E-01	9.56E-01	1.29E+00	2.98E+00	4.00E+00	4.00E+00	4.00E+00
12-19	296000	12	1.44	*	*	*	*	*	*	*	*	*	*	*	*
20-39	1268000	61	2.06	7.95E-01	1.07E-01	1.85E-01	2.30E-01	2.56E-01	3.04E-01	6.02E-01	9.22E-01	1.55E+00	1.97E+00	5.42E+00	5.42E+00
40-69	1719000	90	3.03	9.61E-01	1.37E-01	5.57E-02	8.94E-02	2.55E-01	3.98E-01	6.48E-01	1.08E+00	1.59E+00	2.38E+00	9.83E+00	9.83E+00
70 +	1061000	52	6.68	1.45E+00	1.41E-01	1.99E-01	2.60E-01	4.46E-01	6.27E-01	1.18E+00	1.82E+00	3.40E+00	3.62E+00	4.20E+00	4.20E+00
Season															
Fall	1707000	60	3.58	1.28E+00	1.24E-01	2.56E-01	2.95E-01	3.20E-01	5.83E-01	1.03E+00	1.66E+00	2.69E+00	3.40E+00	4.25E+00	4.25E+00
Spring	639000	74	1.38	9.50E-01	1.14E-01	1.94E-01	2.38E-01	2.84E-01	3.76E-01	5.67E-01	1.10E+00	2.00E+00	2.78E+00	5.87E+00	5.87E+00
Summer	1935000	68	4.25	1.12E+00	1.69E-01	5.57E-02	8.94E-02	1.86E-01	3.98E-01	6.92E-01	1.41E+00	2.29E+00	2.98E+00	9.83E+00	9.83E+00
Winter	1025000	70	2.10	1.30E+00	1.78E-01	1.85E-01	2.30E-01	3.23E-01	5.71E-01	8.81E-01	1.59E+00	2.75E+00	3.40E+00	1.01E+01	1.01E+01
Urbanization															
Central City	912000	30	1.62	1.24E+00	2.60E-01	2.31E-01	2.56E-01	3.92E-01	5.10E-01	9.17E-01	1.59E+00	2.19E+00	2.26E+00	1.01E+01	1.01E+01
Nonmetropolitan	2118000	122	4.70	1.27E+00	1.26E-01	5.57E-02	1.18E-01	2.49E-01	4.11E-01	9.00E-01	1.55E+00	2.92E+00	3.48E+00	9.83E+00	9.83E+00
Suburban	2276000	120	2.63	1.09E+00	9.16E-02	1.86E-01	2.37E-01	2.91E-01	4.37E-01	7.74E-01	1.29E+00	2.29E+00	3.40E+00	5.42E+00	5.42E+00
Race															
Black	84000	4	0.39	*	*	*	*	*	*	*	*	*	*	*	*
White	5222000	268	3.31	1.18E+00	7.67E-02	8.34E-02	2.30E-01	2.79E-01	4.48E-01	7.98E-01	1.41E+00	2.38E+00	3.40E+00	5.42E+00	1.01E+01
Region															
Midwest	2044000	123	4.41	1.38E+00	1.45E-01	2.16E-01	2.85E-01	3.04E-01	5.20E-01	9.23E-01	1.61E+00	2.69E+00	3.40E+00	9.83E+00	1.01E+01
Northeast	442000	18	1.07	*	*	*	*	*	*	*	*	*	*	*	*
South	1310000	65	2.04	1.10E+00	1.07E-01	1.99E-01	2.38E-01	3.01E-01	4.39E-01	9.17E-01	1.38E+00	1.90E+00	2.98E+00	4.00E+00	4.91E+00
West	1510000	66	4.19	1.20E+00	1.29E-01	5.57E-02	1.86E-01	2.64E-01	4.72E-01	7.89E-01	1.82E+00	2.75E+00	3.62E+00	4.25E+00	4.25E+00
Response to Questionnaire															
Households who garden	4707000	246	6.91	1.21E+00	8.22E-02	1.27E-01	2.49E-01	2.95E-01	4.70E-01	8.17E-01	1.47E+00	2.38E+00	3.40E+00	5.87E+00	1.01E+01
Households who farm	1299000	68	17.72	1.39E+00	1.31E-01	5.57E-02	3.57E-01	5.36E-01	7.03E-01	9.56E-01	1.58E+00	2.99E+00	4.00E+00	4.91E+00	5.87E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distibution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-35. Intake of Homegrown Asparagus (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	763000	66	0.41	5.59E-01	5.12E-02	1.00E-01	1.41E-01	1.91E-01	2.75E-01	4.00E-01	7.07E-01	1.12E+00	1.63E+00	1.97E+00	1.97E+00
Age															
01-02	8000	1	0.14	*	*	*	*	*	*	*	*	*	*	*	*
03-05	25000	3	0.31	*	*	*	*	*	*	*	*	*	*	*	*
06-11	31000	3	0.19	*	*	*	*	*	*	*	*	*	*	*	*
12-19	70000	5	0.34	*	*	*	*	*	*	*	*	*	*	*	*
20-39	144000	11	0.23	*	*	*	*	*	*	*	*	*	*	*	*
40-69	430000	38	0.76	4.65E-01	5.38E-02	1.10E-01	1.13E-01	1.81E-01	2.34E-01	4.00E-01	5.96E-01	8.84E-01	1.24E+00	1.75E+00	1.75E+00
70 +	55000	5	0.35	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	62000	2	0.13	*	*	*	*	*	*	*	*	*	*	*	*
Spring	608000	59	1.32	6.12E-01	5.75E-02	1.00E-01	1.57E-01	1.91E-01	2.98E-01	4.46E-01	8.84E-01	1.18E+00	1.63E+00	1.97E+00	1.97E+00
Summer	0	0	0.00												
Winter	93000	5	0.19	*	*	*	*	*	*	*	*	*	*	*	*
Urbanization															
Central City	190000	9	0.34	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	215000	27	0.48	7.59E-01	1.19E-01	1.00E-01	1.13E-01	1.41E-01	2.30E-01	5.43E-01	1.24E+00	1.75E+00	1.92E+00	1.97E+00	1.97E+00
Suburban	358000	30	0.41	4.27E-01	4.05E-02	1.10E-01	1.69E-01	1.81E-01	2.75E-01	3.65E-01	5.79E-01	7.01E-01	9.31E-01	1.12E+00	1.12E+00
Race															
Black	0	0	0.00												
White	763000	66	0.48	5.59E-01	5.12E-02	1.00E-01	1.41E-01	1.91E-01	2.75E-01	4.00E-01	7.07E-01	1.12E+00	1.63E+00	1.97E+00	1.97E+00
Region															
Midwest	368000	33	0.79	4.78E-01	6.49E-02	1.00E-01	1.10E-01	1.41E-01	2.28E-01	4.00E-01	6.14E-01	9.31E-01	1.12E+00	1.97E+00	1.97E+00
Northeast	270000	20	0.66	7.17E-01	9.99E-02	1.81E-01	2.34E-01	2.34E-01	3.65E-01	5.96E-01	9.29E-01	1.24E+00	1.63E+00	1.92E+00	1.92E+00
South	95000	9	0.15	*	*	*	*	*	*	*	*	*	*	*	*
West	30000	4	0.08	*	*	*	*	*	*	*	*	*	*	*	*
Response to Questionnaire															
Households who garden	669000	59	0.98	5.33E-01	5.50E-02	1.00E-01	1.41E-01	1.81E-01	2.75E-01	4.00E-01	6.99E-01	1.12E+00	1.63E+00	1.97E+00	1.97E+00
Households who farm	157000	16	2.14	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-36. Intake of Home Produced Beef (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	4958000	304	2.64	2.45E+00	1.49E-01	1.83E-01	3.74E-01	4.65E-01	8.78E-01	1.61E+00	3.07E+00	5.29E+00	7.24E+00	1.33E+01	1.94E+01
Age															
01-02	110000	8	1.93	*	*	*	*	*	*	*	*	*	*	*	*
03-05	234000	13	2.89	*	*	*	*	*	*	*	*	*	*	*	*
06-11	695000	38	4.16	3.77E+00	5.94E-01	3.54E-01	6.63E-01	7.53E-01	1.32E+00	2.11E+00	4.43E+00	1.14E+01	1.25E+01	1.33E+01	1.33E+01
12-19	656000	41	3.20	1.72E+00	1.63E-01	3.78E-01	4.78E-01	5.13E-01	8.96E-01	1.51E+00	2.44E+00	3.53E+00	3.57E+00	4.28E+00	4.28E+00
20-39	1495000	83	2.43	2.06E+00	2.00E-01	2.69E-01	3.52E-01	3.94E-01	6.80E-01	1.59E+00	2.73E+00	4.88E+00	6.50E+00	8.26E+00	8.26E+00
40-69	1490000	105	2.63	1.84E+00	1.41E-01	1.83E-01	3.61E-01	4.55E-01	8.33E-01	1.52E+00	2.38E+00	4.10E+00	5.39E+00	5.90E+00	5.90E+00
70 +	188000	11	1.18	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	1404000	55	2.95	1.55E+00	1.74E-01	1.83E-01	3.52E-01	3.61E-01	5.17E-01	1.33E+00	2.01E+00	2.86E+00	3.90E+00	7.24E+00	7.24E+00
Spring	911000	108	1.97	2.32E+00	1.63E-01	2.70E-01	3.90E-01	5.10E-01	1.04E+00	1.96E+00	3.29E+00	4.22E+00	5.23E+00	8.62E+00	9.28E+00
Summer	1755000	69	3.86	3.48E+00	4.12E-01	1.02E-01	6.08E-01	7.45E-01	1.02E+00	2.44E+00	4.43E+00	7.51E+00	1.14E+01	1.87E+01	1.87E+01
Winter	888000	72	1.82	1.95E+00	2.75E-01	3.93E-02	3.75E-01	3.94E-01	6.74E-01	1.33E+00	2.14E+00	4.23E+00	5.39E+00	1.94E+01	1.94E+01
Urbanization															
Central City	100000	5	0.18	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	3070000	194	6.82	2.80E+00	2.18E-01	1.83E-01	3.77E-01	4.99E-01	8.64E-01	1.81E+00	3.57E+00	6.03E+00	8.44E+00	1.87E+01	1.94E+01
Suburban	1788000	105	2.07	1.93E+00	1.50E-01	2.67E-01	3.75E-01	4.16E-01	9.07E-01	1.52E+00	2.44E+00	4.06E+00	5.10E+00	7.51E+00	9.28E+00
Race															
Black	0	0	0.00												
White	4950000	303	3.14	2.45E+00	1.50E-01	1.83E-01	3.74E-01	4.65E-01	8.78E-01	1.61E+00	3.07E+00	5.29E+00	7.24E+00	1.33E+01	1.94E+01
Region															
Midwest	2261000	161	4.87	2.83E+00	2.31E-01	1.83E-01	3.54E-01	4.16E-01	8.47E-01	2.01E+00	3.66E+00	5.90E+00	8.39E+00	1.87E+01	1.87E+01
Northeast	586000	25	1.42	1.44E+00	2.13E-01	3.52E-01	3.52E-01	4.73E-01	7.42E-01	1.06E+00	1.68E+00	2.62E+00	2.62E+00	6.03E+00	6.03E+00
South	1042000	61	1.62	2.45E+00	3.46E-01	1.02E-01	3.90E-01	5.84E-01	8.16E-01	1.59E+00	2.41E+00	6.36E+00	7.24E+00	1.33E+01	1.33E+01
West	1069000	57	2.96	2.20E+00	2.83E-01	3.13E-01	3.80E-01	5.56E-01	1.04E+00	1.60E+00	2.86E+00	4.06E+00	4.42E+00	7.51E+00	1.94E+01
Response to Questionnaire															
Households who raise animals	3699000	239	36.63	2.66E+00	1.60E-01	1.83E-01	3.88E-01	6.63E-01	1.04E+00	1.83E+00	3.48E+00	5.39E+00	7.51E+00	1.25E+01	1.94E+01
Households who farm	2850000	182	38.89	2.63E+00	1.96E-01	2.70E-01	3.94E-01	5.85E-01	8.96E-01	1.64E+00	3.25E+00	5.39E+00	7.51E+00	1.13E+01	1.94E+01

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-37. Intake of Homegrown Beets (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	2214000	125	1.18	5.12E-01	4.96E-02	3.21E-02	7.37E-02	1.09E-01	1.88E-01	3.97E-01	5.87E-01	1.03E+00	1.36E+00	3.69E+00	4.08E+00
Age															
01-02	27000	2	0.47	*	*	*	*	*	*	*	*	*	*	*	*
03-05	51000	4	0.63	*	*	*	*	*	*	*	*	*	*	*	*
06-11	167000	10	1.00	*	*	*	*	*	*	*	*	*	*	*	*
12-19	227000	13	1.11	*	*	*	*	*	*	*	*	*	*	*	*
20-39	383000	22	0.62	3.81E-01	6.26E-02	7.57E-02	7.57E-02	1.22E-01	1.43E-01	2.85E-01	5.56E-01	9.99E-01	9.99E-01	1.12E+00	1.12E+00
40-69	951000	51	1.68	4.28E-01	4.34E-02	5.00E-02	7.31E-02	7.46E-02	2.05E-01	3.97E-01	5.49E-01	9.25E-01	1.15E+00	1.40E+00	1.40E+00
70 +	408000	23	2.57	5.80E-01	8.80E-02	3.21E-02	3.21E-02	4.76E-02	2.71E-01	4.49E-01	9.09E-01	1.36E+00	1.36E+00	1.59E+00	1.59E+00
Season															
Fall	562000	21	1.18	5.45E-01	9.36E-02	3.21E-02	4.76E-02	5.00E-02	2.57E-01	3.56E-01	9.49E-01	1.36E+00	1.36E+00	1.40E+00	1.40E+00
Spring	558000	55	1.21	4.70E-01	8.98E-02	7.46E-02	8.06E-02	1.09E-01	1.43E-01	2.73E-01	4.47E-01	8.73E-01	1.59E+00	4.08E+00	4.08E+00
Summer	676000	22	1.49	3.85E-01	4.54E-02	7.57E-02	1.20E-01	1.22E-01	1.84E-01	3.97E-01	5.49E-01	6.24E-01	9.09E-01	9.09E-01	9.09E-01
Winter	418000	27	0.86	7.30E-01	1.54E-01	7.31E-02	7.31E-02	7.37E-02	2.80E-01	5.20E-01	8.28E-01	1.13E+00	2.32E+00	3.69E+00	3.69E+00
Urbanization															
Central City	651000	27	1.16	5.18E-01	1.15E-01	1.11E-01	1.35E-01	1.83E-01	2.57E-01	4.01E-01	5.49E-01	9.09E-01	1.12E+00	3.69E+00	3.69E+00
Nonmetropolitan	758000	51	1.68	5.77E-01	9.06E-02	5.00E-02	7.31E-02	7.37E-02	1.80E-01	3.86E-01	6.61E-01	1.36E+00	1.40E+00	4.08E+00	4.08E+00
Suburban	805000	47	0.93	4.45E-01	5.77E-02	3.21E-02	4.76E-02	8.06E-02	1.43E-01	3.97E-01	5.56E-01	9.25E-01	9.99E-01	2.32E+00	2.32E+00
Race															
Black	0	0	0.00												
White	2186000	124	1.39	5.18E-01	4.99E-02	3.21E-02	7.46E-02	1.13E-01	2.05E-01	3.97E-01	5.87E-01	1.03E+00	1.36E+00	3.69E+00	4.08E+00
Region															
Midwest	885000	53	1.91	6.30E-01	7.93E-02	5.00E-02	1.13E-01	1.83E-01	3.15E-01	4.54E-01	9.09E-01	1.15E+00	1.36E+00	3.69E+00	3.69E+00
Northeast	230000	13	0.56	*	*	*	*	*	*	*	*	*	*	*	*
South	545000	31	0.85	4.51E-01	1.17E-01	7.46E-02	7.57E-02	8.06E-02	1.80E-01	2.64E-01	4.84E-01	6.61E-01	9.44E-01	4.08E+00	4.08E+00
West	554000	28	1.54	3.96E-01	7.75E-02	3.21E-02	4.76E-02	7.31E-02	1.21E-01	2.86E-01	5.49E-01	6.24E-01	7.04E-01	2.32E+00	2.32E+00
Response to Questionnaire															
Households who garden	2107000	120	3.09	5.26E-01	5.16E-02	3.21E-02	7.37E-02	9.56E-02	2.05E-01	4.01E-01	6.06E-01	1.03E+00	1.36E+00	3.69E+00	4.08E+00
Households who farm	229000	11	3.12	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-38. Intake of Homegrown Broccoli (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1745000	80	0.93	4.20E-01	4.75E-02	7.61E-02	8.24E-02	1.56E-01	1.96E-01	2.90E-01	4.59E-01	8.15E-01	9.74E-01	2.48E+00	3.02E+00
Age															
01-02	0	0	0.00												
03-05	13000	1	0.16	*	*	*	*	*	*	*	*	*	*	*	*
06-11	187000	9	1.12	*	*	*	*	*	*	*	*	*	*	*	*
12-19	102000	4	0.50	*	*	*	*	*	*	*	*	*	*	*	*
20-39	486000	19	0.79	*	*	*	*	*	*	*	*	*	*	*	*
40-69	761000	37	1.34	4.12E-01	6.50E-02	8.24E-02	1.06E-01	1.64E-01	2.22E-01	3.51E-01	4.61E-01	6.14E-01	8.15E-01	3.02E+00	3.02E+00
70 +	196000	10	1.23	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	624000	20	1.31	2.87E-01	3.70E-02	7.99E-02	7.99E-02	8.24E-02	1.75E-01	2.31E-01	3.79E-01	4.52E-01	5.29E-01	8.15E-01	8.15E-01
Spring	258000	27	0.56	5.43E-01	1.18E-01	4.50E-02	1.54E-01	1.70E-01	2.65E-01	3.31E-01	5.89E-01	1.25E+00	2.37E+00	3.02E+00	3.02E+00
Summer	682000	22	1.50	5.08E-01	1.05E-01	7.61E-02	1.29E-01	1.78E-01	2.15E-01	3.99E-01	6.61E-01	8.86E-01	9.74E-01	2.48E+00	2.48E+00
Winter	181000	11	0.37	*	*	*	*	*	*	*	*	*	*	*	*
Urbanization															
Central City	165000	5	0.29	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	647000	34	1.44	4.23E-01	4.21E-02	4.50E-02	1.29E-01	1.70E-01	2.23E-01	3.69E-01	5.89E-01	7.47E-01	8.86E-01	9.74E-01	9.74E-01
Suburban	933000	41	1.08	4.29E-01	8.26E-02	7.99E-02	8.24E-02	1.44E-01	2.13E-01	2.44E-01	4.41E-01	6.84E-01	2.37E+00	2.48E+00	3.02E+00
Race															
Black	0	0	0.00												
White	1719000	79	1.09	4.22E-01	4.81E-02	7.61E-02	8.24E-02	1.56E-01	1.96E-01	2.88E-01	4.59E-01	8.15E-01	9.74E-01	2.48E+00	3.02E+00
Region															
Midwest	792000	38	1.71	2.63E-01	5.86E-02	7.61E-02	7.99E-02	8.24E-02	1.75E-01	2.13E-01	2.75E-01	3.44E-01	4.03E-01	3.02E+00	3.02E+00
Northeast	427000	19	1.04	*	*	*	*	*	*	*	*	*	*	*	*
South	373000	16	0.58	*	*	*	*	*	*	*	*	*	*	*	*
West	153000	7	0.42	*	*	*	*	*	*	*	*	*	*	*	*
Response to Questionnaire															
Households who garden	1729000	78	2.54	4.22E-01	4.83E-02	7.61E-02	8.24E-02	1.64E-01	1.96E-01	2.90E-01	4.59E-01	8.15E-01	9.74E-01	2.48E+00	3.02E+00
Households who farm	599000	29	8.17	4.66E-01	8.37E-02	4.50E-02	7.61E-02	1.54E-01	1.95E-01	3.10E-01	6.61E-01	8.86E-01	9.74E-01	3.02E+00	3.02E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distibution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-39. Intake of Homegrown Cabbage (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	2019000	89	1.07	1.03E+00	1.00E-01	1.07E-01	2.03E-01	3.17E-01	4.21E-01	7.76E-01	1.33E+00	1.97E+00	2.35E+00	5.43E+00	5.43E+00
Age															
01-02	14000	2	0.25	*	*	*	*	*	*	*	*	*	*	*	*
03-05	29000	1	0.36	*	*	*	*	*	*	*	*	*	*	*	*
06-11	61000	3	0.37	*	*	*	*	*	*	*	*	*	*	*	*
12-19	203000	9	0.99	*	*	*	*	*	*	*	*	*	*	*	*
20-39	391000	16	0.63	*	*	*	*	*	*	*	*	*	*	*	*
40-69	966000	44	1.70	1.14E+00	1.80E-01	2.17E-01	2.22E-01	3.25E-01	4.08E-01	7.13E-01	1.41E+00	1.82E+00	5.29E+00	5.43E+00	5.43E+00
70 +	326000	13	2.05	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	570000	21	1.20	1.28E+00	3.24E-01	1.86E-01	1.86E-01	2.03E-01	3.85E-01	5.42E-01	1.49E+00	5.29E+00	5.43E+00	5.43E+00	5.43E+00
Spring	126000	15	0.27	*	*	*	*	*	*	*	*	*	*	*	*
Summer	1142000	39	2.51	9.65E-01	9.35E-02	2.01E-01	2.22E-01	3.25E-01	5.55E-01	8.28E-01	1.24E+00	1.79E+00	2.35E+00	2.77E+00	2.77E+00
Winter	181000	14	0.37	*	*	*	*	*	*	*	*	*	*	*	*
Urbanization															
Central City	157000	5	0.28	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	1079000	48	2.40	9.37E-01	8.83E-02	2.01E-01	3.17E-01	3.40E-01	4.54E-01	7.13E-01	1.33E+00	1.79E+00	2.35E+00	2.77E+00	2.77E+00
Suburban	783000	36	0.90	1.26E+00	2.11E-01	3.20E-02	2.22E-01	3.25E-01	4.49E-01	1.05E+00	1.37E+00	2.17E+00	5.29E+00	5.43E+00	5.43E+00
Race															
Black	7000	1	0.03	*	*	*	*	*	*	*	*	*	*	*	*
White	1867000	83	1.19	1.05E+00	1.07E-01	1.07E-01	2.03E-01	2.46E-01	4.13E-01	7.88E-01	1.37E+00	1.97E+00	2.35E+00	5.43E+00	5.43E+00
Region															
Midwest	884000	37	1.91	7.42E-01	7.35E-02	1.07E-01	1.86E-01	2.22E-01	3.55E-01	5.95E-01	1.10E+00	1.29E+00	1.49E+00	1.82E+00	1.98E+00
Northeast	277000	11	0.67	*	*	*	*	*	*	*	*	*	*	*	*
South	616000	32	0.96	1.11E+00	1.34E-01	3.20E-02	2.01E-01	2.17E-01	4.49E-01	8.50E-01	1.79E+00	2.17E+00	2.35E+00	2.77E+00	2.77E+00
West	242000	9	0.67	*	*	*	*	*	*	*	*	*	*	*	*
Response to Questionnaire															
Households who garden	1921000	86	2.82	1.07E+00	1.03E-01	1.07E-01	2.03E-01	3.17E-01	4.54E-01	7.88E-01	1.37E+00	1.97E+00	2.35E+00	5.43E+00	5.43E+00
Households who farm	546000	26	7.45	9.96E-01	1.15E-01	2.01E-01	2.06E-01	3.51E-01	5.87E-01	8.28E-01	1.37E+00	1.79E+00	2.35E+00	2.35E+00	2.35E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-40. Intake of Homegrown Carrots (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	4322000	193	2.30	4.38E-01	4.29E-02	4.12E-02	6.35E-02	9.23E-02	1.79E-01	3.28E-01	5.25E-01	7.95E-01	1.08E+00	2.21E+00	7.79E+00
Age															
01-02	51000	4	0.89	*	*	*	*	*	*	*	*	*	*	*	*
03-05	53000	3	0.65	*	*	*	*	*	*	*	*	*	*	*	*
06-11	299000	14	1.79	*	*	*	*	*	*	*	*	*	*	*	*
12-19	389000	17	1.90	*	*	*	*	*	*	*	*	*	*	*	*
20-39	1043000	46	1.69	2.83E-01	3.46E-02	4.47E-02	5.02E-02	8.00E-02	1.20E-01	1.99E-01	4.09E-01	5.64E-01	7.56E-01	1.19E+00	1.19E+00
40-69	1848000	82	3.26	4.25E-01	3.42E-02	3.90E-02	6.74E-02	1.23E-01	2.15E-01	3.67E-01	5.50E-01	7.76E-01	1.01E+00	1.53E+00	2.21E+00
70 +	574000	24	3.61	4.44E-01	5.50E-02	7.39E-02	1.79E-01	1.96E-01	2.60E-01	3.70E-01	5.39E-01	9.64E-01	1.08E+00	1.08E+00	1.08E+00
Season															
Fall	1810000	66	3.80	4.61E-01	9.77E-02	9.09E-02	1.10E-01	1.20E-01	1.99E-01	3.08E-01	5.09E-01	7.76E-01	1.08E+00	1.71E+00	7.79E+00
Spring	267000	28	0.58	5.55E-01	1.01E-01	1.39E-01	1.49E-01	2.02E-01	2.16E-01	3.92E-01	6.09E-01	9.94E-01	2.11E+00	2.94E+00	2.94E+00
Summer	1544000	49	3.39	3.88E-01	3.95E-02	4.12E-02	5.02E-02	6.74E-02	1.64E-01	3.76E-01	5.13E-01	8.40E-01	9.64E-01	1.19E+00	1.19E+00
Winter	701000	50	1.44	4.44E-01	7.44E-02	3.90E-02	4.34E-02	6.35E-02	1.56E-01	2.25E-01	6.40E-01	1.05E+00	1.53E+00	3.06E+00	3.06E+00
Urbanization															
Central City	963000	29	1.71	2.82E-01	3.86E-02	3.90E-02	6.35E-02	8.00E-02	1.63E-01	2.09E-01	3.85E-01	5.25E-01	5.88E-01	9.64E-01	9.64E-01
Nonmetropolitan	1675000	94	3.72	5.18E-01	8.98E-02	4.12E-02	5.36E-02	6.81E-02	2.00E-01	3.28E-01	5.13E-01	9.55E-01	1.19E+00	7.79E+00	7.79E+00
Suburban	1684000	70	1.94	4.48E-01	4.02E-02	6.74E-02	9.09E-02	1.16E-01	2.02E-01	3.77E-01	6.35E-01	7.95E-01	1.09E+00	1.71E+00	1.71E+00
Race															
Black	107000	7	0.49	*	*	*	*	*	*	*	*	*	*	*	*
White	3970000	178	2.52	4.13E-01	2.58E-02	4.34E-02	7.96E-02	1.11E-01	1.94E-01	3.33E-01	5.27E-01	7.76E-01	1.01E+00	1.59E+00	3.06E+00
Region															
Midwest	2001000	97	4.31	4.57E-01	3.99E-02	3.90E-02	8.00E-02	1.37E-01	2.00E-01	3.73E-01	5.39E-01	9.55E-01	1.10E+00	2.11E+00	3.06E+00
Northeast	735000	29	1.79	4.05E-01	8.79E-02	4.12E-02	5.36E-02	6.15E-02	9.34E-02	1.49E-01	6.35E-01	1.09E+00	1.71E+00	2.21E+00	2.21E+00
South	378000	20	0.59	6.27E-01	3.60E-01	4.47E-02	4.47E-02	5.02E-02	1.49E-01	2.72E-01	4.09E-01	5.02E-01	9.94E-01	7.79E+00	7.79E+00
West	1208000	47	3.35	3.68E-01	3.24E-02	6.74E-02	9.11E-02	1.43E-01	1.90E-01	3.33E-01	4.59E-01	7.56E-01	8.40E-01	9.64E-01	9.64E-01
Response to Questionnaire															
Households who garden	4054000	182	5.95	4.04E-01	2.67E-02	4.12E-02	6.81E-02	9.34E-02	1.79E-01	3.28E-01	5.09E-01	7.62E-01	1.08E+00	1.71E+00	3.06E+00
Households who farm	833000	40	11.37	3.60E-01	5.95E-02	9.09E-02	9.34E-02	1.10E-01	1.79E-01	2.28E-01	4.59E-01	6.19E-01	1.19E+00	2.11E+00	2.94E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA' analyses of the 1987/88 NFCS

Table 12-41. Intake of Homegrown Corn (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	6891000	421	3.67	8.92E-01	6.48E-02	5.15E-02	1.22E-01	1.65E-01	2.44E-01	4.80E-01	9.07E-01	1.88E+00	3.37E+00	7.44E+00	9.23E+00
Age															
01-02	205000	13	3.60	*	*	*	*	*	*	*	*	*	*	*	*
03-05	313000	24	3.86	1.25E+00	2.57E-01	3.25E-01	3.25E-01	4.00E-01	5.98E-01	1.00E+00	1.21E+00	1.67E+00	5.35E+00	5.35E+00	5.35E+00
06-11	689000	43	4.12	9.32E-01	1.66E-01	1.10E-01	1.19E-01	1.89E-01	2.52E-01	5.13E-01	1.08E+00	3.13E+00	3.37E+00	4.52E+00	4.52E+00
12-19	530000	32	2.59	5.92E-01	9.56E-02	9.87E-02	1.05E-01	1.35E-01	2.12E-01	3.43E-01	7.11E-01	1.55E+00	1.88E+00	1.88E+00	1.88E+00
20-39	1913000	108	3.11	5.97E-01	6.00E-02	6.59E-02	1.41E-01	1.52E-01	2.08E-01	3.71E-01	7.08E-01	1.53E+00	2.04E+00	3.70E+00	3.70E+00
40-69	2265000	142	3.99	8.64E-01	1.05E-01	1.13E-01	1.52E-01	1.66E-01	2.55E-01	5.16E-01	8.83E-01	1.42E+00	3.22E+00	7.44E+00	7.44E+00
70 +	871000	53	5.48	9.43E-01	2.59E-01	3.91E-02	5.15E-02	1.05E-01	1.88E-01	3.64E-01	7.57E-01	1.34E+00	6.49E+00	9.23E+00	9.23E+00
Season															
Fall	2458000	89	5.16	5.44E-01	8.37E-02	3.91E-02	1.05E-01	1.42E-01	1.88E-01	3.17E-01	5.46E-01	1.27E+00	1.42E+00	5.35E+00	5.69E+00
Spring	1380000	160	2.99	6.35E-01	5.57E-02	1.42E-01	1.68E-01	1.93E-01	2.64E-01	4.48E-01	7.68E-01	1.21E+00	1.57E+00	5.15E+00	6.68E+00
Summer	1777000	62	3.91	1.82E+00	2.62E-01	6.59E-02	1.78E-01	3.43E-01	6.44E-01	9.36E-01	2.13E+00	4.52E+00	6.84E+00	9.23E+00	9.23E+00
Winter	1276000	110	2.62	5.45E-01	4.67E-02	1.14E-01	1.20E-01	1.49E-01	2.22E-01	4.05E-01	6.14E-01	1.16E+00	1.47E+00	2.04E+00	3.94E+00
Urbanization															
Central City	748000	27	1.33	7.37E-01	1.41E-01	3.91E-02	3.91E-02	5.15E-02	1.77E-01	5.46E-01	9.29E-01	2.04E+00	2.23E+00	3.04E+00	3.04E+00
Nonmetropolitan	4122000	268	9.16	9.63E-01	8.18E-02	7.40E-02	1.22E-01	1.66E-01	2.49E-01	5.31E-01	1.00E+00	2.13E+00	3.38E+00	7.44E+00	8.97E+00
Suburban	2021000	126	2.33	8.04E-01	1.30E-01	1.05E-01	1.53E-01	1.66E-01	2.39E-01	3.96E-01	6.47E-01	1.34E+00	1.71E+00	9.23E+00	9.23E+00
Race															
Black	188000	9	0.86	*	*	*	*	*	*	*	*	*	*	*	*
White	6703000	412	4.26	8.87E-01	6.51E-02	5.15E-02	1.22E-01	1.63E-01	2.37E-01	4.80E-01	8.84E-01	1.88E+00	3.22E+00	7.44E+00	9.23E+00
Region															
Midwest	2557000	188	5.51	9.34E-01	9.74E-02	3.91E-02	1.19E-01	1.68E-01	2.47E-01	4.56E-01	9.29E-01	2.28E+00	3.22E+00	6.84E+00	7.44E+00
Northeast	586000	33	1.42	6.14E-01	8.42E-02	9.87E-02	1.66E-01	1.86E-01	2.44E-01	3.81E-01	8.83E-01	1.34E+00	1.71E+00	1.71E+00	1.71E+00
South	2745000	153	4.27	8.73E-01	9.52E-02	7.40E-02	1.22E-01	1.66E-01	2.83E-01	5.61E-01	9.35E-01	1.55E+00	3.37E+00	5.69E+00	8.97E+00
West	1003000	47	2.78	9.99E-01	2.77E-01	1.05E-01	1.47E-01	1.52E-01	1.77E-01	3.96E-01	7.45E-01	2.23E+00	6.49E+00	9.23E+00	9.23E+00
Response to Questionnaire															
Households who garden	6233000	387	9.15	8.75E-01	6.30E-02	5.15E-02	1.35E-01	1.65E-01	2.44E-01	5.02E-01	9.14E-01	1.82E+00	3.13E+00	6.84E+00	9.23E+00
Households who farm	1739000	114	23.73	1.20E+00	1.77E-01	3.91E-02	1.08E-01	1.66E-01	2.29E-01	3.81E-01	9.74E-01	3.37E+00	6.49E+00	9.23E+00	9.23E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distributions

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-42. Intake of Homegrown Cucumber (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	3994000	141	2.12	1.02E+00	1.55E-01	3.08E-02	6.71E-02	1.08E-01	2.40E-01	5.40E-01	1.13E+00	2.11E+00	2.79E+00	1.34E+01	1.37E+01
Age															
01-02	132000	5	2.32	*	*	*	*	*	*	*	*	*	*	*	*
03-05	107000	4	1.32	*	*	*	*	*	*	*	*	*	*	*	*
06-11	356000	12	2.13	*	*	*	*	*	*	*	*	*	*	*	*
12-19	254000	10	1.24	*	*	*	*	*	*	*	*	*	*	*	*
20-39	864000	29	1.40	5.04E-01	9.27E-02	3.08E-02	5.45E-02	6.31E-02	1.83E-01	3.09E-01	6.17E-01	1.35E+00	1.49E+00	2.12E+00	2.12E+00
40-69	1882000	68	3.32	1.33E+00	3.01E-01	4.16E-02	7.46E-02	1.76E-01	3.93E-01	6.84E-01	1.29E+00	2.11E+00	3.27E+00	1.37E+01	1.37E+01
70 +	399000	13	2.51	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	370000	12	0.78	*	*	*	*	*	*	*	*	*	*	*	*
Spring	197000	15	0.43	*	*	*	*	*	*	*	*	*	*	*	*
Summer	3427000	114	7.53	1.06E+00	1.83E-01	0.00E+00	7.46E-02	1.08E-01	2.42E-01	5.18E-01	1.13E+00	2.12E+00	2.79E+00	1.34E+01	1.37E+01
Winter	0	0	0.00												
Urbanization															
Central City	640000	18	1.14	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	1530000	64	3.40	1.74E+00	3.43E-01	1.01E-01	1.21E-01	1.90E-01	3.86E-01	1.06E+00	1.67E+00	3.09E+00	4.50E+00	1.37E+01	1.37E+01
Suburban	1824000	59	2.11	6.71E-01	7.52E-02	0.00E+00	7.46E-02	1.62E-01	2.78E-01	4.99E-01	8.33E-01	1.34E+00	1.73E+00	3.27E+00	3.27E+00
Race															
Black	86000	2	0.40	*	*	*	*	*	*	*	*	*	*	*	*
White	3724000	132	2.36	9.35E-01	1.62E-01	3.08E-02	6.31E-02	1.01E-01	2.22E-01	5.01E-01	1.03E+00	1.49E+00	2.40E+00	1.34E+01	1.37E+01
Region															
Midwest	969000	31	2.09	1.00E+00	3.92E-01	3.08E-02	4.16E-02	5.45E-02	1.35E-01	4.53E-01	1.03E+00	2.35E+00	2.45E+00	1.34E+01	1.34E+01
Northeast	689000	22	1.67	1.92E+00	6.78E-01	2.33E-01	2.78E-01	2.78E-01	4.75E-01	6.84E-01	1.53E+00	4.18E+00	1.17E+01	1.37E+01	1.37E+01
South	1317000	54	2.05	8.85E-01	1.05E-01	0.00E+00	1.21E-01	1.83E-01	2.87E-01	7.53E-01	1.28E+00	1.73E+00	2.13E+00	4.50E+00	4.50E+00
West	1019000	34	2.83	6.01E-01	1.06E-01	6.71E-02	7.46E-02	1.01E-01	2.09E-01	4.30E-01	7.01E-01	1.29E+00	2.11E+00	3.27E+00	3.27E+00
Response to Questionnaire															
Households who garden	3465000	123	5.08	1.05E+00	1.75E-01	3.08E-02	6.71E-02	1.01E-01	2.78E-01	5.18E-01	1.13E+00	2.11E+00	2.79E+00	1.34E+01	1.37E+01
Households who farm	710000	29	9.69	6.99E-01	1.07E-01	0.00E+00	0.00E+00	1.43E-01	1.88E-01	3.86E-01	1.27E+00	1.49E+00	1.71E+00	2.09E+00	2.09E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-43. Intake of Home Produced Eggs (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	2075000	124	1.10	7.31E-01	1.00E-01	7.16E-02	1.50E-01	1.75E-01	2.68E-01	4.66E-01	9.02E-01	1.36E+00	1.69E+00	6.58E+00	1.35E+01
Age															
01-02	21000	3	0.37	*	*	*	*	*	*	*	*	*	*	*	*
03-05	20000	2	0.25	*	*	*	*	*	*	*	*	*	*	*	*
06-11	170000	12	1.02	*	*	*	*	*	*	*	*	*	*	*	*
12-19	163000	14	0.80	*	*	*	*	*	*	*	*	*	*	*	*
20-39	474000	30	0.77	6.32E-01	9.23E-02	7.16E-02	7.16E-02	2.15E-01	3.00E-01	4.16E-01	8.14E-01	1.32E+00	1.93E+00	2.50E+00	2.50E+00
40-69	718000	43	1.27	5.91E-01	5.77E-02	1.37E-01	1.41E-01	1.52E-01	3.17E-01	5.14E-01	8.44E-01	1.30E+00	1.36E+00	1.38E+00	1.38E+00
70 +	489000	18	3.08	*	*	*	*	*	*	*	*	*	*	*	*
Seasons															
Fall	542000	18	1.14	*	*	*	*	*	*	*	*	*	*	*	*
Spring	460000	54	1.00	1.31E+00	2.88E-01	1.57E-01	3.25E-01	3.94E-01	5.02E-01	6.66E-01	1.31E+00	2.10E+00	3.26E+00	1.35E+01	1.35E+01
Summer	723000	26	1.59	4.96E-01	8.14E-02	7.16E-02	1.37E-01	1.41E-01	2.60E-01	3.32E-01	5.41E-01	1.36E+00	1.51E+00	1.65E+00	1.65E+00
Winter	350000	26	0.72	8.60E-01	9.50E-02	1.67E-01	1.75E-01	2.15E-01	4.03E-01	7.51E-01	1.17E+00	1.62E+00	1.93E+00	1.93E+00	1.93E+00
Urbanization															
Central City	251000	9	0.45	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	1076000	65	2.39	7.34E-01	1.23E-01	7.16E-02	1.41E-01	1.67E-01	2.60E-01	4.74E-01	9.16E-01	1.34E+00	1.65E+00	6.58E+00	9.16E+00
Suburban	748000	50	0.86	8.54E-01	1.98E-01	1.37E-01	1.50E-01	2.06E-01	3.80E-01	5.88E-01	1.17E+00	1.36E+00	1.85E+00	1.35E+01	1.35E+01
Race															
Black	63000	9	0.29	*	*	*	*	*	*	*	*	*	*	*	*
White	2012000	115	1.28	7.41E-01	1.05E-01	7.16E-02	1.50E-01	1.75E-01	2.68E-01	4.82E-01	9.03E-01	1.36E+00	1.69E+00	6.58E+00	1.35E+01
Region															
Midwest	665000	37	1.43	7.93E-01	1.96E-01	7.16E-02	1.37E-01	1.41E-01	2.17E-01	3.39E-01	1.08E+00	1.51E+00	2.10E+00	9.16E+00	9.16E+00
Northeast	87000	7	0.21	*	*	*	*	*	*	*	*	*	*	*	*
South	823000	44	1.28	5.36E-01	6.46E-02	1.52E-01	1.77E-01	1.96E-01	2.60E-01	3.60E-01	5.99E-01	1.18E+00	1.62E+00	1.93E+00	1.93E+00
West	500000	36	1.39	9.21E-01	2.75E-01	1.67E-01	2.06E-01	2.08E-01	4.58E-01	6.66E-01	1.05E+00	1.36E+00	1.36E+00	1.35E+01	1.35E+01
Response to Questionnaire															
Households who raise animals	1824000	113	18.06	7.46E-01	1.11E-01	7.16E-02	1.50E-01	1.65E-01	2.56E-01	4.82E-01	9.02E-01	1.36E+00	1.85E+00	6.58E+00	1.35E+01
Households who farm	741000	44	10.11	8.98E-01	1.70E-01	1.52E-01	1.65E-01	1.77E-01	2.72E-01	6.66E-01	1.19E+00	1.65E+00	1.85E+00	6.58E+00	9.16E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-44. Intake of Home Produced Game (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	2707000	185	1.44	9.67E-01	6.14E-02	0.00E+00	1.17E-01	2.10E-01	3.97E-01	7.09E-01	1.22E+00	2.27E+00	2.67E+00	3.61E+00	4.59E+00
Age															
01-02	89000	8	1.56	*	*	*	*	*	*	*	*	*	*	*	*
03-05	94000	8	1.16	*	*	*	*	*	*	*	*	*	*	*	*
06-11	362000	28	2.17	1.09E+00	1.44E-01	1.16E-01	2.31E-01	4.28E-01	6.33E-01	7.61E-01	1.48E+00	2.67E+00	2.85E+00	2.90E+00	2.90E+00
12-19	462000	27	2.25	1.04E+00	1.39E-01	2.10E-01	2.10E-01	2.91E-01	6.30E-01	8.46E-01	1.22E+00	1.99E+00	3.13E+00	3.13E+00	3.13E+00
20-39	844000	59	1.37	8.24E-01	1.08E-01	1.04E-01	1.17E-01	1.88E-01	3.01E-01	6.31E-01	1.09E+00	1.57E+00	2.50E+00	4.59E+00	4.59E+00
40-69	694000	41	1.22	9.64E-01	1.40E-01	1.24E-01	1.72E-01	2.87E-01	3.42E-01	5.10E-01	1.41E+00	2.51E+00	3.19E+00	3.61E+00	3.61E+00
70 +	74000	7	0.47	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	876000	31	1.84	9.97E-01	1.56E-01	1.17E-01	1.48E-01	2.18E-01	4.28E-01	6.33E-01	1.19E+00	2.50E+00	3.13E+00	3.19E+00	3.19E+00
Spring	554000	68	1.20	9.06E-01	8.78E-02	0.00E+00	1.04E-01	1.72E-01	4.43E-01	7.46E-01	1.22E+00	1.75E+00	2.52E+00	3.61E+00	3.61E+00
Summer	273000	9	0.60	*	*	*	*	*	*	*	*	*	*	*	*
Winter	1004000	77	2.06	1.07E+00	1.05E-01	0.00E+00	0.00E+00	1.65E-01	3.88E-01	8.18E-01	1.52E+00	2.20E+00	2.67E+00	4.59E+00	4.59E+00
Urbanization															
Central City	506000	20	0.90	6.89E-01	1.27E-01	0.00E+00	0.00E+00	1.88E-01	2.77E-01	6.30E-01	7.74E-01	1.48E+00	1.99E+00	2.34E+00	2.34E+00
Nonmetropolitan	1259000	101	2.80	9.45E-01	8.91E-02	0.00E+00	1.17E-01	1.65E-01	3.20E-01	6.59E-01	1.19E+00	2.27E+00	3.05E+00	4.59E+00	4.59E+00
Suburban	942000	64	1.09	1.15E+00	1.04E-01	0.00E+00	2.56E-01	3.97E-01	5.21E-01	8.18E-01	1.52E+00	2.51E+00	2.85E+00	3.13E+00	3.61E+00
Race															
Black	0	0	0.00												
White	2605000	182	1.65	9.77E-01	6.30E-02	0.00E+00	1.17E-01	2.02E-01	3.76E-01	7.29E-01	1.38E+00	2.34E+00	2.85E+00	3.61E+00	4.59E+00
Region															
Midwest	1321000	97	2.85	8.83E-01	8.32E-02	0.00E+00	7.53E-02	2.18E-01	3.42E-01	6.12E-01	1.10E+00	1.99E+00	2.51E+00	4.59E+00	4.59E+00
Northeast	394000	20	0.96	1.13E+00	2.16E-01	2.87E-01	2.87E-01	3.21E-01	4.30E-01	7.74E-01	1.41E+00	3.13E+00	3.13E+00	3.61E+00	3.61E+00
South	609000	47	0.95	1.26E+00	1.29E-01	0.00E+00	1.17E-01	1.48E-01	6.32E-01	1.09E+00	1.93E+00	2.38E+00	3.19E+00	3.19E+00	3.19E+00
West	383000	21	1.06	6.28E-01	7.21E-02	1.24E-01	1.51E-01	1.88E-01	3.97E-01	6.33E-01	7.74E-01	1.12E+00	1.22E+00	1.52E+00	1.52E+00
Response to Questionnaire															
Households who hunt	2357000	158	11.66	1.04E+00	6.84E-02	0.00E+00	1.40E-01	2.77E-01	4.42E-01	7.46E-01	1.44E+00	2.38E+00	2.90E+00	3.61E+00	4.59E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-45. Intake of Home Produced Lettuce (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1520000	80	0.81	3.87E-01	3.18E-02	0.00E+00	4.49E-02	9.43E-02	1.70E-01	2.84E-01	5.45E-01	8.36E-01	1.03E+00	1.05E+00	1.28E+00
Age															
01-02	54000	4	0.95	*	*	*	*	*	*	*	*	*	*	*	*
03-05	25000	2	0.31	*	*	*	*	*	*	*	*	*	*	*	*
06-11	173000	7	1.04	*	*	*	*	*	*	*	*	*	*	*	*
12-19	71000	3	0.35	*	*	*	*	*	*	*	*	*	*	*	*
20-39	379000	17	0.62	*	*	*	*	*	*	*	*	*	*	*	*
40-69	485000	26	0.86	4.84E-01	6.07E-02	1.15E-01	1.15E-01	1.24E-01	2.21E-01	4.91E-01	6.84E-01	8.86E-01	1.05E+00	1.28E+00	1.28E+00
70 +	317000	20	2.00	4.52E-01	7.17E-02	5.04E-02	6.71E-02	1.12E-01	2.23E-01	2.88E-01	5.68E-01	1.03E+00	1.03E+00	1.03E+00	1.03E+00
Season															
Fall	214000	8	0.45	*	*	*	*	*	*	*	*	*	*	*	*
Spring	352000	35	0.76	4.52E-01	4.86E-02	5.04E-02	6.71E-02	1.24E-01	1.99E-01	4.53E-01	5.79E-01	7.98E-01	9.94E-01	1.28E+00	1.28E+00
Summer	856000	30	1.88	3.02E-01	3.96E-02	1.98E-02	3.35E-02	4.93E-02	1.42E-01	2.30E-01	4.24E-01	5.98E-01	8.14E-01	8.86E-01	8.86E-01
Winter	98000	7	0.20	*	*	*	*	*	*	*	*	*	*	*	*
Urbanization															
Central City	268000	8	0.48	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	566000	36	1.26	3.67E-01	4.78E-02	1.98E-02	3.35E-02	4.49E-02	1.23E-01	2.88E-01	5.45E-01	8.14E-01	8.86E-01	1.28E+00	1.28E+00
Suburban	686000	36	0.79	3.49E-01	4.32E-02	0.00E+00	9.43E-02	9.68E-02	1.53E-01	2.30E-01	4.91E-01	7.67E-01	9.94E-01	1.05E+00	1.05E+00
Race															
Black	51000	3	0.23	*	*	*	*	*	*	*	*	*	*	*	*
White	1434000	75	0.91	3.79E-01	3.33E-02	0.00E+00	4.49E-02	9.43E-02	1.56E-01	2.75E-01	5.45E-01	8.86E-01	1.03E+00	1.05E+00	1.28E+00
Region															
Midwest	630000	33	1.36	3.83E-01	5.54E-02	1.98E-02	3.35E-02	4.49E-02	1.56E-01	2.34E-01	5.68E-01	9.42E-01	1.03E+00	1.03E+00	1.03E+00
Northeast	336000	16	0.82	*	*	*	*	*	*	*	*	*	*	*	*
South	305000	20	0.47	3.52E-01	5.74E-02	0.00E+00	0.00E+00	1.27E-01	1.64E-01	2.75E-01	4.83E-01	5.79E-01	1.04E+00	1.28E+00	1.28E+00
West	249000	11	0.69	*	*	*	*	*	*	*	*	*	*	*	*
Responses to Questionnaire															
Households who garden	1506000	78	2.21	3.90E-01	3.22E-02	0.00E+00	4.49E-02	9.43E-02	1.74E-01	2.84E-01	5.45E-01	8.36E-01	1.03E+00	1.05E+00	1.28E+00
Households who farm	304000	18	4.15	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-46. Intake of Home Produced LIma Beans (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1917000	109	1.02	4.53E-01	4.11E-02	0.00E+00	9.19E-02	1.21E-01	1.88E-01	2.90E-01	5.45E-01	9.90E-01	1.69E+00	1.86E+00	1.91E+00
Age															
01-02	62000	3	1.09	*	*	*	*	*	*	*	*	*	*	*	*
03-05	35000	2	0.43	*	*	*	*	*	*	*	*	*	*	*	*
06-11	95000	7	0.57	*	*	*	*	*	*	*	*	*	*	*	*
12-19	108000	6	0.53	*	*	*	*	*	*	*	*	*	*	*	*
20-39	464000	20	0.75	3.84E-01	6.87E-02	3.23E-02	1.08E-01	1.30E-01	1.77E-01	2.34E-01	4.87E-01	9.37E-01	1.10E+00	1.10E+00	1.10E+00
40-69	757000	44	1.33	4.54E-01	6.30E-02	9.19E-02	1.06E-01	1.21E-01	2.04E-01	2.93E-01	5.60E-01	8.69E-01	1.71E+00	1.91E+00	1.91E+00
70 +	361000	25	2.27	5.23E-01	1.05E-01	8.20E-02	1.86E-01	1.88E-01	2.25E-01	2.86E-01	6.38E-01	1.86E+00	1.86E+00	1.86E+00	1.86E+00
Season															
Fall	375000	14	0.79	*	*	*	*	*	*	*	*	*	*	*	*
Spring	316000	39	0.68	4.19E-01	5.50E-02	8.20E-02	9.02E-02	1.31E-01	2.32E-01	3.06E-01	5.45E-01	7.48E-01	1.31E+00	1.91E+00	1.91E+00
Summer	883000	29	1.94	4.99E-01	9.68E-02	0.00E+00	9.43E-02	1.21E-01	1.72E-01	2.90E-01	4.87E-01	1.53E+00	1.71E+00	1.86E+00	1.86E+00
Winter	343000	27	0.70	5.27E-01	6.25E-02	0.00E+00	3.23E-02	1.08E-01	3.05E-01	5.39E-01	7.58E-01	8.61E-01	8.69E-01	1.69E+00	1.69E+00
Urbanization															
Central City	204000	8	0.36	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	1075000	69	2.39	2.99E-01	3.22E-02	3.23E-02	9.43E-02	1.21E-01	1.71E-01	2.12E-01	3.20E-01	4.87E-01	7.69E-01	1.69E+00	1.91E+00
Suburban	638000	32	0.74	7.53E-01	9.60E-02	0.00E+00	8.20E-02	9.19E-02	3.20E-01	6.78E-01	9.90E-01	1.71E+00	1.86E+00	1.86E+00	1.86E+00
Race															
Black	213000	9	0.98	*	*	*	*	*	*	*	*	*	*	*	*
White	1704000	100	1.08	3.83E-01	3.27E-02	0.00E+00	9.19E-02	1.08E-01	1.77E-01	2.54E-01	4.87E-01	8.61E-01	9.90E-01	1.53E+00	1.91E+00
Region															
Midwest	588000	36	1.27	4.28E-01	6.17E-02	0.00E+00	0.00E+00	1.06E-01	2.53E-01	3.06E-01	4.15E-01	9.90E-01	1.53E+00	1.69E+00	1.69E+00
Northeast	68000	6	0.17	*	*	*	*	*	*	*	*	*	*	*	*
South	1261000	67	1.96	4.72E-01	5.62E-02	3.23E-02	1.03E-01	1.30E-01	1.77E-01	2.49E-01	6.34E-01	1.10E+00	1.71E+00	1.86E+00	1.91E+00
West	0	0	0.00												
Response to Questionnaire															
Households who garden	1610000	97	2.36	4.47E-01	4.49E-02	3.23E-02	9.43E-02	1.21E-01	1.77E-01	2.85E-01	5.26E-01	9.37E-01	1.71E+00	1.86E+00	1.91E+00
Households who farm	62000	6	0.85	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-47. Intake of Homegrown Okra (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1696000	82	0.90	3.91E-01	3.81E-02	0.00E+00	5.03E-02	9.59E-02	1.48E-01	2.99E-01	4.58E-01	7.81E-01	1.21E+00	1.53E+00	1.53E+00
Age															
01-02	53000	2	0.93	*	*	*	*	*	*	*	*	*	*	*	*
03-05	68000	3	0.84	*	*	*	*	*	*	*	*	*	*	*	*
06-11	218000	11	1.30	*	*	*	*	*	*	*	*	*	*	*	*
12-19	194000	9	0.95	*	*	*	*	*	*	*	*	*	*	*	*
20-39	417000	18	0.68	*	*	*	*	*	*	*	*	*	*	*	*
40-69	587000	32	1.03	4.00E-01	4.73E-02	6.57E-02	1.11E-01	1.37E-01	2.47E-01	3.07E-01	4.62E-01	7.81E-01	1.14E+00	1.14E+00	1.14E+00
70 +	130000	6	0.82	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	228000	9	0.48	*	*	*	*	*	*	*	*	*	*	*	*
Spring	236000	24	0.51	3.87E-01	6.22E-02	2.98E-02	4.58E-02	6.57E-02	1.10E-01	4.10E-01	5.95E-01	7.81E-01	9.99E-01	1.07E+00	1.07E+00
Summer	1144000	41	2.52	3.86E-01	5.75E-02	0.00E+00	5.03E-02	9.59E-02	1.44E-01	2.99E-01	4.38E-01	1.15E+00	1.53E+00	1.53E+00	1.53E+00
Winter	88000	8	0.18	*	*	*	*	*	*	*	*	*	*	*	*
Urbanization															
Central City	204000	6	0.36	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	1043000	55	2.32	3.65E-01	4.99E-02	0.00E+00	2.69E-02	8.48E-02	1.48E-01	2.57E-01	4.38E-01	7.81E-01	1.53E+00	1.53E+00	1.53E+00
Suburban	449000	21	0.52	5.14E-01	6.97E-02	6.57E-02	9.60E-02	1.11E-01	3.13E-01	4.62E-01	6.00E-01	1.14E+00	1.15E+00	1.15E+00	1.15E+00
Race															
Black	236000	13	1.09	*	*	*	*	*	*	*	*	*	*	*	*
White	1419000	68	0.90	4.26E-01	4.40E-02	0.00E+00	6.57E-02	9.60E-02	1.76E-01	3.30E-01	5.23E-01	1.14E+00	1.21E+00	1.53E+00	1.53E+00
Region															
Midwest	113000	7	0.24	*	*	*	*	*	*	*	*	*	*	*	*
Northeast															
South	1443000	70	2.24	3.73E-01	4.21E-02	0.00E+00	5.03E-02	8.48E-02	1.44E-01	2.59E-01	4.38E-01	7.47E-01	1.21E+00	1.53E+00	1.53E+00
West	140000	5	0.39	*	*	*	*	*	*	*	*	*	*	*	*
Response to Questionnaire															
Households who garden	1564000	77	2.29	3.84E-01	4.05E-02	0.00E+00	5.03E-02	9.59E-02	1.48E-01	2.98E-01	4.52E-01	1.07E+00	1.21E+00	1.53E+00	1.53E+00
Households who farm	233000	14	3.18	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-48. Intake of Homegrown Onions (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	6718000	370	3.57	2.96E-01	1.87E-02	3.68E-03	9.09E-03	2.90E-02	8.81E-02	2.06E-01	3.77E-01	6.09E-01	9.12E-01	1.49E+00	3.11E+00
Age															
01-02	291000	17	5.11	*	*	*	*	*	*	*	*	*	*	*	*
03-05	178000	9	2.20	*	*	*	*	*	*	*	*	*	*	*	*
06-11	530000	31	3.17	3.03E-01	5.61E-02	9.80E-03	1.08E-02	2.76E-02	1.06E-01	2.28E-01	3.83E-01	6.09E-01	1.36E+00	1.36E+00	1.36E+00
12-19	652000	37	3.18	2.11E-01	3.65E-02	5.14E-03	8.36E-03	8.58E-03	5.97E-02	1.42E-01	2.55E-01	5.74E-01	7.59E-01	9.12E-01	9.12E-01
20-39	1566000	78	2.54	2.88E-01	3.40E-02	9.09E-03	3.80E-02	5.80E-02	9.40E-02	1.91E-01	3.04E-01	6.38E-01	9.35E-01	1.49E+00	1.49E+00
40-69	2402000	143	4.23	2.50E-01	2.07E-02	3.03E-03	4.59E-03	1.11E-02	7.66E-02	1.72E-01	3.58E-01	5.52E-01	6.90E-01	1.11E+00	1.41E+00
70 +	1038000	52	6.54	4.33E-01	8.86E-02	4.76E-03	6.68E-03	2.68E-02	1.35E-01	2.86E-01	4.61E-01	5.63E-01	2.68E+00	3.11E+00	3.11E+00
Season															
Fall	1557000	59	3.27	3.75E-01	6.93E-02	3.68E-03	2.55E-02	5.80E-02	1.23E-01	2.55E-01	4.36E-01	6.03E-01	7.83E-01	3.11E+00	3.11E+00
Spring	1434000	147	3.11	1.95E-01	1.96E-02	2.01E-03	5.47E-03	2.68E-02	5.73E-02	1.06E-01	2.59E-01	4.26E-01	5.23E-01	1.41E+00	1.77E+00
Summer	2891000	101	6.36	3.06E-01	2.91E-02	8.58E-03	1.68E-02	4.22E-02	1.08E-01	2.28E-01	3.76E-01	6.90E-01	9.69E-01	1.49E+00	1.49E+00
Winter	836000	63	1.72	2.88E-01	3.86E-02	3.03E-03	4.59E-03	5.04E-03	3.06E-02	1.99E-01	4.60E-01	6.42E-01	9.16E-01	1.36E+00	1.36E+00
Urbanization															
Central City	890000	37	1.58	2.16E-01	2.85E-02	4.76E-03	1.02E-02	2.55E-02	6.60E-02	1.93E-01	2.96E-01	5.18E-01	5.63E-01	5.63E-01	5.63E-01
Nonmetropolitan	2944000	177	6.54	3.24E-01	2.06E-02	8.12E-03	3.14E-02	6.75E-02	1.42E-01	2.55E-01	4.33E-01	6.30E-01	9.12E-01	1.49E+00	1.77E+00
Suburban	2884000	156	3.33	2.92E-01	3.70E-02	3.03E-03	5.20E-03	1.10E-02	5.85E-02	1.30E-01	3.56E-01	6.35E-01	9.69E-01	3.11E+00	3.11E+00
Race															
Black	253000	16	1.16	*	*	*	*	*	*	*	*	*	*	*	*
White	6266000	345	3.98	3.08E-01	1.99E-02	3.57E-03	9.09E-03	3.06E-02	9.16E-02	2.24E-01	3.86E-01	6.18E-01	9.35E-01	1.77E+00	3.11E+00
Region															
Midwest	2487000	143	5.36	2.70E-01	1.94E-02	4.25E-03	4.02E-02	5.73E-02	1.02E-01	2.24E-01	3.43E-01	5.63E-01	7.24E-01	1.34E+00	1.34E+00
Northeast	876000	52	2.13	2.32E-01	4.43E-02	2.01E-03	3.73E-03	8.36E-03	1.08E-02	1.08E-01	3.53E-01	6.35E-01	1.05E+00	1.36E+00	1.41E+00
South	1919000	107	2.98	3.32E-01	2.93E-02	4.79E-03	2.76E-02	3.70E-02	1.46E-01	2.51E-01	3.93E-01	6.90E-01	1.08E+00	1.49E+00	1.77E+00
West	1436000	68	3.98	3.32E-01	6.90E-02	3.57E-03	6.68E-03	1.68E-02	5.68E-02	1.52E-01	3.86E-01	5.49E-01	9.69E-01	3.11E+00	3.11E+00
Response to Questionnaire															
Households who garden	6441000	356	9.45	3.00E-01	1.93E-02	3.68E-03	9.09E-03	3.06E-02	9.11E-02	2.13E-01	3.81E-01	6.09E-01	9.16E-01	1.77E+00	3.11E+00
Households who farm	1390000	81	18.97	3.75E-01	3.84E-02	3.00E-02	4.04E-02	5.15E-02	1.11E-01	2.78E-01	5.15E-01	9.35E-01	1.11E+00	1.49E+00	1.49E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distributions

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-49. Intake of Homegrown Other Berrires (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1626000	99	0.86	4.80E-01	4.24E-02	0.00E+00	4.68E-02	9.24E-02	2.32E-01	3.84E-01	5.89E-01	1.07E+00	1.28E+00	2.21E+00	2.21E+00
Age															
01-02	41000	2	0.72	*	*	*	*	*	*	*	*	*	*	*	*
03-05	53000	3	0.65	*	*	*	*	*	*	*	*	*	*	*	*
06-11	106000	10	0.63	*	*	*	*	*	*	*	*	*	*	*	*
12-19	79000	5	0.39	*	*	*	*	*	*	*	*	*	*	*	*
20-39	309000	20	0.50	3.90E-01	6.31E-02	7.95E-02	9.18E-02	9.18E-02	1.25E-01	3.30E-01	5.52E-01	7.94E-01	1.07E+00	1.07E+00	1.07E+00
40-69	871000	51	1.54	4.89E-01	5.72E-02	7.69E-02	1.01E-01	1.34E-01	2.48E-01	3.89E-01	6.12E-01	7.68E-01	1.28E+00	2.21E+00	2.21E+00
70 +	159000	7	1.00	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	379000	13	0.80	*	*	*	*	*	*	*	*	*	*	*	*
Spring	287000	29	0.62	3.06E-01	4.11E-02	4.68E-02	4.68E-02	7.69E-02	1.84E-01	2.54E-01	4.08E-01	5.40E-01	7.24E-01	1.07E+00	1.07E+00
Summer	502000	18	1.10	*	*	*	*	*	*	*	*	*	*	*	*
Winter	458000	39	0.94	5.35E-01	7.39E-02	0.00E+00	1.02E-01	1.59E-01	2.32E-01	3.89E-01	6.23E-01	1.07E+00	1.95E+00	2.08E+00	2.08E+00
Urbanization															
Central City	378000	15	0.67	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	466000	37	1.04	6.43E-01	8.96E-02	0.00E+00	9.24E-02	1.02E-01	2.51E-01	4.39E-01	1.02E+00	1.31E+00	2.21E+00	2.21E+00	2.21E+00
Suburban	722000	45	0.83	4.48E-01	5.32E-02	9.18E-02	1.25E-01	1.58E-01	2.58E-01	3.84E-01	5.35E-01	5.89E-01	9.02E-01	2.08E+00	2.08E+00
Race															
Black	76000	4	0.35	*	*	*	*	*	*	*	*	*	*	*	*
White	1490000	93	0.95	5.03E-01	4.43E-02	4.68E-02	9.18E-02	1.01E-01	2.51E-01	3.95E-01	6.04E-01	1.07E+00	1.31E+00	2.21E+00	2.21E+00
Region															
Midwest	736000	56	1.59	4.57E-01	6.26E-02	0.00E+00	7.69E-02	9.18E-02	1.25E-01	3.00E-01	5.87E-01	1.12E+00	1.28E+00	2.21E+00	2.21E+00
Northeast	211000	11	0.51	*	*	*	*	*	*	*	*	*	*	*	*
South	204000	12	0.32	*	*	*	*	*	*	*	*	*	*	*	*
West	415000	18	1.15	*	*	*	*	*	*	*	*	*	*	*	*
Response to Questionnaire															
Households who garden	1333000	84	1.96	4.72E-01	4.83E-02	1.00E-02	0.00E+00	9.18E-02	2.00E-01	3.53E-01	5.52E-01	1.07E+00	1.28E+00	2.21E+00	2.21E+00
Households who farm	219000	16	2.99	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-50. Intake of Homegrown Peaches (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	2941000	193	1.56	1.67E+00	1.70E-01	5.20E-02	1.65E-01	2.25E-01	4.74E-01	8.97E-01	1.88E+00	3.79E+00	6.36E+00	1.23E+01	2.23E+01
Age															
01-02	103000	8	1.81	*	*	*	*	*	*	*	*	*	*	*	*
03-05	65000	6	0.80	*	*	*	*	*	*	*	*	*	*	*	*
06-11	329000	26	1.97	3.11E+00	6.32E-01	9.75E-02	1.01E-01	1.40E-01	6.25E-01	1.13E+00	6.36E+00	8.53E+00	8.53E+00	1.15E+01	1.15E+01
12-19	177000	13	0.86	*	*	*	*	*	*	*	*	*	*	*	*
20-39	573000	35	0.93	1.17E+00	1.74E-01	5.07E-02	5.50E-02	2.25E-01	4.74E-01	8.09E-01	1.30E+00	2.92E+00	2.99E+00	5.27E+00	5.27E+00
40-69	1076000	70	1.90	1.53E+00	2.83E-01	5.87E-02	1.90E-01	2.39E-01	5.56E-01	8.92E-01	1.61E+00	2.63E+00	4.43E+00	1.23E+01	1.23E+01
70 +	598000	33	3.77	1.01E+00	1.97E-01	9.13E-02	1.38E-01	1.79E-01	2.82E-01	8.22E-01	1.19E+00	1.60E+00	3.79E+00	7.13E+00	7.13E+00
Season															
Fall	485000	19	1.02	*	*	*	*	*	*	*	*	*	*	*	*
Spring	756000	91	1.64	1.67E+00	3.04E-01	5.07E-02	5.87E-02	1.01E-01	2.76E-01	7.74E-01	1.45E+00	4.44E+00	6.77E+00	2.23E+01	2.23E+01
Summer	1081000	35	2.38	2.26E+00	4.78E-01	1.65E-01	2.25E-01	3.61E-01	5.67E-01	1.12E+00	2.99E+00	6.36E+00	8.53E+00	1.23E+01	1.23E+01
Winter	619000	48	1.27	1.25E+00	1.03E-01	3.52E-02	2.39E-01	5.56E-01	7.79E-01	1.04E+00	1.71E+00	2.35E+00	2.60E+00	3.56E+00	3.56E+00
Urbanization															
Central City	429000	12	0.76	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	1110000	99	2.47	1.87E+00	2.59E-01	5.87E-02	2.62E-01	3.93E-01	6.46E-01	1.02E+00	2.18E+00	3.86E+00	6.36E+00	1.15E+01	2.23E+01
Suburban	1402000	82	1.62	1.47E+00	1.75E-01	5.07E-02	1.40E-01	2.04E-01	4.61E-01	9.20E-01	1.87E+00	3.79E+00	4.43E+00	7.37E+00	7.37E+00
Race															
Black	39000	1	0.18	*	*	*	*	*	*	*	*	*	*	*	*
White	2861000	191	1.82	1.70E+00	1.73E-01	5.20E-02	1.65E-01	2.30E-01	5.03E-01	8.97E-01	1.96E+00	3.79E+00	6.36E+00	1.23E+01	2.23E+01
Region															
Midwest	824000	75	1.78	1.39E+00	2.91E-01	1.76E-01	2.20E-01	2.59E-01	4.60E-01	7.40E-01	1.19E+00	3.06E+00	3.56E+00	1.15E+01	2.23E+01
Northeast	75000	5	0.18	*	*	*	*	*	*	*	*	*	*	*	*
South	852000	51	1.32	1.67E+00	2.57E-01	3.52E-02	1.38E-01	1.79E-01	6.43E-01	1.02E+00	1.96E+00	3.83E+00	6.36E+00	8.53E+00	8.53E+00
West	1190000	62	3.30	1.80E+00	3.26E-01	5.07E-02	1.40E-01	2.25E-01	4.68E-01	8.63E-01	1.94E+00	4.43E+00	7.37E+00	1.23E+01	1.23E+01
Response to Questionnaire															
Households who garden	2660000	174	3.90	1.75E+00	1.85E-01	5.20E-02	1.66E-01	2.59E-01	5.26E-01	9.25E-01	1.96E+00	3.79E+00	6.36E+00	1.23E+01	2.23E+01
Households who farm	769000	54	10.49	1.56E+00	2.49E-01	6.79E-02	1.76E-01	2.26E-01	4.61E-01	9.02E-01	2.02E+00	2.99E+00	6.36E+00	8.53E+00	8.53E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-51. Intake of Homegrown Pears (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1513000	94	0.80	9.37E-01	9.68E-02	1.01E-01	1.84E-01	2.38E-01	4.28E-01	6.82E-01	1.09E+00	1.60E+00	2.76E+00	5.16E+00	5.16E+00
Age															
01-02	24000	3	0.42	*	*	*	*	*	*	*	*	*	*	*	*
03-05	45000	3	0.56	*	*	*	*	*	*	*	*	*	*	*	*
06-11	145000	10	0.87	*	*	*	*	*	*	*	*	*	*	*	*
12-19	121000	7	0.59	*	*	*	*	*	*	*	*	*	*	*	*
20-39	365000	23	0.59	6.19E-01	6.42E-02	1.13E-01	3.18E-01	3.79E-01	4.28E-01	5.03E-01	6.82E-01	1.22E+00	1.24E+00	1.24E+00	1.24E+00
40-69	557000	33	0.98	6.57E-01	5.53E-02	1.01E-01	1.08E-01	3.33E-01	4.23E-01	6.45E-01	9.22E-01	1.10E+00	1.13E+00	1.51E+00	1.51E+00
70 +	256000	15	1.61	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	308000	11	0.65	*	*	*	*	*	*	*	*	*	*	*	*
Spring	355000	39	0.77	6.87E-01	7.89E-02	1.01E-01	1.13E-01	1.82E-01	3.38E-01	6.02E-01	8.66E-01	1.15E+00	1.83E+00	2.54E+00	2.54E+00
Summer	474000	16	1.04	*	*	*	*	*	*	*	*	*	*	*	*
Winter	376000	28	0.77	1.48E+00	2.77E-01	1.08E-01	1.08E-01	3.79E-01	6.45E-01	9.49E-01	1.38E+00	4.82E+00	5.16E+00	5.16E+00	5.16E+00
Urbanization															
Central City	222000	11	0.39	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	634000	44	1.41	7.81E-01	8.52E-02	3.33E-01	3.52E-01	4.19E-01	4.43E-01	5.70E-01	8.13E-01	1.56E+00	1.86E+00	2.88E+00	2.88E+00
Suburban	657000	39	0.76	8.50E-01	1.17E-01	1.01E-01	1.08E-01	1.82E-01	3.89E-01	7.29E-01	1.10E+00	1.50E+00	2.57E+00	4.79E+00	4.79E+00
Race															
Black	51000	3	0.23	*	*	*	*	*	*	*	*	*	*	*	*
White	1462000	91	0.93	9.65E-01	9.88E-02	1.08E-01	2.38E-01	3.52E-01	4.43E-01	7.01E-01	1.09E+00	1.60E+00	2.88E+00	5.16E+00	5.16E+00
Region															
Midwest	688000	57	1.48	8.71E-01	9.49E-02	2.22E-01	3.38E-01	3.76E-01	4.43E-01	6.45E-01	1.04E+00	1.60E+00	2.57E+00	4.79E+00	4.79E+00
Northeast	18000	2	0.04	*	*	*	*	*	*	*	*	*	*	*	*
South	377000	13	0.59	*	*	*	*	*	*	*	*	*	*	*	*
West	430000	22	1.19	1.14E+00	2.89E-01	1.01E-01	1.08E-01	1.13E-01	3.56E-01	7.52E-01	1.13E+00	2.76E+00	4.82E+00	5.16E+00	5.16E+00
Response to Questionnaire															
Households who garden	1312000	85	1.93	9.45E-01	1.04E-01	1.01E-01	1.82E-01	3.52E-01	4.31E-01	6.75E-01	1.09E+00	1.56E+00	2.88E+00	5.16E+00	5.16E+00
Households who farm	528000	35	7.20	1.09E+00	2.10E-01	1.08E-01	2.22E-01	3.76E-01	4.28E-01	6.14E-01	1.09E+00	2.76E+00	4.82E+00	5.16E+00	5.16E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-52. Intake of Homegrown Peas (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	4252000	226	2.26	5.05E-01	3.23E-02	4.58E-02	1.02E-01	1.40E-01	2.28E-01	3.21E-01	6.22E-01	1.04E+00	1.46E+00	2.66E+00	2.89E+00
Age															
01-02	163000	9	2.86	*	*	*	*	*	*	*	*	*	*	*	*
03-05	140000	7	1.73	*	*	*	*	*	*	*	*	*	*	*	*
06-11	515000	26	3.08	6.05E-01	8.91E-02	1.54E-01	1.54E-01	2.18E-01	3.04E-01	3.87E-01	9.00E-01	1.35E+00	1.40E+00	2.06E+00	2.06E+00
12-19	377000	22	1.84	4.08E-01	4.28E-02	5.81E-02	1.33E-01	1.58E-01	2.35E-01	3.58E-01	5.02E-01	7.10E-01	8.22E-01	8.22E-01	8.22E-01
20-39	1121000	52	1.82	4.08E-01	6.21E-02	9.96E-02	1.15E-01	1.40E-01	1.80E-01	2.54E-01	4.06E-01	8.47E-01	1.36E+00	2.71E+00	2.71E+00
40-69	1366000	80	2.41	4.58E-01	4.61E-02	6.78E-02	1.02E-01	1.20E-01	2.26E-01	3.04E-01	6.10E-01	9.95E-01	1.30E+00	2.36E+00	2.36E+00
70 +	458000	26	2.88	3.34E-01	5.58E-02	3.48E-02	3.48E-02	4.58E-02	1.84E-01	2.73E-01	3.72E-01	9.95E-01	9.95E-01	1.46E+00	1.46E+00
Season															
Fall	1239000	41	2.60	3.03E-01	2.97E-02	3.48E-02	4.58E-02	1.15E-01	2.09E-01	2.62E-01	3.53E-01	5.99E-01	7.14E-01	9.95E-01	9.95E-01
Spring	765000	78	1.66	4.38E-01	4.26E-02	5.81E-02	1.08E-01	1.18E-01	1.90E-01	3.26E-01	5.16E-01	9.19E-01	1.40E+00	2.06E+00	2.06E+00
Summer	1516000	51	3.33	5.85E-01	7.36E-02	6.78E-02	1.27E-01	1.74E-01	2.24E-01	3.87E-01	8.22E-01	1.35E+00	1.60E+00	2.66E+00	2.66E+00
Winter	732000	56	1.50	7.53E-01	8.86E-02	1.17E-01	1.84E-01	2.12E-01	2.73E-01	5.44E-01	9.48E-01	1.54E+00	2.36E+00	2.89E+00	2.89E+00
Urbanization															
Central City	558000	19	0.99	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	2028000	126	4.50	4.81E-01	3.55E-02	8.42E-02	1.36E-01	1.74E-01	2.48E-01	3.53E-01	5.79E-01	1.04E+00	1.36E+00	1.89E+00	2.89E+00
Suburban	1666000	81	1.92	5.13E-01	4.63E-02	6.78E-02	1.15E-01	1.34E-01	2.29E-01	3.87E-01	6.84E-01	9.95E-01	1.30E+00	2.28E+00	2.36E+00
Race															
Black	355000	19	1.63	*	*	*	*	*	*	*	*	*	*	*	*
White	3784000	203	2.40	4.95E-01	3.35E-02	3.48E-02	1.02E-01	1.33E-01	2.18E-01	3.26E-01	6.00E-01	9.99E-01	1.40E+00	2.66E+00	2.89E+00
Region															
Midwest	1004000	55	2.16	4.03E-01	7.24E-02	3.48E-02	4.58E-02	9.96E-02	1.40E-01	2.52E-01	3.53E-01	8.80E-01	1.54E+00	2.71E+00	2.89E+00
Northeast	241000	14	0.59	*	*	*	*	*	*	*	*	*	*	*	*
South	2449000	132	3.81	5.67E-01	4.30E-02	1.27E-01	1.74E-01	1.96E-01	2.62E-01	3.72E-01	6.82E-01	1.24E+00	1.60E+00	2.66E+00	2.66E+00
West	558000	25	1.55	3.77E-01	5.70E-02	6.78E-02	6.78E-02	1.02E-01	2.18E-01	2.73E-01	4.79E-01	9.00E-01	9.40E-01	1.40E+00	1.40E+00
Response to Questionnaire															
Households who garden	3980000	214	5.84	5.13E-01	3.39E-02	3.48E-02	1.02E-01	1.40E-01	2.28E-01	3.21E-01	6.28E-01	1.04E+00	1.54E+00	2.66E+00	2.89E+00
Households who farm	884000	55	12.06	4.59E-01	5.83E-02	3.48E-02	4.58E-02	8.65E-02	2.08E-01	3.53E-01	5.16E-01	9.00E-01	1.40E+00	1.60E+00	2.89E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-53. Intake of Homegrown Peppers (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	5153000	208	2.74												
Age															
01-02	163000	6	2.86	*	*	*	*	*	*	*	*	*	*	*	*
03-05	108000	5	1.33	*	*	*	*	*	*	*	*	*	*	*	*
06-11	578000	26	3.46	2.26E-01	4.09E-02	0.00E+00	0.00E+00	3.03E-02	8.99E-02	1.62E-01	2.98E-01	4.25E-01	7.70E-01	8.45E-01	8.45E-01
12-19	342000	16	1.67	*	*	*	*	*	*	*	*	*	*	*	*
20-39	1048000	40	1.70	2.24E-01	6.10E-02	1.74E-02	3.26E-02	5.66E-02	8.55E-02	1.19E-01	2.18E-01	3.97E-01	6.24E-01	2.48E+00	2.48E+00
40-69	2221000	88	3.92	2.50E-01	2.78E-02	5.32E-03	3.40E-02	4.52E-02	7.58E-02	1.66E-01	3.21E-01	4.77E-01	7.44E-01	1.50E+00	1.50E+00
70 +	646000	25	4.07	2.56E-01	6.22E-02	1.73E-02	2.15E-02	2.30E-02	7.47E-02	1.38E-01	2.39E-01	9.24E-01	9.39E-01	1.07E+00	1.07E+00
Season															
Fall	1726000	53	3.62	1.97E-01	2.51E-02	0.00E+00	3.26E-02	4.05E-02	8.55E-02	1.66E-01	2.39E-01	3.49E-01	3.97E-01	1.07E+00	1.07E+00
Spring	255000	28	0.55	2.95E-01	7.15E-02	0.00E+00	1.73E-02	3.86E-02	6.93E-02	1.47E-01	3.21E-01	1.09E+00	1.20E+00	1.53E+00	1.53E+00
Summer	2672000	94	5.87												
Winter	500000	33	1.03												
Urbanization															
Central City	865000	30	1.53	2.46E-01	4.23E-02	3.86E-02	5.66E-02	6.72E-02	1.10E-01	1.84E-01	2.73E-01	3.61E-01	9.39E-01	1.10E+00	1.10E+00
Nonmetropolitan	1982000	89	4.40	2.42E-01	3.93E-02	5.32E-03	2.22E-02	3.34E-02	6.93E-02	1.19E-01	2.72E-01	5.37E-01	7.70E-01	2.48E+00	2.48E+00
Suburban	2246000	87	2.59	2.47E-01	3.00E-02	0.00E+00	2.70E-02	3.50E-02	8.55E-02	1.60E-01	2.91E-01	4.90E-01	9.73E-01	1.50E+00	1.53E+00
Race															
Black	127000	6	0.58	*	*	*	*	*	*	*	*	*	*	*	*
White	4892000	198	3.11	2.47E-01	2.23E-02	1.74E-02	2.96E-02	4.05E-02	8.55E-02	1.54E-01	2.91E-01	4.90E-01	9.24E-01	1.81E+00	2.48E+00
Region															
Midwest	1790000	74	3.86	2.34E-01	4.06E-02	5.32E-03	2.22E-02	3.26E-02	5.98E-02	1.47E-01	2.57E-01	3.90E-01	8.45E-01	2.48E+00	2.48E+00
Northeast	786000	31	1.91												
South	1739000	72	2.70	2.30E-01	2.89E-02	3.34E-02	6.74E-02	7.60E-02	1.07E-01	1.66E-01	2.73E-01	4.25E-01	5.26E-01	1.81E+00	1.81E+00
West	778000	29	2.16	2.13E-01	5.04E-02	1.73E-02	2.30E-02	2.70E-02	4.05E-02	8.58E-02	2.53E-01	5.37E-01	9.24E-01	1.07E+00	1.07E+00
Response to Questionnaire															
Households who garden	4898000	199	7.19	2.35E-01	2.09E-02	0.00E+00	2.22E-02	3.40E-02	7.58E-02	1.54E-01	2.85E-01	4.77E-01	8.45E-01	1.50E+00	2.48E+00
Households who farm	867000	35	11.83	3.03E-01	7.50E-02	0.00E+00	2.70E-02	2.96E-02	7.11E-02	1.66E-01	3.55E-01	6.00E-01	8.45E-01	2.48E+00	2.48E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-54. Intake of Home Produced Pork (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1732000	121	0.92	1.23E+00	9.63E-02	9.26E-02	1.40E-01	3.05E-01	5.41E-01	8.96E-01	1.71E+00	2.73E+00	3.37E+00	4.93E+00	7.41E+00
Age															
01-02	38000	5	0.67	*	*	*	*	*	*	*	*	*	*	*	*
03-05	26000	3	0.32	*	*	*	*	*	*	*	*	*	*	*	*
06-11	129000	11	0.77	*	*	*	*	*	*	*	*	*	*	*	*
12-19	291000	20	1.42	1.28E+00	2.42E-01	3.05E-01	3.23E-01	3.37E-01	5.24E-01	8.85E-01	1.75E+00	3.69E+00	3.69E+00	4.29E+00	4.29E+00
20-39	511000	32	0.83	1.21E+00	1.80E-01	1.11E-01	2.83E-01	4.09E-01	5.52E-01	7.89E-01	1.43E+00	2.90E+00	3.08E+00	4.93E+00	4.93E+00
40-69	557000	38	0.98	1.02E+00	1.15E-01	1.19E-01	1.81E-01	2.22E-01	4.05E-01	8.11E-01	1.71E+00	1.78E+00	2.28E+00	3.16E+00	3.16E+00
70 +	180000	12	1.13	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	362000	13	0.76	*	*	*	*	*	*	*	*	*	*	*	*
Spring	547000	59	1.19	1.13E+00	1.29E-01	1.11E-01	1.40E-01	2.22E-01	3.52E-01	8.96E-01	1.50E+00	2.68E+00	3.68E+00	4.29E+00	4.29E+00
Summer	379000	15	0.83	*	*	*	*	*	*	*	*	*	*	*	*
Winter	444000	34	0.91	1.40E+00	2.39E-01	1.26E-01	2.58E-01	3.77E-01	5.03E-01	8.83E-01	2.21E+00	3.08E+00	4.93E+00	7.41E+00	7.41E+00
Urbanization															
Central City	90000	2	0.16	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	1178000	77	2.62	1.39E+00	1.31E-01	9.26E-02	2.15E-01	4.05E-01	6.17E-01	9.66E-01	1.75E+00	3.16E+00	3.69E+00	4.93E+00	7.41E+00
Suburban	464000	42	0.54	8.77E-01	1.20E-01	1.11E-01	1.19E-01	1.81E-01	3.31E-01	5.89E-01	1.10E+00	2.28E+00	2.73E+00	2.90E+00	2.90E+00
Race															
Black	0	0	0.00												
White	1732000	121	1.10	1.23E+00	9.63E-02	9.26E-02	1.40E-01	3.05E-01	5.41E-01	8.96E-01	1.71E+00	2.73E+00	3.37E+00	4.93E+00	7.41E+00
Region															
Midwest	844000	64	1.82	1.06E+00	1.19E-01	9.26E-02	1.19E-01	2.13E-01	5.02E-01	6.72E-01	1.20E+00	2.68E+00	3.37E+00	3.69E+00	3.73E+00
Northeast	97000	5	0.24	*	*	*	*	*	*	*	*	*	*	*	*
South	554000	32	0.86	1.35E+00	1.46E-01	1.81E-01	2.58E-01	3.37E-01	8.11E-01	1.26E+00	1.75E+00	2.44E+00	3.08E+00	4.29E+00	4.29E+00
West	237000	20	0.66	1.15E+00	3.09E-01	1.26E-01	3.23E-01	3.77E-01	4.40E-01	7.29E-01	1.10E+00	1.75E+00	2.73E+00	7.41E+00	7.41E+00
Response to Questionnaire															
Households who raise animals	1428000	100	14.14	1.34E+00	9.86E-02	1.40E-01	3.23E-01	4.05E-01	5.89E-01	9.66E-01	1.75E+00	2.90E+00	3.37E+00	4.29E+00	4.93E+00
Households who farm	1218000	82	16.62	1.30E+00	1.11E-01	2.15E-01	3.42E-01	4.08E-01	5.85E-01	9.24E-01	1.71E+00	3.08E+00	3.69E+00	4.93E+00	4.93E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-55. Intake of Home Produced Poultry (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1816000	105	0.97	1.57E+00	1.15E-01	1.95E-01	3.03E-01	4.18E-01	6.37E-01	1.23E+00	2.19E+00	3.17E+00	3.83E+00	5.33E+00	6.17E+00
Age															
01-02	91000	8	1.60	*	*	*	*	*	*	*	*	*	*	*	*
03-05	70000	5	0.86	*	*	*	*	*	*	*	*	*	*	*	*
06-11	205000	12	1.23	*	*	*	*	*	*	*	*	*	*	*	*
12-19	194000	12	0.95	*	*	*	*	*	*	*	*	*	*	*	*
20-39	574000	33	0.93	1.17E+00	1.47E-01	1.73E-01	4.02E-01	4.02E-01	5.57E-01	1.15E+00	1.37E+00	1.80E+00	2.93E+00	4.59E+00	4.59E+00
40-69	568000	30	1.00	1.51E+00	2.43E-01	1.95E-01	1.97E-01	3.03E-01	4.91E-01	7.74E-01	2.69E+00	3.29E+00	4.60E+00	5.15E+00	5.15E+00
70 +	80000	3	0.50	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	562000	23	1.18	1.52E+00	1.75E-01	4.07E-01	4.18E-01	4.60E-01	8.11E-01	1.39E+00	2.23E+00	2.69E+00	3.17E+00	3.17E+00	3.17E+00
Spring	374000	34	0.81	1.87E+00	2.79E-01	1.73E-01	2.28E-01	3.03E-01	5.22E-01	1.38E+00	3.29E+00	4.60E+00	5.15E+00	5.33E+00	5.33E+00
Summer	312000	11	0.69	*	*	*	*	*	*	*	*	*	*	*	*
Winter	568000	37	1.17	1.55E+00	2.00E-01	1.95E-01	1.97E-01	4.33E-01	5.95E-01	1.23E+00	2.18E+00	2.95E+00	3.47E+00	6.17E+00	6.17E+00
Urbanization															
Central City	230000	8	0.41	*	*	*	*	*	*	*	*	*	*	*	*
Nonmetropolitan	997000	56	2.21	1.48E+00	1.32E-01	1.95E-01	2.82E-01	4.07E-01	6.72E-01	1.19E+00	2.10E+00	3.17E+00	3.29E+00	3.86E+00	5.33E+00
Suburban	589000	41	0.68	1.94E+00	2.30E-01	2.28E-01	2.67E-01	4.33E-01	6.24E-01	1.59E+00	2.69E+00	4.59E+00	4.83E+00	6.17E+00	6.17E+00
Race															
Black	44000	2	0.20	*	*	*	*	*	*	*	*	*	*	*	*
White	1772000	103	1.12	1.57E+00	1.17E-01	1.95E-01	3.03E-01	4.18E-01	6.24E-01	1.23E+00	2.19E+00	3.17E+00	3.86E+00	5.33E+00	6.17E+00
Region															
Midwest	765000	41	1.65	1.60E+00	1.40E-01	4.07E-01	4.18E-01	5.57E-01	9.79E-01	1.39E+00	2.19E+00	2.70E+00	3.17E+00	3.86E+00	5.33E+00
Northeast	64000	4	0.16	*	*	*	*	*	*	*	*	*	*	*	*
South	654000	38	1.02	1.67E+00	2.50E-01	1.73E-01	1.97E-01	3.03E-01	4.60E-01	9.08E-01	2.11E+00	4.59E+00	4.83E+00	6.17E+00	6.17E+00
West	333000	22	0.92	1.24E+00	1.80E-01	2.67E-01	2.67E-01	4.27E-01	5.60E-01	1.02E+00	1.89E+00	2.45E+00	2.93E+00	2.93E+00	2.93E+00
Response to Questionnaire															
Households who raise animals	1333000	81	13.20	1.58E+00	1.18E-01	2.28E-01	4.07E-01	4.72E-01	7.09E-01	1.37E+00	2.19E+00	2.93E+00	3.29E+00	5.33E+00	6.17E+00
Households who farm	917000	59	12.51	1.54E+00	1.79E-01	1.95E-01	2.28E-01	3.03E-01	5.95E-01	1.06E+00	2.18E+00	3.47E+00	4.83E+00	6.17E+00	6.17E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-56. Intake of Homegrown Pumpkins (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	2041000	87	1.09	7.78E-01	6.83E-02	1.25E-01	1.84E-01	2.41E-01	3.18E-01	5.55E-01	1.07E+00	1.47E+00	1.79E+00	3.02E+00	4.48E+00
Age															
01-02	73000	4	1.28	*	*	*	*	*	*	*	*	*	*	*	*
03-05	18000	2	0.22	*	*	*	*	*	*	*	*	*	*	*	*
06-11	229000	9	1.37	*	*	*	*	*	*	*	*	*	*	*	*
12-19	244000	10	1.19	*	*	*	*	*	*	*	*	*	*	*	*
20-39	657000	26	1.07	8.01E-01	1.29E-01	1.76E-01	1.84E-01	3.01E-01	3.77E-01	4.77E-01	1.03E+00	1.73E+00	2.67E+00	2.67E+00	2.67E+00
40-69	415000	20	0.73	8.22E-01	1.57E-01	2.86E-01	2.86E-01	3.16E-01	3.71E-01	5.23E-01	9.62E-01	1.47E+00	3.02E+00	3.02E+00	3.02E+00
70 +	373000	15	2.35	*	*	*	*	*	*	*	*	*	*	*	*
Season															
Fall	1345000	49	2.82	8.19E-01	8.91E-02	1.25E-01	1.76E-01	2.81E-01	3.71E-01	6.14E-01	1.17E+00	1.73E+00	1.79E+00	3.02E+00	3.02E+00
Spring	48000	6	0.10	*	*	*	*	*	*	*	*	*	*	*	*
Summer	405000	13	0.89	*	*	*	*	*	*	*	*	*	*	*	*
Winter	243000	19	0.50	*	*	*	*	*	*	*	*	*	*	*	*
Urbanization															
Central City	565000	20	1.00	6.29E-01	1.08E-01	1.84E-01	1.84E-01	2.41E-01	2.81E-01	3.77E-01	9.40E-01	1.24E+00	1.33E+00	2.24E+00	2.24E+00
Nonmetropolitan	863000	44	1.92	6.44E-01	9.64E-02	1.25E-01	1.65E-01	1.89E-01	3.10E-01	5.10E-01	6.65E-01	1.22E+00	1.45E+00	4.48E+00	4.48E+00
Suburban	613000	23	0.71	1.10E+00	1.34E-01	2.86E-01	2.88E-01	3.01E-01	4.67E-01	1.04E+00	1.47E+00	1.79E+00	2.67E+00	2.67E+00	2.67E+00
Race															
Black	22000	1	0.10	*	*	*	*	*	*	*	*	*	*	*	*
White	2019000	86	1.28	7.82E-01	6.90E-02	1.25E-01	1.84E-01	2.41E-01	3.16E-01	5.55E-01	1.10E+00	1.47E+00	1.79E+00	3.02E+00	4.48E+00
Region															
Midwest	1370000	54	2.95	8.21E-01	9.68E-02	1.25E-01	2.34E-01	2.41E-01	3.18E-01	5.72E-01	1.04E+00	1.73E+00	2.67E+00	3.02E+00	4.48E+00
Northeast	15000	1	0.04	*	*	*	*	*	*	*	*	*	*	*	*
South	179000	10	0.28	*	*	*	*	*	*	*	*	*	*	*	*
West	477000	22	1.32	7.87E-01	9.65E-02	1.76E-01	1.89E-01	3.08E-01	3.71E-01	7.44E-01	1.17E+00	1.47E+00	1.51E+00	1.51E+00	1.51E+00
Response to Questionnaire															
Households who garden	1987000	85	2.92	7.70E-01	6.93E-02	1.25E-01	1.84E-01	2.41E-01	3.16E-01	5.55E-01	1.04E+00	1.46E+00	1.79E+00	3.02E+00	4.48E+00
Households who farm	449000	18	6.13	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-57. Intake of Homegrown Snap Beans (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	12308000	739	6.55	8.00E-01	3.02E-02	5.65E-02	1.49E-01	1.88E-01	3.38E-01	5.69E-01	1.04E+00	1.58E+00	2.01E+00	3.90E+00	9.96E+00
Age															
01-02	246000	17	4.32	*	*	*	*	*	*	*	*	*	*	*	*
03-05	455000	32	5.62	1.49E+00	2.37E-01	0.00E+00	0.00E+00	3.49E-01	9.01E-01	1.16E+00	1.66E+00	3.20E+00	4.88E+00	6.90E+00	6.90E+00
06-11	862000	62	5.16	8.97E-01	1.15E-01	0.00E+00	1.99E-01	2.21E-01	3.21E-01	6.42E-01	1.21E+00	1.79E+00	2.75E+00	4.81E+00	5.66E+00
12-19	1151000	69	5.62	6.38E-01	6.10E-02	0.00E+00	1.61E-01	2.22E-01	3.20E-01	5.04E-01	8.11E-01	1.34E+00	1.79E+00	2.72E+00	2.72E+00
20-39	2677000	160	4.35	6.13E-01	4.09E-02	7.05E-02	1.31E-01	1.57E-01	2.60E-01	4.96E-01	7.85E-01	1.24E+00	1.64E+00	2.05E+00	4.26E+00
40-69	4987000	292	8.79	7.19E-01	3.20E-02	9.99E-02	1.61E-01	2.28E-01	3.62E-01	5.61E-01	8.59E-01	1.45E+00	1.77E+00	2.70E+00	4.23E+00
70 +	1801000	100	11.34	9.15E-01	1.16E-01	5.65E-02	7.44E-02	1.51E-01	3.69E-01	6.38E-01	1.22E+00	1.70E+00	2.01E+00	9.96E+00	9.96E+00
Season															
Fall	3813000	137	8.00	8.12E-01	8.19E-02	5.65E-02	1.50E-01	1.83E-01	2.72E-01	5.39E-01	1.18E+00	1.52E+00	2.01E+00	4.82E+00	9.96E+00
Spring	2706000	288	5.86	9.00E-01	5.44E-02	2.93E-02	1.51E-01	2.19E-01	3.70E-01	5.91E-01	1.11E+00	1.72E+00	2.85E+00	5.66E+00	6.90E+00
Summer	2946000	98	6.48	6.33E-01	4.81E-02	0.00E+00	1.18E-01	1.57E-01	3.31E-01	5.04E-01	8.50E-01	1.30E+00	1.70E+00	2.05E+00	2.63E+00
Winter	2843000	216	5.84	8.64E-01	5.28E-02	1.14E-01	1.80E-01	2.44E-01	4.24E-01	6.20E-01	1.12E+00	1.72E+00	2.02E+00	3.85E+00	7.88E+00
Urbanization															
Central City	2205000	78	3.91	5.97E-01	5.59E-02	5.65E-02	7.44E-02	1.59E-01	2.56E-01	5.12E-01	7.12E-01	1.23E+00	1.54E+00	1.93E+00	3.35E+00
Nonmetropolitan	5696000	404	12.65	9.61E-01	5.06E-02	9.35E-02	1.77E-01	2.29E-01	3.67E-01	6.75E-01	1.19E+00	1.89E+00	2.70E+00	4.88E+00	9.96E+00
Suburban	4347000	255	5.02	7.04E-01	3.76E-02	9.67E-02	1.39E-01	1.88E-01	3.41E-01	5.20E-01	9.32E-01	1.36E+00	1.77E+00	2.98E+00	6.08E+00
Race															
Black	634000	36	2.92	7.55E-01	1.43E-01	2.51E-01	2.51E-01	2.79E-01	2.99E-01	4.78E-01	1.04E+00	1.30E+00	1.34E+00	5.98E+00	5.98E+00
White	11519000	694	7.31	8.10E-01	3.12E-02	7.05E-02	1.50E-01	1.89E-01	3.49E-01	5.73E-01	1.06E+00	1.63E+00	2.01E+00	3.90E+00	9.96E+00
Region															
Midwest	4651000	307	10.02	8.60E-01	6.11E-02	7.44E-02	1.54E-01	1.89E-01	3.36E-01	5.50E-01	9.88E-01	1.70E+00	2.47E+00	4.88E+00	9.96E+00
Northeast	990000	52	2.40	5.66E-01	6.63E-02	0.00E+00	9.66E-02	1.06E-01	1.81E-01	4.91E-01	8.15E-01	1.28E+00	1.36E+00	1.97E+00	3.09E+00
South	4755000	286	7.39	8.82E-01	4.04E-02	1.33E-01	2.13E-01	2.51E-01	3.98E-01	6.75E-01	1.22E+00	1.72E+00	2.01E+00	3.23E+00	5.98E+00
West	1852000	92	5.14	5.92E-01	4.35E-02	7.05E-02	1.43E-01	1.83E-01	2.72E-01	5.14E-01	7.41E-01	1.20E+00	1.52E+00	2.19E+00	2.19E+00
Response to Questionnaire															
Households who garden	11843000	700	17.38	7.90E-01	3.08E-02	5.65E-02	1.49E-01	1.87E-01	3.31E-01	5.63E-01	1.02E+00	1.60E+00	2.01E+00	3.85E+00	9.96E+00
Households who farm	2591000	157	35.35	7.95E-01	4.78E-02	5.65E-02	1.27E-01	1.89E-01	4.05E-01	6.59E-01	1.12E+00	1.54E+00	1.98E+00	2.96E+00	4.23E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-58. Intake of Homegrown Strawberries (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	2057000	139	1.09	6.52E-01	5.15E-02	4.15E-02	8.16E-02	1.18E-01	2.55E-01	4.67E-01	8.20E-01	1.47E+00	1.77E+00	2.72E+00	4.83E+00
Age															
01-02	30000	2	0.53	*	*	*	*	*	*	*	*	*	*	*	*
03-05	66000	6	0.81	*	*	*	*	*	*	*	*	*	*	*	*
06-11	153000	15	0.92	*	*	*	*	*	*	*	*	*	*	*	*
12-19	201000	11	0.98	*	*	*	*	*	*	*	*	*	*	*	*
20-39	316000	22	0.51	3.21E-01	6.41E-02	7.92E-02	8.16E-02	1.05E-01	1.18E-01	2.05E-01	4.59E-01	8.20E-01	9.73E-01	1.56E+00	1.56E+00
40-69	833000	55	1.47	6.44E-01	6.37E-02	2.44E-02	6.53E-02	1.75E-01	3.55E-01	5.83E-01	9.41E-01	1.42E+00	1.47E+00	2.37E+00	2.37E+00
70 +	449000	27	2.83	6.36E-01	1.11E-01	4.15E-02	4.41E-02	8.64E-02	2.62E-01	4.69E-01	7.00E-01	1.66E+00	1.89E+00	2.72E+00	2.72E+00
Season															
Fall	250000	8	0.52	*	*	*	*	*	*	*	*	*	*	*	*
Spring	598000	66	1.30	8.30E-01	1.03E-01	7.92E-02	8.92E-02	1.80E-01	2.75E-01	4.69E-01	9.73E-01	1.93E+00	2.54E+00	4.83E+00	4.83E+00
Summer	388000	11	0.85	*	*	*	*	*	*	*	*	*	*	*	*
Winter	821000	54	1.69	5.13E-01	6.42E-02	2.44E-02	4.41E-02	1.05E-01	2.07E-01	3.86E-01	6.01E-01	1.27E+00	1.46E+00	2.37E+00	2.37E+00
Urbanization															
Central City	505000	23	0.90	7.54E-01	1.22E-01	4.15E-02	4.41E-02	8.92E-02	3.82E-01	4.88E-01	1.33E+00	1.47E+00	1.69E+00	2.37E+00	2.37E+00
Nonmetropolitan	664000	52	1.47	6.18E-01	1.05E-01	2.44E-02	6.53E-02	8.16E-02	1.25E-01	3.85E-01	8.14E-01	1.66E+00	2.16E+00	4.83E+00	4.83E+00
Suburban	888000	64	1.03	6.20E-01	5.88E-02	7.92E-02	1.81E-01	2.21E-01	3.45E-01	5.30E-01	6.96E-01	1.27E+00	1.56E+00	2.97E+00	2.97E+00
Race															
Black	0	0	0.00												
White	2057000	139	1.31	6.52E-01	5.15E-02	4.15E-02	8.16E-02	1.18E-01	2.55E-01	4.67E-01	8.20E-01	1.47E+00	1.77E+00	2.72E+00	4.83E+00
Region															
Midwest	1123000	76	2.42	6.85E-01	8.28E-02	2.44E-02	6.53E-02	8.16E-02	1.82E-01	4.16E-01	1.00E+00	1.66E+00	1.93E+00	2.97E+00	4.83E+00
Northeast	382000	25	0.93	6.35E-01	1.01E-01	8.92E-02	1.59E-01	1.82E-01	2.55E-01	4.67E-01	8.65E-01	1.46E+00	1.83E+00	2.16E+00	2.16E+00
South	333000	23	0.52	6.69E-01	8.41E-02	1.33E-01	2.05E-01	3.77E-01	5.15E-01	6.21E-01	6.96E-01	1.00E+00	1.00E+00	2.72E+00	2.72E+00
West	219000	15	0.61	*	*	*	*	*	*	*	*	*	*	*	*
Response to Questionnaire															
Households who garden	1843000	123	2.70	6.37E-01	5.48E-02	4.15E-02	7.92E-02	1.18E-01	2.28E-01	4.53E-01	8.20E-01	1.46E+00	1.77E+00	2.54E+00	4.83E+00
Households who farm	87000	9	1.19	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-59. Intake of Homegrown Tomatoes (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	16737000	743	8.90	1.18E+00	5.26E-02	7.57E-02	1.52E-01	2.34E-01	3.92E-01	7.43E-01	1.46E+00	2.50E+00	3.54E+00	7.26E+00	1.93E+01
Age															
01-02	572000	26	10.04	3.14E+00	5.30E-01	7.26E-01	8.55E-01	9.34E-01	1.23E+00	1.66E+00	4.00E+00	7.26E+00	1.07E+01	1.07E+01	1.07E+01
03-05	516000	26	6.37	1.61E+00	2.65E-01	4.96E-01	5.07E-01	5.07E-01	7.54E-01	1.25E+00	1.65E+00	3.00E+00	6.25E+00	6.25E+00	6.25E+00
06-11	1093000	51	6.54	1.63E+00	2.68E-01	2.17E-01	3.10E-01	3.92E-01	5.30E-01	7.55E-01	1.66E+00	5.20E+00	5.70E+00	9.14E+00	9.14E+00
12-19	1411000	61	6.89	7.15E-01	8.52E-02	0.00E+00	0.00E+00	1.82E-01	2.68E-01	5.21E-01	8.50E-01	1.67E+00	1.94E+00	3.39E+00	3.39E+00
20-39	4169000	175	6.77	8.54E-01	1.03E-01	7.32E-02	1.31E-01	1.47E-01	2.54E-01	5.15E-01	1.00E+00	1.83E+00	2.10E+00	5.52E+00	1.93E+01
40-69	6758000	305	11.92	1.05E+00	5.23E-02	1.13E-01	1.73E-01	2.81E-01	3.97E-01	7.46E-01	1.41E+00	2.40E+00	3.05E+00	4.50E+00	5.00E+00
70 +	1989000	89	12.53	1.26E+00	9.40E-02	1.13E-01	2.36E-01	2.98E-01	4.82E-01	1.14E+00	1.77E+00	2.51E+00	2.99E+00	3.67E+00	3.67E+00
Season															
Fall	5516000	201	11.57	1.02E+00	8.55E-02	7.32E-02	1.35E-01	2.23E-01	3.43E-01	5.95E-01	1.34E+00	2.24E+00	2.87E+00	6.25E+00	1.07E+01
Spring	1264000	127	2.74	8.39E-01	6.26E-02	1.36E-01	1.89E-01	2.39E-01	3.73E-01	6.31E-01	1.11E+00	1.75E+00	2.00E+00	3.79E+00	5.28E+00
Summer	8122000	279	17.86	1.30E+00	8.75E-02	1.05E-01	1.66E-01	2.36E-01	4.08E-01	8.03E-01	1.55E+00	3.05E+00	4.05E+00	7.26E+00	1.09E+01
Winter	1835000	136	3.77	1.37E+00	1.77E-01	9.07E-02	2.07E-01	2.85E-01	4.97E-01	8.29E-01	1.49E+00	2.48E+00	3.38E+00	8.29E+00	1.93E+01
Urbanization															
Central City	2680000	90	4.76	1.10E+00	1.27E-01	0.00E+00	1.52E-01	2.25E-01	3.54E-01	7.54E-01	1.51E+00	2.16E+00	2.95E+00	7.26E+00	8.29E+00
Nonmetropolitan	7389000	378	16.41	1.26E+00	7.35E-02	1.13E-01	2.16E-01	2.62E-01	4.23E-01	7.62E-01	1.47E+00	2.77E+00	3.85E+00	6.87E+00	1.07E+01
Suburban	6668000	275	7.70	1.13E+00	9.14E-02	7.57E-02	1.35E-01	1.78E-01	3.70E-01	6.68E-01	1.38E+00	2.35E+00	3.32E+00	5.52E+00	1.93E+01
Race															
Black	743000	28	3.42	6.14E-01	8.60E-02	0.00E+00	0.00E+00	7.32E-02	2.36E-01	5.07E-01	9.02E-01	1.18E+00	1.55E+00	1.66E+00	1.66E+00
White	15658000	703	9.94	1.22E+00	5.54E-02	1.05E-01	1.68E-01	2.41E-01	4.06E-01	7.55E-01	1.49E+00	2.55E+00	3.59E+00	7.26E+00	1.93E+01
Region															
Midwest	6747000	322	14.54	1.18E+00	8.91E-02	6.34E-02	1.45E-01	2.06E-01	3.62E-01	6.82E-01	1.41E+00	2.51E+00	3.69E+00	6.87E+00	1.93E+01
Northeast	2480000	87	6.02	1.17E+00	1.64E-01	7.57E-02	1.35E-01	1.48E-01	3.50E-01	7.51E-01	1.38E+00	2.44E+00	3.52E+00	1.09E+01	1.09E+01
South	4358000	202	6.77	1.15E+00	9.07E-02	0.00E+00	2.07E-01	2.53E-01	4.23E-01	7.46E-01	1.43E+00	2.32E+00	3.67E+00	6.82E+00	9.14E+00
West	3152000	132	8.74	1.23E+00	9.90E-02	1.80E-01	2.39E-01	2.84E-01	4.11E-01	7.65E-01	1.84E+00	2.78E+00	3.08E+00	7.26E+00	7.26E+00
Response to Questionnaire															
Households who garden	14791000	661	21.70	1.21E+00	5.70E-02	7.57E-02	1.52E-01	2.34E-01	4.06E-01	7.58E-01	1.50E+00	2.51E+00	3.52E+00	7.26E+00	1.93E+01
Households who farm	2269000	112	30.96	1.42E+00	1.58E-01	0.00E+00	1.80E-01	2.26E-01	4.23E-01	7.66E-01	1.86E+00	3.55E+00	5.20E+00	9.14E+00	9.14E+00

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-60. Intake of Homegrown White Potatoes (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	5895000	281	3.14	1.66E+00	1.05E-01	0.00E+00	1.87E-01	3.08E-01	5.50E-01	1.27E+00	2.07E+00	3.11E+00	4.76E+00	9.52E+00	1.28E+01
Age															
01-02	147000	10	2.58	*	*	*	*	*	*	*	*	*	*	*	*
03-05	119000	6	1.47	*	*	*	*	*	*	*	*	*	*	*	*
06-11	431000	24	2.58	2.19E+00	3.85E-01	0.00E+00	0.00E+00	4.10E-01	7.20E-01	1.76E+00	3.10E+00	5.94E+00	6.52E+00	6.52E+00	6.52E+00
12-19	751000	31	3.67	1.26E+00	1.85E-01	6.67E-02	1.87E-01	2.59E-01	3.84E-01	1.22E+00	1.80E+00	2.95E+00	3.11E+00	4.14E+00	4.14E+00
20-39	1501000	66	2.44	1.24E+00	1.21E-01	1.64E-01	1.64E-01	1.96E-01	4.77E-01	1.00E+00	1.62E+00	2.54E+00	3.08E+00	4.29E+00	5.09E+00
40-69	1855000	95	3.27	1.86E+00	2.29E-01	1.27E-01	2.62E-01	3.50E-01	6.99E-01	1.31E+00	2.04E+00	3.43E+00	5.29E+00	1.28E+01	1.28E+01
70 +	1021000	45	6.43	1.27E+00	1.22E-01	2.06E-01	2.17E-01	3.57E-01	5.50E-01	1.21E+00	1.69E+00	2.35E+00	2.88E+00	3.92E+00	3.92E+00
Season															
Fall	2267000	86	4.76	1.63E+00	2.23E-01	1.64E-01	2.23E-01	2.65E-01	4.61E-01	1.13E+00	1.79E+00	3.43E+00	4.14E+00	1.28E+01	1.28E+01
Spring	527000	58	1.14	1.23E+00	1.28E-01	6.67E-02	1.05E-01	1.96E-01	4.10E-01	8.55E-01	1.91E+00	2.86E+00	3.08E+00	4.28E+00	4.28E+00
Summer	2403000	81	5.28	1.63E+00	1.82E-01	0.00E+00	1.87E-01	3.19E-01	6.20E-01	1.32E+00	2.09E+00	3.08E+00	5.29E+00	9.43E+00	9.43E+00
Winter	698000	56	1.43	2.17E+00	1.98E-01	1.41E-01	3.95E-01	4.97E-01	8.64E-01	2.02E+00	2.95E+00	4.26E+00	5.40E+00	6.00E+00	6.00E+00
Urbanization															
Central City	679000	25	1.20	9.60E-01	1.51E-01	1.64E-01	1.64E-01	1.75E-01	3.75E-01	5.55E-01	1.52E+00	2.07E+00	2.25E+00	2.54E+00	2.54E+00
Nonmetropolitan	3046000	159	6.77	1.96E+00	1.55E-01	1.84E-01	2.65E-01	3.68E-01	7.67E-01	1.50E+00	2.38E+00	3.55E+00	5.64E+00	1.28E+01	1.28E+01
Suburban	2110000	95	2.44	1.49E+00	1.67E-01	1.05E-01	1.87E-01	3.19E-01	5.40E-01	9.29E-01	1.68E+00	3.11E+00	4.76E+00	9.43E+00	9.43E+00
Race															
Black	140000	5	0.64	*	*	*	*	*	*	*	*	*	*	*	*
White	5550000	269	3.52	1.67E+00	1.09E-01	1.41E-01	2.06E-01	3.08E-01	5.50E-01	1.28E+00	2.09E+00	3.11E+00	4.76E+00	9.52E+00	1.28E+01
Region															
Midwest	2587000	133	5.58	1.77E+00	1.47E-01	1.75E-01	2.36E-01	3.39E-01	6.41E-01	1.35E+00	2.15E+00	3.77E+00	5.29E+00	9.43E+00	9.43E+00
Northeast	656000	31	1.59	1.28E+00	2.04E-01	6.67E-02	1.27E-01	1.67E-01	3.48E-01	8.64E-01	1.97E+00	2.95E+00	3.80E+00	5.09E+00	5.09E+00
South	1796000	84	2.79	2.08E+00	2.39E-01	1.64E-01	3.50E-01	4.61E-01	9.24E-01	1.56E+00	2.40E+00	3.44E+00	5.64E+00	1.28E+01	1.28E+01
West	796000	31	2.21	7.61E-01	1.05E-01	1.64E-01	2.16E-01	2.59E-01	4.11E-01	5.43E-01	9.63E-01	1.40E+00	1.95E+00	3.11E+00	3.11E+00
Response to Questionnaire															
Households who garden	5291000	250	7.76	1.65E+00	1.09E-01	0.00E+00	2.06E-01	3.08E-01	5.55E-01	1.28E+00	2.09E+00	3.10E+00	4.28E+00	9.52E+00	1.28E+01
Households who farm	1082000	62	14.76	1.83E+00	1.78E-01	6.67E-02	2.06E-01	5.76E-01	9.24E-01	1.46E+00	2.31E+00	3.80E+00	5.09E+00	6.52E+00	6.52E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-61. Intake of Homegrown Exposed Fruit (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	11770000	679	6.26	1.49E+00	8.13E-02	4.41E-02	1.37E-01	2.55E-01	4.46E-01	8.33E-01	1.70E+00	3.16E+00	4.78E+00	1.20E+01	3.25E+01
Age															
01-02	306000	19	5.37	*	*	*	*	*	*	*	*	*	*	*	*
03-05	470000	30	5.80	2.60E+00	7.78E-01	0.00E+00	0.00E+00	3.73E-01	1.00E+00	1.82E+00	2.64E+00	5.41E+00	6.07E+00	3.25E+01	3.25E+01
06-11	915000	68	5.48	2.52E+00	4.24E-01	0.00E+00	1.71E-01	3.73E-01	6.19E-01	1.11E+00	2.91E+00	6.98E+00	1.17E+01	1.57E+01	1.59E+01
12-19	896000	50	4.37	1.33E+00	2.06E-01	8.46E-02	1.23E-01	2.58E-01	4.04E-01	6.09E-01	2.27E+00	3.41E+00	4.78E+00	5.90E+00	5.90E+00
20-39	2521000	139	4.09	1.09E+00	1.44E-01	7.93E-02	1.30E-01	1.67E-01	3.04E-01	6.15E-01	1.07E+00	2.00E+00	3.58E+00	1.29E+01	1.29E+01
40-69	4272000	247	7.53	1.25E+00	1.10E-01	6.46E-02	1.64E-01	2.54E-01	4.39E-01	7.19E-01	1.40E+00	2.61E+00	3.25E+00	1.30E+01	1.30E+01
70 +	2285000	118	14.39	1.39E+00	1.17E-01	4.41E-02	2.07E-01	2.82E-01	5.71E-01	9.57E-01	1.66E+00	3.73E+00	4.42E+00	5.39E+00	7.13E+00
Season															
Fall	2877000	100	6.04	1.37E+00	1.16E-01	2.59E-01	2.91E-01	3.42E-01	5.43E-01	1.03E+00	1.88E+00	2.88E+00	4.25E+00	5.41E+00	5.41E+00
Spring	2466000	265	5.34	1.49E+00	1.51E-01	8.91E-02	1.98E-01	2.54E-01	4.32E-01	8.56E-01	1.65E+00	2.91E+00	4.67E+00	8.27E+00	3.25E+01
Summer	3588000	122	7.89	1.75E+00	2.50E-01	0.00E+00	8.66E-02	1.30E-01	3.89E-01	6.41E-01	1.76E+00	4.29E+00	6.12E+00	1.30E+01	1.57E+01
Winter	2839000	192	5.83	1.27E+00	1.06E-01	4.15E-02	1.04E-01	2.31E-01	4.59E-01	8.29E-01	1.55E+00	2.61E+00	4.66E+00	8.16E+00	1.13E+01
Urbanization															
Central City	2552000	99	4.53	1.34E+00	1.98E-01	4.41E-02	1.01E-01	2.59E-01	4.46E-01	8.63E-01	1.60E+00	2.37E+00	2.88E+00	1.30E+01	1.30E+01
Nonmetropolitan	3891000	269	8.64	1.78E+00	1.67E-01	6.46E-02	1.04E-01	1.67E-01	4.15E-01	9.42E-01	1.94E+00	4.07E+00	5.98E+00	1.57E+01	3.25E+01
Suburban	5267000	309	6.08	1.36E+00	9.00E-02	9.18E-02	2.07E-01	2.93E-01	4.69E-01	7.73E-01	1.65E+00	3.16E+00	4.67E+00	7.29E+00	1.29E+01
Race															
Black	250000	12	1.15	*	*	*	*	*	*	*	*	*	*	*	*
White	11411000	663	7.24	1.51E+00	8.33E-02	6.49E-02	1.55E-01	2.59E-01	4.49E-01	8.56E-01	1.72E+00	3.31E+00	4.78E+00	1.20E+01	3.25E+01
Region															
Midwest	4429000	293	9.55	1.60E+00	1.42E-01	4.41E-02	1.25E-01	2.23E-01	4.23E-01	8.78E-01	1.88E+00	3.58E+00	4.78E+00	1.20E+01	3.25E+01
Northeast	1219000	69	2.96	7.55E-01	1.18E-01	8.08E-02	8.66E-02	1.65E-01	3.00E-01	4.74E-01	7.84E-01	1.39E+00	2.86E+00	5.21E+00	7.13E+00
South	2532000	141	3.94	1.51E+00	1.84E-01	7.93E-02	2.32E-01	3.01E-01	5.08E-01	9.16E-01	1.63E+00	2.63E+00	5.98E+00	1.57E+01	1.57E+01
West	3530000	174	9.79	1.60E+00	1.43E-01	1.00E-01	2.40E-01	3.17E-01	5.69E-01	9.57E-01	1.97E+00	3.72E+00	5.00E+00	1.30E+01	1.30E+01
Response to Questionnaire															
Households who garden	10197000	596	14.96	1.55E+00	9.12E-02	4.15E-02	1.58E-01	2.58E-01	4.49E-01	8.78E-01	1.73E+00	3.41E+00	5.00E+00	1.29E+01	3.25E+01
Households who farm	1917000	112	26.16	2.32E+00	2.50E-01	7.21E-02	2.76E-01	3.71E-01	6.81E-01	1.30E+00	3.14E+00	5.00E+00	6.12E+00	1.57E+01	1.57E+01

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-62. Intake of Homegrown Protected Fruits (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	3855000	173	2.05	5.74E+00	6.25E-01	1.50E-01	2.66E-01	3.35E-01	9.33E-01	2.34E+00	7.45E+00	1.60E+01	1.97E+01	4.73E+01	5.36E+01
Age															
01-02	79000	5	1.39	*	*	*	*	*	*	*	*	*	*	*	*
03-05	80000	4	0.99	*	*	*	*	*	*	*	*	*	*	*	*
06-11	181000	9	1.08	*	*	*	*	*	*	*	*	*	*	*	*
12-19	377000	20	1.84	2.96E+00	9.93E-01	1.17E-01	1.60E-01	2.83E-01	3.93E-01	1.23E+00	2.84E+00	7.44E+00	1.14E+01	1.91E+01	1.91E+01
20-39	755000	29	1.23	4.51E+00	1.08E+00	1.81E-01	3.62E-01	4.87E-01	1.22E+00	1.88E+00	4.47E+00	1.46E+01	1.61E+01	2.41E+01	2.41E+01
40-69	1702000	77	3.00	5.65E+00	8.66E-01	1.12E-01	2.44E-01	2.87E-01	6.69E-01	2.22E+00	9.36E+00	1.55E+01	2.12E+01	4.13E+01	4.13E+01
70 +	601000	26	3.78	4.44E+00	6.91E-01	2.62E-01	2.62E-01	2.85E-01	1.95E+00	3.29E+00	7.06E+00	8.97E+00	9.97E+00	1.52E+01	1.52E+01
Season															
Fall	394000	12	0.83	*	*	*	*	*	*	*	*	*	*	*	*
Spring	497000	36	1.08	2.08E+00	3.47E-01	1.60E-01	1.81E-01	2.55E-01	3.78E-01	1.22E+00	4.08E+00	5.10E+00	6.57E+00	6.79E+00	6.79E+00
Summer	1425000	47	3.13	7.39E+00	1.45E+00	1.12E-01	2.66E-01	3.93E-01	1.25E+00	3.06E+00	1.03E+01	1.66E+01	2.41E+01	5.36E+01	5.36E+01
Winter	1539000	78	3.16	6.24E+00	9.10E-01	1.50E-01	3.02E-01	3.76E-01	1.39E+00	2.65E+00	8.23E+00	1.78E+01	2.12E+01	4.73E+01	4.73E+01
Urbanization															
Central City	1312000	50	2.33	3.94E+00	5.80E-01	1.50E-01	2.62E-01	3.33E-01	8.34E-01	3.01E+00	5.01E+00	9.23E+00	9.97E+00	1.88E+01	1.88E+01
Nonmetropolitan	506000	19	1.12	*	*	*	*	*	*	*	*	*	*	*	*
Suburban	2037000	104	2.35	6.83E+00	9.38E-01	1.12E-01	2.53E-01	2.92E-01	5.94E-01	2.01E+00	1.03E+01	1.79E+01	2.38E+01	5.36E+01	5.36E+01
Race															
Black	200000	8	0.92	*	*	*	*	*	*	*	*	*	*	*	*
White	3655000	165	2.32	5.91E+00	6.48E-01	1.17E-01	2.62E-01	3.33E-01	1.06E+00	2.44E+00	7.46E+00	1.60E+01	2.12E+01	4.73E+01	5.36E+01
Region															
Midwest	657000	24	1.42	1.07E+01	2.60E+00	2.53E-01	2.62E-01	2.85E-01	1.18E+00	7.44E+00	1.46E+01	2.41E+01	4.13E+01	5.36E+01	5.36E+01
Northeast	105000	5	0.26	*	*	*	*	*	*	*	*	*	*	*	*
South	1805000	74	2.81	4.77E+00	6.47E-01	1.60E-01	3.64E-01	4.50E-01	1.23E+00	2.54E+00	5.10E+00	1.52E+01	1.66E+01	2.38E+01	2.40E+01
West	1288000	70	3.57	4.85E+00	9.26E-01	1.12E-01	1.81E-01	2.68E-01	4.94E-01	1.84E+00	5.34E+00	1.23E+01	1.88E+01	4.73E+01	4.73E+01
Response to Questionnaire															
Households who garden	3360000	146	4.93	5.90E+00	6.97E-01	1.17E-01	2.65E-01	3.35E-01	1.16E+00	2.42E+00	7.46E+00	1.60E+01	1.91E+01	4.73E+01	5.36E+01
Households who farm	357000	14	4.87	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-63. Intake of Homegrown Exposed Vegetables (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	28762000	1511	15.30	1.52E+00	5.10E-02	3.25E-03	9.15E-02	1.72E-01	3.95E-01	8.60E-01	1.83E+00	3.55E+00	5.12E+00	1.03E+01	2.06E+01
Age															
01-02	815000	43	14.30	3.48E+00	5.14E-01	2.28E-02	2.39E-01	8.34E-01	1.20E+00	1.89E+00	4.23E+00	1.07E+01	1.19E+01	1.21E+01	1.21E+01
03-05	1069000	62	13.19	1.74E+00	2.20E-01	0.00E+00	7.23E-03	4.85E-02	5.79E-01	1.16E+00	2.53E+00	3.47E+00	6.29E+00	7.36E+00	8.86E+00
06-11	2454000	134	14.68	1.39E+00	1.76E-01	0.00E+00	4.44E-02	9.42E-02	3.12E-01	6.43E-01	1.60E+00	3.22E+00	5.47E+00	1.33E+01	1.33E+01
12-19	2611000	143	12.74	1.07E+00	9.43E-02	0.00E+00	2.92E-02	1.42E-01	3.04E-01	6.56E-01	1.46E+00	2.35E+00	3.78E+00	5.67E+00	5.67E+00
20-39	6969000	348	11.31	1.05E+00	8.14E-02	8.20E-03	6.56E-02	1.17E-01	2.55E-01	5.58E-01	1.26E+00	2.33E+00	3.32E+00	7.57E+00	2.06E+01
40-69	10993000	579	19.38	1.60E+00	8.32E-02	3.25E-03	1.41E-01	2.44E-01	4.79E-01	9.81E-01	1.92E+00	3.59E+00	5.22E+00	8.99E+00	1.90E+01
70 +	3517000	185	22.15	1.68E+00	1.21E-01	5.21E-03	1.51E-01	2.39E-01	5.22E-01	1.13E+00	2.38E+00	4.08E+00	4.96E+00	6.96E+00	1.02E+01
Season															
Fall	8865000	314	18.60	1.31E+00	9.80E-02	5.24E-02	1.11E-01	1.80E-01	3.33E-01	6.49E-01	1.56E+00	3.13E+00	4.45E+00	8.92E+00	1.22E+01
Spring	4863000	487	10.54	1.14E+00	6.35E-02	2.35E-03	4.53E-02	1.53E-01	3.38E-01	6.58E-01	1.39E+00	2.76E+00	4.02E+00	7.51E+00	1.07E+01
Summer	10151000	348	22.32	2.03E+00	1.26E-01	2.17E-03	1.13E-01	2.04E-01	6.07E-01	1.30E+00	2.52E+00	4.32E+00	6.35E+00	1.27E+01	1.90E+01
Winter	4883000	362	10.02	1.21E+00	9.50E-02	4.23E-03	2.28E-02	1.37E-01	3.70E-01	6.67E-01	1.42E+00	2.76E+00	3.69E+00	8.86E+00	2.06E+01
Urbanization															
Central City	4859000	173	8.62	1.11E+00	1.02E-01	1.01E-02	6.04E-02	8.02E-02	2.83E-01	7.01E-01	1.43E+00	2.49E+00	3.29E+00	8.34E+00	1.21E+01
Nonmetropolitan	11577000	711	25.71	1.87E+00	8.79E-02	1.65E-02	1.72E-01	2.52E-01	5.01E-01	1.16E+00	2.20E+00	4.12E+00	6.10E+00	1.22E+01	1.90E+01
Suburban	12266000	625	14.17	1.35E+00	7.01E-02	2.93E-03	9.68E-02	1.56E-01	3.55E-01	7.44E-01	1.58E+00	3.22E+00	5.22E+00	8.61E+00	2.06E+01
Race															
Black	1713000	100	7.88	1.23E+00	1.27E-01	0.00E+00	7.74E-02	1.41E-01	3.52E-01	8.93E-01	1.51E+00	3.32E+00	3.92E+00	5.55E+00	7.19E+00
White	26551000	1386	16.85	1.53E+00	5.41E-02	4.67E-03	9.74E-02	1.77E-01	3.95E-01	8.59E-01	1.82E+00	3.48E+00	5.12E+00	1.03E+01	2.06E+01
Region															
Midwest	10402000	570	22.42	1.48E+00	8.91E-02	1.00E-02	7.14E-02	1.57E-01	3.88E-01	8.06E-01	1.69E+00	3.55E+00	4.67E+00	1.19E+01	2.06E+01
Northeast	4050000	191	9.84	1.65E+00	1.78E-01	2.35E-03	8.05E-02	1.38E-01	2.61E-01	6.65E-01	1.75E+00	5.58E+00	6.80E+00	1.27E+01	1.49E+01
South	9238000	503	14.36	1.55E+00	7.79E-02	5.20E-02	1.63E-01	2.61E-01	5.18E-01	9.99E-01	1.92E+00	3.19E+00	4.52E+00	9.92E+00	1.33E+01
West	5012000	245	13.90	1.43E+00	1.02E-01	3.25E-03	2.61E-02	1.45E-01	3.91E-01	7.63E-01	2.13E+00	3.45E+00	4.84E+00	7.51E+00	8.34E+00
Response to Questionnaire															
Households who garden	25737000	1361	37.76	1.57	5.50E-02	3.25E-03	8.87E-02	1.68E-01	4.13E-01	8.89E-01	1.97E+00	3.63E+00	5.45E+00	1.03E+01	2.06E+01
Households who farm	3596000	207	49.07	2.17	1.61E-01	0.00E+00	1.84E-01	3.72E-01	6.47E-01	1.38E+00	2.81E+00	6.01E+00	6.83E+00	1.03E+01	1.33E+01

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-64. Intake of Homegrown Protected Vegetables (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	11428000	656	6.08	1.01E+00	4.95E-02	1.03E-01	1.54E-01	1.94E-01	3.22E-01	6.25E-01	1.20E+00	2.24E+00	3.05E+00	6.49E+00	9.42E+00
Age															
01-02	348000	21	6.11	2.46E+00	4.91E-01	3.15E-01	3.15E-01	5.38E-01	1.36E+00	1.94E+00	2.96E+00	3.88E+00	9.42E+00	9.42E+00	9.42E+00
03-05	440000	32	5.43	1.30E+00	2.13E-01	2.33E-01	2.33E-01	3.22E-01	4.80E-01	1.04E+00	1.48E+00	2.51E+00	5.10E+00	5.31E+00	5.31E+00
06-11	1052000	63	6.30	1.10E+00	1.34E-01	1.89E-01	2.08E-01	3.18E-01	3.87E-01	7.91E-01	1.31E+00	2.14E+00	3.12E+00	5.40E+00	5.40E+00
12-19	910000	51	4.44	7.76E-01	8.71E-02	5.88E-02	1.61E-01	2.39E-01	3.54E-01	5.83E-01	8.24E-01	1.85E+00	2.20E+00	2.69E+00	2.69E+00
20-39	3227000	164	5.24	7.62E-01	6.03E-02	1.13E-01	1.52E-01	1.71E-01	2.41E-01	5.08E-01	9.67E-01	1.73E+00	2.51E+00	3.63E+00	4.76E+00
40-69	3818000	226	6.73	9.30E-01	7.32E-02	6.87E-02	1.35E-01	1.66E-01	3.16E-01	6.03E-01	1.11E+00	1.87E+00	3.04E+00	6.84E+00	7.44E+00
70 +	1442000	89	9.08	1.05E+00	1.62E-01	1.19E-01	2.10E-01	2.42E-01	3.57E-01	5.72E-01	1.21E+00	1.86E+00	3.05E+00	9.23E+00	9.23E+00
Season															
Fall	3907000	143	8.20	8.51E-01	7.02E-02	1.19E-01	1.61E-01	2.04E-01	3.22E-01	5.68E-01	1.10E+00	1.73E+00	2.51E+00	4.78E+00	5.31E+00
Spring	2086000	236	4.52	7.02E-01	4.48E-02	5.88E-02	1.35E-01	1.70E-01	2.66E-01	4.90E-01	9.08E-01	1.44E+00	1.86E+00	3.74E+00	5.73E+00
Summer	3559000	118	7.82	1.40E+00	1.56E-01	1.03E-01	1.77E-01	2.33E-01	3.81E-01	7.81E-01	1.69E+00	3.05E+00	5.40E+00	9.23E+00	9.42E+00
Winter	1876000	159	3.85	9.30E-01	7.70E-02	1.18E-01	1.42E-01	1.82E-01	3.12E-01	6.01E-01	1.20E+00	2.32E+00	3.06E+00	4.76E+00	6.39E+00
Urbanization															
Central City	1342000	49	2.38	9.96E-01	1.51E-01	1.19E-01	1.53E-01	1.67E-01	3.18E-01	7.21E-01	1.18E+00	2.36E+00	2.83E+00	4.78E+00	4.78E+00
Nonmetropolitan	5934000	391	13.18	1.07E+00	6.36E-02	1.14E-01	1.66E-01	2.14E-01	3.53E-01	6.48E-01	1.30E+00	2.51E+00	3.55E+00	6.84E+00	9.42E+00
Suburban	4152000	216	4.80	9.26E-01	7.97E-02	6.87E-02	1.50E-01	1.88E-01	2.94E-01	5.64E-01	1.15E+00	1.85E+00	2.67E+00	6.49E+00	9.23E+00
Race															
Black	479000	27	2.20	1.50E+00	2.25E-01	1.62E-01	2.64E-01	3.31E-01	8.66E-01	9.35E-01	2.20E+00	3.05E+00	3.23E+00	4.95E+00	4.95E+00
White	10836000	625	6.88	9.93E-01	4.83E-02	1.03E-01	1.53E-01	1.92E-01	3.21E-01	6.10E-01	1.20E+00	2.17E+00	3.04E+00	6.49E+00	9.42E+00
Region															
Midwest	4359000	273	9.40	1.01E+00	7.38E-02	1.13E-01	1.71E-01	2.31E-01	3.26E-01	5.72E-01	1.08E+00	2.45E+00	3.68E+00	6.84E+00	7.44E+00
Northeast	807000	48	1.96	7.01E-01	8.99E-02	5.88E-02	1.50E-01	1.68E-01	2.65E-01	5.09E-01	9.91E-01	1.71E+00	2.33E+00	2.77E+00	2.77E+00
South	4449000	253	6.92	1.08E+00	7.17E-02	1.29E-01	1.71E-01	2.14E-01	3.76E-01	7.12E-01	1.38E+00	2.32E+00	3.05E+00	5.40E+00	9.42E+00
West	1813000	82	5.03	9.57E-01	1.62E-01	6.87E-02	1.19E-01	1.52E-01	2.08E-01	4.79E-01	1.01E+00	1.86E+00	3.12E+00	9.23E+00	9.23E+00
Response to Questionnaire															
Households who garden	10286000	602	15.09	1.01E+00	4.73E-02	1.03E-01	1.53E-01	1.92E-01	3.36E-01	6.42E-01	1.21E+00	2.32E+00	3.05E+00	6.49E+00	9.23E+00
Households who farm	2325000	142	31.72	1.30E+00	1.45E-01	8.65E-02	1.66E-01	2.09E-01	3.37E-01	5.99E-01	1.40E+00	3.55E+00	5.40E+00	9.23E+00	9.23E+00

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-65. Intake of Homegrown Root Vegetables (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	13750000	743	7.31	1.16E+00	5.84E-02	4.72E-03	3.64E-02	1.12E-01	2.51E-01	6.66E-01	1.47E+00	2.81E+00	3.71E+00	9.52E+00	1.28E+01
Age															
01-02	371000	22	6.51	2.52E+00	6.10E-01	1.66E-01	1.66E-01	2.19E-01	3.59E-01	9.20E-01	3.67E+00	7.25E+00	1.04E+01	1.04E+01	1.04E+01
03-05	390000	23	4.81	1.28E+00	3.24E-01	0.00E+00	0.00E+00	1.17E-01	2.25E-01	4.62E-01	1.68E+00	4.26E+00	4.73E+00	4.73E+00	4.73E+00
06-11	1106000	67	6.62	1.32E+00	2.14E-01	0.00E+00	1.39E-02	3.64E-02	2.32E-01	5.23E-01	1.63E+00	3.83E+00	5.59E+00	7.47E+00	7.47E+00
12-19	1465000	76	7.15	9.37E-01	1.19E-01	7.59E-03	8.00E-03	6.84E-02	2.69E-01	5.65E-01	1.37E+00	2.26E+00	3.32E+00	5.13E+00	5.13E+00
20-39	3252000	164	5.28	8.74E-01	7.39E-02	1.21E-02	5.35E-02	9.93E-02	2.00E-01	5.64E-01	1.24E+00	2.11E+00	3.08E+00	4.64E+00	6.03E+00
40-69	4903000	276	8.64	1.13E+00	9.86E-02	3.34E-03	3.29E-02	1.17E-01	2.51E-01	6.75E-01	1.27E+00	2.74E+00	3.56E+00	9.52E+00	1.28E+01
70 +	2096000	107	13.20	1.22E+00	1.02E-01	1.73E-02	2.90E-02	1.69E-01	3.76E-01	8.51E-01	1.71E+00	2.86E+00	3.21E+00	4.01E+00	4.77E+00
Season															
Fall	4026000	153	8.45	1.42E+00	1.53E-01	5.15E-02	1.38E-01	1.72E-01	3.09E-01	9.20E-01	1.67E+00	3.26E+00	3.85E+00	1.23E+01	1.28E+01
Spring	2552000	260	5.53	6.87E-01	6.08E-02	3.34E-03	1.73E-02	3.00E-02	1.44E-01	3.65E-01	7.69E-01	1.69E+00	2.80E+00	4.24E+00	7.69E+00
Summer	5011000	169	11.02	1.19E+00	1.20E-01	0.00E+00	4.76E-02	1.32E-01	2.77E-01	7.26E-01	1.51E+00	2.74E+00	3.64E+00	1.04E+01	1.19E+01
Winter	2161000	161	4.44	1.17E+00	1.19E-01	3.23E-03	8.57E-03	4.34E-02	2.38E-01	5.57E-01	1.56E+00	3.08E+00	4.14E+00	6.21E+00	1.13E+01
Urbanization															
Central City	2385000	96	4.23	7.49E-01	8.40E-02	2.68E-02	3.90E-02	1.43E-01	2.23E-01	4.26E-01	9.16E-01	1.91E+00	2.70E+00	3.56E+00	3.93E+00
Nonmetropolitan	6094000	366	13.54	1.43E+00	9.81E-02	8.57E-03	6.87E-02	1.29E-01	2.78E-01	7.58E-01	1.85E+00	3.32E+00	4.24E+00	1.13E+01	1.28E+01
Suburban	5211000	279	6.02	1.06E+00	8.62E-02	3.73E-03	1.21E-02	7.17E-02	2.32E-01	7.34E-01	1.19E+00	2.34E+00	3.26E+00	6.29E+00	1.19E+01
Race															
Black	521000	31	2.40	8.83E-01	3.93E-01	4.72E-03	9.28E-03	3.64E-02	8.82E-02	5.42E-01	7.65E-01	1.06E+00	1.25E+00	1.23E+01	1.23E+01
White	12861000	697	8.16	1.18E+00	5.97E-02	7.79E-03	4.58E-02	1.29E-01	2.61E-01	6.80E-01	1.50E+00	2.82E+00	3.72E+00	9.52E+00	1.28E+01
Region															
Midwest	5572000	314	12.01	1.31E+00	9.54E-02	3.37E-02	7.48E-02	1.66E-01	2.69E-01	7.39E-01	1.67E+00	3.23E+00	4.26E+00	1.04E+01	1.19E+01
Northeast	1721000	92	4.18	8.38E-01	1.03E-01	3.23E-03	7.79E-03	8.69E-03	1.43E-01	4.81E-01	1.18E+00	2.05E+00	2.77E+00	4.78E+00	6.03E+00
South	3842000	205	5.97	1.38E+00	1.38E-01	1.10E-02	5.35E-02	1.32E-01	2.77E-01	6.90E-01	1.70E+00	3.32E+00	3.83E+00	1.23E+01	1.28E+01
West	2555000	130	7.08	7.68E-01	6.43E-02	4.72E-03	2.24E-02	1.14E-01	2.38E-01	5.70E-01	9.77E-01	1.69E+00	2.45E+00	3.72E+00	3.72E+00
Response to Questionnaire															
Households who garden	12578000	682	18.46	1.15E+00	5.72E-02	4.79E-03	3.64E-02	1.17E-01	2.58E-01	6.74E-01	1.50E+00	2.81E+00	3.64E+00	7.47E+00	1.28E+01
Households who farm	2367000	136	32.30	1.39E+00	1.26E-01	1.11E-01	1.58E-01	1.84E-01	3.65E-01	8.83E-01	1.85E+00	3.11E+00	4.58E+00	7.47E+00	7.69E+00

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-66. Intake of Homegrown Dark Green Vegetables (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	8855000	428	4.71	3.91E-01	2.95E-02	2.01E-03	4.28E-03	1.01E-02	8.70E-02	2.11E-01	4.35E-01	9.19E-01	1.25E+00	3.53E+00	5.82E+00
Age															
01-02	180000	8	3.16	*	*	*	*	*	*	*	*	*	*	*	*
03-05	226000	12	2.79	*	*	*	*	*	*	*	*	*	*	*	*
06-11	826000	39	4.94	3.05E-01	5.19E-02	0.00E+00	6.34E-03	2.42E-02	9.00E-02	1.81E-01	3.87E-01	9.48E-01	1.04E+00	1.28E+00	1.28E+00
12-19	628000	32	3.07	4.20E-01	1.47E-01	4.92E-03	5.38E-03	6.65E-03	5.62E-02	2.03E-01	3.73E-01	9.24E-01	1.64E+00	4.86E+00	4.86E+00
20-39	1976000	87	3.21	3.36E-01	6.09E-02	2.21E-03	3.74E-03	1.00E-02	8.70E-02	1.76E-01	3.79E-01	6.69E-01	9.19E-01	2.94E+00	4.29E+00
40-69	3710000	184	6.54	4.01E-01	4.24E-02	2.25E-03	3.67E-03	2.60E-02	8.19E-02	2.33E-01	4.80E-01	9.79E-01	1.25E+00	3.29E+00	5.82E+00
70 +	1253000	63	7.89	4.08E-01	7.27E-02	2.84E-03	4.23E-03	5.68E-03	1.10E-01	2.31E-01	4.69E-01	9.29E-01	1.08E+00	3.45E+00	3.45E+00
Season															
Fall	2683000	88	5.63	4.41E-01	7.42E-02	1.01E-02	4.46E-02	8.70E-02	1.45E-01	2.38E-01	4.59E-01	7.90E-01	1.08E+00	3.86E+00	4.29E+00
Spring	1251000	127	2.71	5.59E-01	7.90E-02	1.63E-03	3.66E-03	5.72E-03	1.01E-01	3.09E-01	5.38E-01	1.28E+00	2.81E+00	4.86E+00	5.82E+00
Summer	3580000	124	7.87	3.39E-01	4.10E-02	0.00E+00	2.84E-03	5.68E-03	6.34E-02	1.51E-01	4.05E-01	9.79E-01	1.15E+00	2.48E+00	2.48E+00
Winter	1341000	89	2.75	2.72E-01	3.92E-02	2.01E-03	3.97E-03	5.21E-03	2.30E-02	1.51E-01	3.71E-01	6.59E-01	1.17E+00	2.04E+00	2.18E+00
Urbanization															
Central City	1298000	48	2.30	2.69E-01	3.68E-02	2.84E-03	4.71E-03	1.01E-02	1.06E-01	2.05E-01	3.24E-01	6.32E-01	9.19E-01	1.07E+00	1.07E+00
Nonmetropolitan	3218000	167	7.15	3.31E-01	3.54E-02	2.21E-03	4.67E-03	1.70E-02	6.86E-02	1.72E-01	4.52E-01	7.52E-01	1.00E+00	2.48E+00	5.82E+00
Suburban	4279000	211	4.94	4.79E-01	5.23E-02	2.25E-03	5.21E-03	2.15E-02	9.22E-02	2.33E-01	4.59E-01	1.15E+00	2.18E+00	3.86E+00	4.86E+00
Race															
Black	724000	49	3.33	1.04E+00	1.80E-01	0.00E+00	1.00E-01	1.13E-01	2.21E-01	5.52E-01	1.17E+00	3.29E+00	3.86E+00	4.86E+00	4.86E+00
White	7963000	373	5.05	3.21E-01	2.20E-02	2.25E-03	4.67E-03	1.01E-02	7.75E-02	1.99E-01	3.79E-01	7.76E-01	1.07E+00	2.37E+00	5.82E+00
Region															
Midwest	2668000	121	5.75	2.81E-01	3.54E-02	2.84E-03	4.77E-03	6.26E-03	6.34E-02	2.11E-01	3.58E-01	4.96E-01	9.79E-01	2.48E+00	3.02E+00
Northeast	1554000	76	3.77	5.08E-01	9.14E-02	2.17E-03	2.80E-03	4.23E-03	5.62E-02	1.96E-01	4.92E-01	1.25E+00	1.93E+00	3.53E+00	5.82E+00
South	2945000	148	4.58	4.78E-01	5.07E-02	3.64E-02	6.83E-02	9.23E-02	1.45E-01	2.87E-01	6.43E-01	9.24E-01	1.28E+00	3.86E+00	4.29E+00
West	1628000	81	4.51	3.18E-01	7.25E-02	2.25E-03	3.37E-03	6.34E-03	3.50E-02	1.10E-01	3.09E-01	6.59E-01	9.29E-01	4.86E+00	4.86E+00
Response to Questionnaire															
Households who garden	8521000	412	12.50	3.95E-01	3.03E-02	1.63E-03	4.23E-03	1.05E-02	8.76E-02	2.12E-01	4.48E-01	9.19E-01	1.25E+00	3.53E+00	5.82E+00
Households who farm	1450000	66	19.78	3.80E-01	6.08E-02	1.62E-03	4.67E-03	5.38E-03	6.68E-02	2.31E-01	4.84E-01	9.48E-01	1.25E+00	2.48E+00	3.02E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-67. Intake of Homegrown Deep Yellow Vegetables (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	5467000	245	2.91	6.43E-01	4.44E-02	4.34E-02	6.70E-02	1.26E-01	2.22E-01	4.17E-01	7.74E-01	1.44E+00	2.03E+00	2.67E+00	6.63E+00
Age															
01-02	124000	8	2.18	*	*	*	*	*	*	*	*	*	*	*	*
03-05	61000	4	0.75	*	*	*	*	*	*	*	*	*	*	*	*
06-11	382000	17	2.29	*	*	*	*	*	*	*	*	*	*	*	*
12-19	493000	21	2.41	4.73E-01	9.18E-02	6.05E-02	6.05E-02	6.29E-02	9.07E-02	3.63E-01	7.79E-01	1.13E+00	1.44E+00	1.58E+00	1.58E+00
20-39	1475000	63	2.39	5.32E-01	7.54E-02	4.89E-02	5.55E-02	1.15E-01	1.66E-01	3.05E-01	5.11E-01	1.22E+00	2.03E+00	2.67E+00	2.67E+00
40-69	2074000	96	3.66	5.39E-01	5.15E-02	3.90E-02	9.22E-02	1.43E-01	2.21E-01	4.03E-01	6.54E-01	1.09E+00	1.33E+00	3.02E+00	3.02E+00
70 +	761000	32	4.79	7.81E-01	9.20E-02	7.64E-02	2.02E-01	2.77E-01	3.70E-01	5.72E-01	1.24E+00	1.61E+00	1.99E+00	1.99E+00	1.99E+00
Season															
Fall	2664000	97	5.59	7.38E-01	8.18E-02	9.21E-02	1.22E-01	1.43E-01	2.61E-01	4.51E-01	9.74E-01	1.73E+00	2.23E+00	3.02E+00	6.63E+00
Spring	315000	34	0.68	5.64E-01	7.52E-02	1.43E-01	1.45E-01	1.98E-01	2.47E-01	4.45E-01	6.43E-01	1.01E+00	1.42E+00	2.41E+00	2.41E+00
Summer	1619000	52	3.56	5.09E-01	6.37E-02	4.16E-02	5.49E-02	6.48E-02	2.26E-01	4.10E-01	6.35E-01	9.64E-01	1.67E+00	2.31E+00	2.31E+00
Winter	869000	62	1.78	6.29E-01	9.15E-02	3.90E-02	4.34E-02	6.29E-02	1.72E-01	3.52E-01	7.96E-01	1.54E+00	2.23E+00	4.37E+00	4.37E+00
Urbanization															
Central City	1308000	43	2.32	5.07E-01	7.07E-02	3.90E-02	6.29E-02	1.43E-01	2.13E-01	3.88E-01	5.88E-01	9.64E-01	1.41E+00	2.24E+00	2.24E+00
Nonmetropolitan	2100000	118	4.66	6.66E-01	7.72E-02	4.16E-02	5.55E-02	9.07E-02	2.20E-01	3.70E-01	8.65E-01	1.39E+00	2.12E+00	4.37E+00	6.63E+00
Suburban	2059000	84	2.38	7.07E-01	6.99E-02	6.48E-02	9.22E-02	1.26E-01	2.62E-01	4.25E-01	9.74E-01	1.67E+00	2.03E+00	2.67E+00	2.67E+00
Race															
Black	129000	8	0.59	*	*	*	*	*	*	*	*	*	*	*	*
White	5093000	229	3.23	6.45E-01	4.03E-02	4.89E-02	9.21E-02	1.43E-01	2.41E-01	4.25E-01	7.96E-01	1.50E+00	2.03E+00	2.67E+00	4.37E+00
Region															
Midwest	2792000	128	6.02	7.52E-01	6.01E-02	4.34E-02	1.32E-01	1.93E-01	2.82E-01	5.09E-01	9.55E-01	1.73E+00	2.23E+00	3.02E+00	4.37E+00
Northeast	735000	29	1.79	3.96E-01	8.06E-02	4.16E-02	5.55E-02	6.05E-02	9.22E-02	1.50E-01	6.35E-01	1.09E+00	1.37E+00	2.21E+00	2.21E+00
South	557000	30	0.87	5.39E-01	2.08E-01	4.89E-02	5.49E-02	7.74E-02	2.20E-01	3.05E-01	4.38E-01	7.74E-01	1.22E+00	6.63E+00	6.63E+00
West	1383000	58	3.83	5.97E-01	7.07E-02	6.48E-02	1.27E-01	1.43E-01	2.21E-01	4.10E-01	6.42E-01	1.44E+00	1.89E+00	2.31E+00	2.31E+00
Response to Questionnaire															
Households who garden	5177000	233	7.60	6.23E-01	3.93E-02	4.16E-02	9.07E-02	1.32E-01	2.32E-01	4.15E-01	7.50E-01	1.42E+00	1.99E+00	2.67E+00	4.37E+00
Households who farm	1088000	51	14.85	6.06E-01	8.52E-02	9.21E-02	9.22E-02	1.22E-01	1.94E-01	3.40E-01	9.40E-01	1.28E+00	1.73E+00	3.02E+00	3.02E+00

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table12-68. Intake of Homegrown Other Vegetables (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	25221000	1437	13.41	1.38E+00	5.00E-02	9.44E-03	1.07E-01	1.76E-01	3.62E-01	7.78E-01	1.65E+00	3.09E+00	4.52E+00	9.95E+00	1.84E+01
Age															
01-02	613000	38	10.76	3.80E+00	6.27E-01	1.92E-01	2.73E-01	4.04E-01	1.04E+00	2.61E+00	4.55E+00	7.74E+00	1.12E+01	1.80E+01	1.80E+01
03-05	887000	59	10.95	2.15E+00	2.67E-01	0.00E+00	2.28E-01	3.72E-01	7.20E-01	1.37E+00	3.16E+00	4.47E+00	5.96E+00	8.41E+00	1.40E+01
06-11	2149000	134	12.86	1.30E+00	1.38E-01	0.00E+00	1.21E-01	1.93E-01	3.54E-01	8.00E-01	1.61E+00	3.04E+00	4.57E+00	9.95E+00	9.95E+00
12-19	2379000	141	11.61	9.80E-01	8.56E-02	0.00E+00	5.76E-02	1.15E-01	3.17E-01	6.40E-01	1.33E+00	2.05E+00	3.17E+00	5.41E+00	5.41E+00
20-39	6020000	328	9.77	9.30E-01	6.00E-02	3.19E-02	9.37E-02	1.48E-01	2.43E-01	5.60E-01	1.12E+00	2.19E+00	3.04E+00	5.10E+00	7.00E+00
40-69	9649000	547	17.01	1.40E+00	8.72E-02	5.20E-03	1.11E-01	1.86E-01	3.95E-01	8.43E-01	1.58E+00	2.92E+00	4.65E+00	1.41E+01	1.84E+01
70 +	3226000	174	20.31	1.58E+00	1.41E-01	1.85E-02	1.52E-01	2.38E-01	4.62E-01	9.48E-01	1.91E+00	3.46E+00	5.79E+00	9.96E+00	1.14E+01
Season															
Fall	6934000	253	14.55	1.19E+00	8.62E-02	4.92E-02	1.48E-01	1.86E-01	3.28E-01	7.16E-01	1.44E+00	2.74E+00	4.00E+00	6.74E+00	9.96E+00
Spring	5407000	567	11.71	1.16E+00	6.19E-02	3.66E-03	4.32E-02	1.04E-01	3.10E-01	7.10E-01	1.39E+00	2.67E+00	4.21E+00	7.35E+00	1.40E+01
Summer	8454000	283	18.59	1.79E+00	1.53E-01	0.00E+00	1.18E-01	1.81E-01	3.85E-01	9.68E-01	1.97E+00	4.13E+00	6.14E+00	1.46E+01	1.84E+01
Winter	4426000	334	9.09	1.19E+00	7.28E-02	4.79E-03	1.41E-01	2.31E-01	4.09E-01	7.33E-01	1.49E+00	2.41E+00	3.37E+00	7.00E+00	1.10E+01
Urbanization															
Central City	4148000	161	7.36	9.66E-01	8.81E-02	3.50E-02	9.37E-02	1.63E-01	3.24E-01	6.07E-01	1.23E+00	1.97E+00	3.22E+00	7.00E+00	8.85E+00
Nonmetropolitan	10721000	710	23.81	1.78E+00	8.99E-02	2.74E-02	1.60E-01	2.26E-01	4.68E-01	1.01E+00	2.01E+00	4.05E+00	5.74E+00	1.41E+01	1.84E+01
Suburban	10292000	564	11.89	1.14E+00	5.98E-02	4.79E-03	8.98E-02	1.46E-01	3.06E-01	6.47E-01	1.44E+00	2.69E+00	3.77E+00	6.81E+00	1.14E+01
Race															
Black	1347000	84	6.19	1.30E+00	1.70E-01	4.41E-02	1.74E-01	2.06E-01	3.50E-01	7.11E-01	1.49E+00	3.88E+00	5.47E+00	6.21E+00	7.72E+00
White	23367000	1327	14.83	1.39E+00	5.26E-02	1.29E-02	1.10E-01	1.79E-01	3.76E-01	7.93E-01	1.65E+00	3.04E+00	4.49E+00	9.96E+00	1.84E+01
Region															
Midwest	8296000	522	17.88	1.43E+00	9.25E-02	3.19E-02	1.21E-01	1.90E-01	3.66E-01	7.29E-01	1.65E+00	3.05E+00	4.65E+00	1.12E+01	1.84E+01
Northeast	2914000	162	7.08	1.33E+00	1.65E-01	1.97E-03	5.69E-02	1.07E-01	2.44E-01	5.97E-01	1.64E+00	3.07E+00	5.41E+00	1.20E+01	1.41E+01
South	9218000	518	14.33	1.53E+00	7.82E-02	1.41E-02	1.68E-01	2.53E-01	4.87E-01	1.03E+00	1.76E+00	3.37E+00	4.70E+00	8.33E+00	1.80E+01
West	4733000	233	13.12	1.08E+00	9.85E-02	1.11E-02	7.06E-02	1.22E-01	2.55E-01	5.73E-01	1.21E+00	2.41E+00	3.73E+00	8.02E+00	1.14E+01
Response to Questionnaire															
Households who garden	22417000	1291	32.89	1.44E+00	5.25E-02	1.11E-02	1.11E-01	1.80E-01	3.84E-01	8.18E-01	1.70E+00	3.22E+00	4.65E+00	9.95E+00	1.84E+01
Households who farm	3965000	239	54.10	1.95E+00	1.63E-01	1.41E-02	1.36E-01	2.34E-01	5.20E-01	1.21E+00	2.04E+00	5.32E+00	7.02E+00	1.46E+01	1.59E+01

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-69. Intake of Homegrown Citrus (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	2530000	125	1.35	4.76E+00	6.05E-01	7.82E-02	1.57E-01	2.86E-01	7.56E-01	1.99E+00	5.10E+00	1.41E+01	1.97E+01	3.22E+01	4.79E+01
Age															
01-02	54000	4	0.95	*	*	*	*	*	*	*	*	*	*	*	*
03-05	51000	3	0.63	*	*	*	*	*	*	*	*	*	*	*	*
06-11	181000	9	1.08	*	*	*	*	*	*	*	*	*	*	*	*
12-19	194000	14	0.95	*	*	*	*	*	*	*	*	*	*	*	*
20-39	402000	18	0.65	*	*	*	*	*	*	*	*	*	*	*	*
40-69	1183000	55	2.09	4.54E+00	8.06E-01	8.11E-02	1.50E-01	2.47E-01	5.21E-01	1.74E+00	5.24E+00	1.52E+01	1.97E+01	2.38E+01	2.38E+01
70 +	457000	21	2.88	4.43E+00	7.58E-01	7.82E-02	7.82E-02	4.94E-01	1.95E+00	3.53E+00	6.94E+00	8.97E+00	8.97E+00	1.57E+01	1.57E+01
Season															
Fall	280000	8	0.59	*	*	*	*	*	*	*	*	*	*	*	*
Spring	437000	33	0.95	2.31E+00	3.76E-01	1.57E-01	1.84E-01	2.35E-01	3.69E-01	1.36E+00	4.15E+00	5.10E+00	6.50E+00	7.52E+00	7.52E+00
Summer	334000	11	0.73	*	*	*	*	*	*	*	*	*	*	*	*
Winter	1479000	73	3.04	6.47E+00	9.53E-01	1.50E-01	3.33E-01	4.94E-01	1.64E+00	2.93E+00	8.59E+00	1.91E+01	2.38E+01	4.79E+01	4.79E+01
Urbanization															
Central City	1053000	43	1.87	3.57E+00	5.18E-01	1.50E-01	3.33E-01	4.50E-01	1.13E+00	3.01E+00	4.97E+00	7.46E+00	8.97E+00	2.00E+01	2.00E+01
Nonmetropolitan	0	0	0.00												
Suburban	1477000	82	1.71	5.61E+00	9.14E-01	7.82E-02	1.14E-01	2.47E-01	5.17E-01	1.81E+00	8.12E+00	1.79E+01	2.38E+01	4.79E+01	4.79E+01
Race															
Black	200000	8	0.92	*	*	*	*	*	*	*	*	*	*	*	*
White	2330000	117	1.48	4.93E+00	6.31E-01	7.82E-02	1.50E-01	2.84E-01	7.82E-01	2.34E+00	5.34E+00	1.41E+01	1.97E+01	3.22E+01	4.79E+01
Region															
Midwest	64000	4	0.14	*	*	*	*	*	*	*	*	*	*	*	*
Northeast	0	0	0.00												
South	1240000	55	1.93	5.18E+00	7.37E-01	1.57E-01	3.76E-01	6.44E-01	1.60E+00	3.42E+00	6.50E+00	1.41E+01	1.97E+01	2.38E+01	2.38E+01
West	1226000	66	3.40	4.56E+00	9.79E-01	7.82E-02	1.14E-01	2.35E-01	3.69E-01	1.42E+00	4.53E+00	1.24E+01	2.00E+01	4.79E+01	4.79E+01
Response to Questionnaire															
Households who garden	2151000	102	3.16	4.55E+00	6.61E-01	7.82E-02	1.50E-01	2.84E-01	7.56E-01	1.99E+00	4.99E+00	1.24E+01	1.79E+01	3.22E+01	4.79E+01
Households who farm	130000	5	1.77	*	*	*	*	*	*	*	*	*	*	*	*

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distributions

Sources: Based on EPA's analyses of the 1987/88 NFCS

Table 12-70. Intake of Homegrown Other Fruit (g/kg-day)

Population Group	N wgtd	N unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	12615000	706	6.71	2.20E+00	1.86E-01	5.41E-02	1.47E-01	2.55E-01	4.60E-01	9.06E-01	1.91E+00	4.59E+00	8.12E+00	1.84E+01	6.26E+01
Age															
01-02	306000	19	5.37	*	*	*	*	*	*	*	*	*	*	*	*
03-05	499000	31	6.16	2.66E+00	7.60E-01	0.00E+00	0.00E+00	3.80E-01	1.02E+00	1.87E+00	2.71E+00	5.54E+00	6.30E+00	3.32E+01	3.32E+01
06-11	915000	68	5.48	2.60E+00	4.38E-01	0.00E+00	1.77E-01	3.86E-01	6.37E-01	1.14E+00	2.99E+00	7.13E+00	1.21E+01	1.62E+01	1.65E+01
12-19	1021000	54	4.98	1.62E+00	2.77E-01	8.40E-02	1.20E-01	2.57E-01	3.86E-01	6.09E-01	2.36E+00	3.92E+00	6.81E+00	8.12E+00	8.12E+00
20-39	2761000	146	4.48	1.85E+00	3.72E-01	7.94E-02	1.30E-01	1.80E-01	3.07E-01	6.20E-01	1.39E+00	3.70E+00	6.64E+00	3.70E+01	3.70E+01
40-69	4610000	259	8.13	2.09E+00	3.08E-01	6.52E-02	1.47E-01	2.54E-01	4.44E-01	7.68E-01	1.77E+00	3.17E+00	9.77E+00	1.84E+01	5.33E+01
70 +	2326000	119	14.65	1.66E+00	1.84E-01	4.41E-02	2.07E-01	3.56E-01	5.71E-01	1.07E+00	1.65E+00	4.06E+00	5.21E+00	1.17E+01	1.17E+01
Season															
Fall	2923000	102	6.13	1.39E+00	1.14E-01	2.59E-01	3.04E-01	3.81E-01	5.67E-01	1.07E+00	1.88E+00	2.89E+00	4.06E+00	5.39E+00	5.54E+00
Spring	2526000	268	5.47	1.47E+00	1.51E-01	8.66E-02	1.98E-01	2.54E-01	4.25E-01	8.33E-01	1.65E+00	2.89E+00	4.59E+00	8.26E+00	3.32E+01
Summer	4327000	144	9.51												
Winter	2839000	192	5.83	1.29E+00	1.08E-01	4.15E-02	1.01E-01	2.25E-01	4.54E-01	8.33E-01	1.55E+00	2.70E+00	4.79E+00	8.06E+00	1.13E+01
Urbanization															
Central City	2681000	102	4.76	1.79E+00	2.88E-01	4.41E-02	1.66E-01	2.91E-01	5.21E-01	8.87E-01	1.60E+00	2.61E+00	1.04E+01	1.54E+01	1.54E+01
Nonmetropolitan	4118000	278	9.15	2.43E+00	3.10E-01	6.52E-02	1.20E-01	2.38E-01	4.50E-01	1.13E+00	2.43E+00	4.60E+00	8.12E+00	2.40E+01	5.33E+01
Suburban	5756000	324	6.65	2.25E+00	3.06E-01	1.25E-01	1.99E-01	2.82E-01	4.46E-01	7.64E-01	1.81E+00	4.72E+00	7.61E+00	1.84E+01	6.26E+01
Race															
Black	250000	12	1.15	*	*	*	*	*	*	*	*	*	*	*	*
White	12256000	690	7.78	2.24E+00	1.91E-01	6.96E-02	1.50E-01	2.59E-01	4.66E-01	9.16E-01	1.94E+00	4.65E+00	8.26E+00	1.84E+01	6.26E+01
Region															
Midwest	4619000	298	9.96	3.07E+00	4.25E-01	4.41E-02	1.25E-01	2.35E-01	4.54E-01	1.04E+00	2.35E+00	6.73E+00	1.42E+01	5.33E+01	6.26E+01
Northeast	1279000	72	3.11	9.32E-01	2.20E-01	7.98E-02	8.55E-02	1.62E-01	3.11E-01	4.75E-01	8.12E-01	1.29E+00	2.16E+00	1.17E+01	1.17E+01
South	3004000	157	4.67	1.99E+00	2.59E-01	7.94E-02	2.38E-01	2.99E-01	5.46E-01	1.10E+00	1.82E+00	4.06E+00	6.30E+00	1.62E+01	2.40E+01
West	3653000	177	10.13	1.76E+00	1.64E-01	1.00E-01	2.16E-01	2.91E-01	5.44E-01	9.71E-01	2.04E+00	4.35E+00	5.75E+00	1.30E+01	1.30E+01
Response to Questionnaire															
Households who garden	10926000	619	16.03	2.38E+00	2.12E-01	4.41E-02	1.58E-01	2.57E-01	4.74E-01	9.94E-01	1.96E+00	4.94E+00	1.04E+01	1.84E+01	6.26E+01
Households who farm	1917000	112	26.16	2.57E+00	2.65E-01	6.96E-02	2.76E-01	3.61E-01	7.33E-01	1.55E+00	3.62E+00	5.80E+00	8.06E+00	1.62E+01	1.62E+01

* Intake data not provided for subpopulations for which there were less than 20 observations

NOTE: SE = standard error
P = percentile of the distribution

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-71. Fraction of Food Intake that is Home Produced

	Total Fruits	Total Vegetables	Total Meats	Total Dairy	Total Fish	Exposed Vegetables	Protected Vegetables	Root Vegetables	Exposed Fruits	Protected Fruits
Total	0.040	0.068	0.024	0.012	0.094	0.095	0.069	0.043	0.050	0.037
Season										
Fall	0.021	0.081	0.020	0.008	0.076	0.106	0.073	0.06	0.039	0.008
Spring	0.021	0.037	0.020	0.011	0.160	0.05	0.039	0.02	0.047	0.008
Summer	0.058	0.116	0.034	0.022	0.079	0.164	0.101	0.066	0.068	0.054
Winter	0.059	0.041	0.022	0.008	0.063	0.052	0.048	0.026	0.044	0.068
Urbanization										
Central City	0.027	0.027	0.003	0.000	0.053	0.037	0.027	0.016	0.030	0.026
Nonmetropolitan	0.052	0.144	0.064	0.043	0.219	0.207	0.134	0.088	0.100	0.025
Surburban	0.047	0.058	0.018	0.004	0.075	0.079	0.054	0.035	0.043	0.050
Race										
Black	0.007	0.027	0.001	0.000	0.063	0.037	0.029	0.012	0.008	0.007
White	0.049	0.081	0.031	0.014	0.110	0.109	0.081	0.050	0.059	0.045
Regions										
Northeast	0.005	0.038	0.009	0.010	0.008	0.062	0.016	0.018	0.010	0.002
Midwest	0.059	0.112	0.046	0.024	0.133	0.148	0.109	0.077	0.078	0.048
South	0.042	0.069	0.017	0.006	0.126	0.091	0.077	0.042	0.040	0.044
West	0.062	0.057	0.023	0.007	0.108	0.079	0.060	0.029	0.075	0.054
Questionnaire Response										
Households who garden	0.101	0.173				0.233	0.178	0.106	0.116	0.094
Households who raise animals			0.306	0.207						
Households who farm	0.161	0.308	0.319	0.254		0.420	0.394	0.173	0.328	0.030
Households who fish					0.325					

Table 12-71. Fraction of Food Intake that is Home Produced (continued)

	Dark Green Vegetables	Deep Yellow Vegetables	Other Vegetables	Citrus Fruits	Other Fruits	Apples	Peaches	Pears	Strawberries	Other Berries
Total	0.044	0.065	0.069	0.038	0.042	0.030	0.147	0.067	0.111	0.217
Season										
Fall	0.059	0.099	0.069	0.114	0.027	0.032	0.09	0.038	0.408	0.163
Spring	0.037	0.017	0.051	0.014	0.025	0.013	0.206	0.075	0.064	0.155
Summer	0.063	0.08	0.114	0.01	0.07	0.053	0.133	0.066	0.088	0.232
Winter	0.018	0.041	0.044	0.091	0.03	0.024	0.183	0.111	0.217	0.308
Urbanization										
Central City	0.012	0.038	0.026	0.035	0.022	0.017	0.087	0.038	0.107	0.228
Nonmetropolitan	0.090	0.122	0.154	0.000	0.077	0.066	0.272	0.155	0.133	0.282
Surburban	0.054	0.058	0.053	0.056	0.042	0.024	0.121	0.068	0.101	0.175
Race										
Black	0.053	0.056	0.026	0.012	0.004	0.007	0.018	0.004	0.000	0.470
White	0.043	0.071	0.082	0.045	0.051	0.035	0.164	0.089	0.125	0.214
Regions										
Northeast	0.039	0.019	0.034	0.000	0.008	0.004	0.027	0.002	0.085	0.205
Midwest	0.054	0.174	0.102	0.001	0.083	0.052	0.164	0.112	0.209	0.231
South	0.049	0.022	0.077	0.060	0.031	0.024	0.143	0.080	0.072	0.177
West	0.034	0.063	0.055	0.103	0.046	0.043	0.238	0.093	0.044	0.233
Questionnaire Response										
Households who garden	0.120	0.140	0.180	0.087	0.107	0.070	0.316	0.169	0.232	0.306
Households who farm	0.220	0.328	0.368	0.005	0.227	0.292	0.461	0.606	0.057	0.548

Table 12-71. Fraction of food Intake that is Home Produced (continued)

	Asparagus	Beets	Broccoli	Cabbage	Carrots	Corn	Cucumbers	Lettuce	Lima Beans	Okra	Onions
Total	0.063	0.203	0.015	0.038	0.043	0.078	0.148	0.010	0.121	0.270	0.056
Season											
Fall	0.024	0.199	0.013	0.054	0.066	0.076	0.055	0.013	0.07	0.299	0.066
Spring	0.103	0.191	0.011	0.011	0.015	0.048	0.04	0.01	0.082	0.211	0.033
Summer	0	0.209	0.034	0.08	0.063	0.118	0.32	0.017	0.176	0.304	0.091
Winter	0.019	0.215	0.006	0.008	0.025	0.043	0	0.002	0.129	0.123	0.029
Urbanization											
Central City	0.058	0.212	0.004	0.004	0.018	0.025	0.029	0.009	0.037	0.068	0.017
Nonmetropolitan	0.145	0.377	0.040	0.082	0.091	0.173	0.377	0.017	0.132	0.411	0.127
Surburban	0.040	0.127	0.016	0.045	0.039	0.047	0.088	0.009	0.165	0.299	0.050
Race											
Black	0.000	0.000	0.000	0.001	0.068	0.019	0.060	0.007	0.103	0.069	0.009
White	0.071	0.224	0.018	0.056	0.042	0.093	0.155	0.011	0.135	0.373	0.068
Regions											
Northeast	0.091	0.074	0.020	0.047	0.025	0.020	0.147	0.009	0.026	0.000	0.022
Midwest	0.194	0.432	0.025	0.053	0.101	0.124	0.193	0.020	0.149	0.224	0.098
South	0.015	0.145	0.013	0.029	0.020	0.088	0.140	0.006	0.140	0.291	0.047
West	0.015	0.202	0.006	0.029	0.039	0.069	0.119	0.009	0.000	0.333	0.083
Questionnaire Response											
Households who garden	0.125	0.420	0.043	0.099	0.103	0.220	0.349	0.031	0.258	0.618	0.148
Households who farm	0.432	0.316	0.159	0.219	0.185	0.524	0.524	0.063	0.103	0.821	0.361

Table 12-71. Fraction of Food Intake that is Home Produced (continued)

	Peas	Peppers	Pumpkin	Snap Beans	Tomatoes	White Potatoes	Beef	Game	Pork	Poultry	Eggs
Total	0.069	0.107	0.155	0.155	0.184	0.038	0.038	0.276	0.013	0.011	0.014
Season											
Fall	0.046	0.138	0.161	0.199	0.215	0.058	0.028	0.336	0.012	0.011	0.009
Spring	0.048	0.031	0.046	0.152	0.045	0.01	0.027	0.265	0.015	0.012	0.022
Summer	0.126	0.194	0.19	0.123	0.318	0.06	0.072	0.1	0.01	0.007	0.013
Winter	0.065	0.03	0.154	0.147	0.103	0.022	0.022	0.33	0.014	0.014	0.011
Urbanization											
Central City	0.033	0.067	0.130	0.066	0.100	0.009	0.001	0.146	0.001	0.002	0.002
Nonmetropolitan	0.123	0.228	0.250	0.307	0.313	0.080	0.107	0.323	0.040	0.026	0.029
Surburban	0.064	0.086	0.127	0.118	0.156	0.029	0.026	0.316	0.006	0.011	0.014
Race											
Black	0.047	0.039	0.022	0.046	0.060	0.007	0.000	0.000	0.000	0.001	0.002
White	0.076	0.121	0.187	0.186	0.202	0.044	0.048	0.359	0.017	0.014	0.017
Regions											
Northeast	0.021	0.067	0.002	0.052	0.117	0.016	0.014	0.202	0.006	0.002	0.004
Midwest	0.058	0.188	0.357	0.243	0.291	0.065	0.076	0.513	0.021	0.021	0.019
South	0.106	0.113	0.044	0.161	0.149	0.042	0.022	0.199	0.012	0.012	0.012
West	0.051	0.082	0.181	0.108	0.182	0.013	0.041	0.207	0.011	0.008	0.021
Questionnaire Response											
Households who garden	0.193	0.246	0.230	0.384	0.398	0.090					
Households who farm	0.308	0.564	0.824	0.623	0.616	0.134	0.485		0.242	0.156	0.146
Households who raise animals							0.478		0.239	0.151	0.214
Households who hunt								0.729			

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 12-72. Confidence in Homegrown Food Consumption Recommendations		
Considerations	Rationale	Rating
Study Elements		
• Level of Peer Review	USDA and EPA review	High
• Accessibility	Methods described in detail in Handbook	High
• Reproducibility	see above	High
• Focus on factor of interest	Yes	High
• Data pertinent to U.S.	U.S. population	High
• Primary data	Yes	High
• Currency	1987/88	Medium
• Adequacy of data collection period	Statistical method used to estimate long-term distribution from one-week survey data.	High (Means & Short-term distributions) Low (Long-term distributions)
• Validity of approach	Individual intakes inferred from household consumption.	Medium (Means) Low (Distributions)
• Study size	10,000 individuals, 4500 households	High
• Representativeness of the population	Nationwide survey representative of general U.S. population	High
• Bias in study design (high rating desirable)	Non-response bias can not be ruled out due to low response rate.	Medium
• Measurement Error (high rating desirable)	Individuals' estimates of food weights imprecise	Medium
Other Elements		
• Number of studies	1	Low
• Agreement between researchers	N/A	
Overall Rating	Highest confidence in means, lowest confidence in long term percentiles	**Medium** (Means) **Medium** (Short-term distributions) **Low** (Long-term distributions)

APPENDIX 12A

Food Codes and Definitions Used in Analysis of the 1987/88 USDA NFCS Data

Appendix 12A. Food Codes and Definitions Used in Analysis of the 1987/88 USDA NFCS Data

Food Product	Household Code/Definition	Individual Code
MAJOR FOOD GROUPS		
Total Fruits	50- Fresh Fruits citrus other vitamin-C rich other fruits 512- Commercially Canned Fruits 522- Commercially Frozen Fruits 533- Canned Fruit Juice 534- Frozen Fruit Juice 535- Aseptically Packed Fruit Juice 536- Fresh Fruit Juice 542- Dried Fruits (includes baby foods)	6- Fruits citrus fruits and juices dried fruits other fruits fruits/juices & nectar fruit/juices baby food (includes baby foods)
Total Vegetables	48- Potatoes, Sweetpotatoes 49- Fresh Vegetables dark green deep yellow tomatoes light green other 511- Commercially Canned Vegetables 521- Commercially Frozen Vegetables 531- Canned Vegetable Juice 532- Frozen Vegetable Juice 537- Fresh Vegetable Juice 538- Aseptically Packed Vegetable Juice 541- Dried Vegetables (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures/dinners)	7- Vegetables (all forms) white potatoes & PR starchy dark green vegetables deep yellow vegetables tomatoes and tom. mixtures other vegetables veg. and mixtures/baby food veg. with meat mixtures (includes baby foods; mixtures, mostly vegetables)
Total Meats	44- Meat beef pork veal lamb mutton goat game lunch meat mixtures 451- Poultry (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	20- Meat, type not specified 21- Beef 22- Pork 23- Lamb, veal, game, carcass meat 24- Poultry 25- Organ meats, sausages, lunchmeats, meat spreads (excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks; includes baby foods)
Total Dairy	40- Milk Equivalent fresh fluid milk processed milk cream and cream substitutes frozen desserts with milk cheese dairy-based dips (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners)	1- Milk and Milk Products milk and milk drinks cream and cream substitutes milk desserts, sauces, and gravies cheeses (includes regular fluid milk, human milk, imitation milk products, yogurt, milk-based meal replacements, and infant formulas)

Appendix 12A. Food Codes and Definitinos Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Total Fish	452- Fish, Shellfish various species fresh, frozen, commercial, dried (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners)	26- Fish, Shellfish various species and forms (excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks)
INDIVIDUAL FOODS		
White Potatoes	4811- White Potatoes, fresh 4821- White Potatoes, commercially canned 4831- White Potatoes, commercially frozen 4841- White Potatoes, dehydrated 4851- White Potatoes, chips, sticks, salad (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners)	71- White Potatoes and PR Starchy Veg. baked, boiled, chips, sticks, creamed, scalloped, au gratin, fried, mashed, stuffed, puffs, salad, recipes, soups, Puerto Rican starchy vegetables (does not include vegetables soups; vegetable mixtures; or vegetable with meat mixtures)
Peppers	4913- Green/Red Peppers, fresh 5111201 Sweet Green Peppers, commercially canned 5111202 Hot Chili Peppers, commercially canned 5211301 Sweet Green Peppers, commercially frozen 5211302 Green Chili Peppers, commercially frozen 5211303 Red Chili Peppers, commercially frozen 5413112 Sweet Green Peppers, dry 5413113 Red Chili Peppers, dry (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners)	7512100 Pepper, hot chili, raw 7512200 Pepper, raw 7512210 Pepper, sweet green, raw 7512220 Pepper, sweet red, raw 7522600 Pepper, green, cooked, NS as to fat added 7522601 Pepper, green, cooked, fat not added 7522602 Pepper, green, cooked, fat added 7522604 Pepper, red, cooked, NS as to fat added 7522605 Pepper, red, cooked, fat not added 7522606 Pepper, red, cooked, fat added 7522609 Pepper, hot, cooked, NS as to fat added 7522610 Pepper, hot, cooked, fat not added 7522611 Pepper, hot, cooked, fat added 7551101 Peppers, hot, sauce 7551102 Peppers, pickled (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Onions	4953- Onions, Garlic, fresh onions chives garlic leeks 5114908 Garlic Pulp, raw 5114915 Onions, commercially canned 5213722 Onions, commercially frozen 5213723 Onions with Sauce, commercially frozen 5413103 Chives, dried 5413105 Garlic Flakes, dried 5413110 Onion Flakes, dried (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners)	7510950 Chives, raw 7511150 Garlic, raw 7511250 Leek, raw 7511701 Onions, young green, raw 7511702 Onions, mature 7521550 Chives, dried 7521740 Garlic, cooked 7522100 Onions, mature cooked, NS as to fat added 7522101 Onions, mature cooked, fat not added 7522102 Onions, mature cooked, fat added 7522103 Onions, pearl cooked 7522104 Onions, young green cooked, NS as to fat 7522105 Onions, young green cooked, fat not added 7522106 Onions, young green cooked, fat added 7522110 Onion, dehydrated 7541501 Onions, creamed 7541502 Onion rings (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)

Appendix 12A. Food Codes and Definitins Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	**Household Code/Definition**	**Individual Code**
Corn	4956- Corn, fresh 5114601 Yellow Corn, commercially canned 5114602 White Corn, commercially canned 5114603 Yellow Creamed Corn, commercially canned 5114604 White Creamed Corn, commercially canned 5114605 Corn on Cob, commercially canned 5114607 Hominy, canned 5115306 Low Sodium Corn, commercially canned 5115307 Low Sodium Cr. Corn, commercially canned 5213501 Yellow Corn on Cob, commercially frozen 5213502 Yellow Corn off Cob, commercially frozen 5213503 Yell. Corn with Sauce, commercially frozen 5213504 Corn with other Veg., commercially frozen 5213505 White Corn on Cob, commercially frozen 5213506 White Corn off Cob, commercially frozen 5213507 Wh. Corn with Sauce, commercially frozen 5413104 Corn, dried 5413106 Hominy, dry 5413603 Corn, instant baby food (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby food)	7510960 Corn, raw 7521600 Corn, cooked, NS as to color/fat added 7521601 Corn, cooked, NS as to color/fat not added 7521602 Corn, cooked, NS as to color/fat added 7521605 Corn, cooked, NS as to color/cream style 7521607 Corn, cooked, dried 7521610 Corn, cooked, yellow/NS as to fat added 7521611 Corn, cooked, yellow/fat not added 7521612 Corn, cooked, yellow/fat added 7521615 Corn, yellow, cream style 7521616 Corn, cooked, yell. & wh./NS as to fat 7521617 Corn, cooked, yell. & wh./fat not added 7521618 Corn, cooked, yell. & wh./fat added 7521619 Corn, yellow, cream style, fat added 7521620 Corn, cooked, white/NS as to fat added 7521621 Corn, cooked, white/fat not added 7521622 Corn, cooked, white/fat added 7521625 Corn, white, cream style 7521630 Corn, yellow, canned, low sodium, NS fat 7521631 Corn, yell., canned, low sod., fat not add 7521632 Corn, yell., canned, low sod., fat added 7521749 Hominy, cooked 752175- Hominy, cooked 7541101 Corn scalloped or pudding 7541102 Corn fritter 7541103 Corn with cream sauce 7550101 Corn relish 76405- Corn, baby (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby food)

Appendix 12A. Food Codes and Definitinos Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Apples	5031- Apples, fresh 5122101 Applesauce with sugar, commercially canned 5122102 Applesauce without sugar, comm. canned 5122103 Apple Pie Filling, commercially canned 5122104 Apples, Applesauce, baby/jr., comm. canned 5122106 Apple Pie Filling, Low Cal., comm. canned 5223101 Apple Slices, commercially frozen 5332101 Apple Juice, canned 5332102 Apple Juice, baby, Comm. canned 5342201 Apple Juice, comm. frozen 5342202 Apple Juice, home frozen 5352101 Apple Juice, aseptically packed 5362101 Apple Juice, fresh 5423101 Apples, dried (includes baby food; except mixtures)	6210110 Apples, dried, uncooked 6210115 Apples, dried, uncooked, low sodium 6210120 Apples, dried, cooked, NS as to sweetener 6210122 Apples, dried, cooked, unsweetened 6210123 Apples, dried, cooked, with sugar 6310100 Apples, raw 6310111 Applesauce, NS as to sweetener 6310112 Applesauce, unsweetened 6310113 Applesauce with sugar 6310114 Applesauce with low calorie sweetener 6310121 Apples, cooked or canned with syrup 6310131 Apple, baked NS as to sweetener 6310132 Apple, baked, unsweetened 6310133 Apple, baked with sugar 6310141 Apple rings, fried 6310142 Apple, pickled 6310150 Apple, fried 6340101 Apple, salad 6340106 Apple, candied 6410101 Apple cider 6410401 Apple juice 6410405 Apple juice with vitamin C 6710200 Applesauce baby fd., NS as to str. or jr. 6710201 Applesauce baby food, strained 6710202 Applesauce baby food, junior 6720200 Apple juice, baby food (includes baby food; except mixtures)
Tomatoes	4931- Tomatoes, fresh 5113- Tomatoes, commercially canned 5115201 Tomatoes, low sodium, commercially canned 5115202 Tomato Sauce, low sodium, comm. canned 5115203 Tomato Paste, low sodium, comm. canned 5115204 Tomato Puree, low sodium, comm. canned 5311- Canned Tomato Juice and Tomato Mixtures 5321- Frozen Tomato Juice 5371- Fresh Tomato Juice 5381102 Tomato Juice, aseptically packed 5413115 Tomatoes, dry 5614- Tomato Soup 5624- Condensed Tomato Soup 5654- Dry Tomato Soup (does not include mixtures, and ready-to-eat dinners)	74- Tomatoes and Tomato Mixtures raw, cooked, juices, sauces, mixtures, soups, sandwiches

Appendix 12A. Food Codes and Definitins Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Snap Beans	4943- Snap or Wax Beans, fresh 5114401 Green or Snap Beans, commercially canned 5114402 Wax or Yellow Beans, commercially canned 5114403 Beans, baby/jr., commercially canned 5115302 Green Beans, low sodium, comm. canned 5115303 Yell. or Wax Beans, low sod., comm. canned 5213301 Snap or Green Beans, comm. frozen 5213302 Snap or Green w/sauce, comm. frozen 5213303 Snap or Green Beans w/other veg., comm. fr. 5213304 Sp. or Gr. Beans w/other veg./sc., comm. fr. 5213305 Wax or Yell. Beans, comm. frozen (does not include soups, mixtures, and ready-to-eat dinners; includes baby foods)	7510180 Beans, string, green, raw 7520498 Beans, string, cooked, NS color/fat added 7520499 Beans, string, cooked, NS color/no fat 7520500 Beans, string, cooked, NS color & fat 7520501 Beans, string, cooked, green/NS fat 7520502 Beans, string, cooked, green/no fat 7520503 Beans, string, cooked, green/fat 7520511 Beans, str., canned, low sod.,green/NS fat 7520512 Beans, str., canned, low sod.,green/no fat 7520513 Beans, str., canned, low sod.,green/fat 7520600 Beans, string, cooked, yellow/NS fat 7520601 Beans, string, cooked, yellow/no fat 7520602 Beans, string, cooked, yellow/fat 7540301 Beans, string, green, creamed 7540302 Beans, string, green, w/mushroom sauce 7540401 Beans, string, yellow, creamed 7550011 Beans, string, green, pickled 7640100 Beans, green, string, baby 7640101 Beans, green, string, baby, str. 7640102 Beans, green, string, baby, junior 7640103 Beans, green, string, baby, creamed (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby foods)
Beef	441- Beef (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	21- Beef beef, nfs beef steak beef oxtails, neckbones, ribs roasts, stew meat, corned, brisket, sandwich steaks ground beef, patties, meatballs other beef items beef baby food (excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks; includes baby food)
Pork	442- Pork (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	22- Pork pork, nfs; ground dehydrated chops steaks, cutlets ham roasts Canadian bacon bacon, salt pork other pork items pork baby food (excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks; includes baby food)
Game	445- Variety Meat, Game (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	233- Game (excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks)

Appendix 12A. Food Codes and Definitinos Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Poultry	451- Poultry (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	24- Poultry chicken turkey duck other poultry poultry baby food (excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks; includes baby food)
Eggs	46- Eggs (fresh equivalent) fresh processed eggs, substitutes (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	3- Eggs eggs egg mixtures egg substitutes eggs baby food froz. meals with egg as main ingred. (includes baby foods)
Broccoli	4912- Fresh Broccoli (and home canned/froz.) 5111203 Broccoli, comm. canned 52112- Comm. Frozen Broccoli (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	722- Broccoli (all forms) (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Carrots	4921- Fresh Carrots (and home canned/froz.) 51121- Comm. Canned Carrots 5115101 Carrots, Low Sodium, Comm. Canned 52121- Comm. Frozen Carrots 5312103 Comm. Canned Carrot Juice 5372102 Carrot Juice Fresh 5413502 Carrots, Dried Baby Food (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	7310- Carrots (all forms) 7311140 Carrots in Sauce 7311200 Carrot Chips 76201- Carrots, baby (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby foods except mixtures)
Pumpkin	4922- Fresh Pumpkin, Winter Squash (and home canned/froz.) 51122- Pumpkin/Squash, Baby or Junior, Comm. Canned 52122- Winter Squash, Comm. Frozen 5413504 Squash, Dried Baby Food (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	732- Pumpkin (all forms) 733- Winter squash (all forms) 76205- Squash, baby (does not include vegetable soups; vegetables mixtures; or vegetable with meat mixtures; includes baby foods)
Asparagus	4941- Fresh Asparagus (and home canned/froz.) 5114101 Comm. Canned Asparagus 5115301 Asparagus, Low Sodium, Comm. Canned 52131- Comm. Frozen Asparagus (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	7510080 Asparagus, raw 75202- Asparagus, cooked 7540101 Asparagus, creamed or with cheese (does not include vegetable soups; vegetables mixtures, or vegetable with meat mixtures)

Appendix 12A. Food Codes and Definitins Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Lima Beans	4942- Fresh Lima and Fava Beans (and home canned/froz.) 5114204 Comm. Canned Mature Lima Beans 5114301 Comm. Canned Green Lima Beans 5115304 Comm. Canned Low Sodium Lima Beans 52132- Comm. Frozen Lima Beans 54111- Dried Lima Beans 5411306 Dried Fava Beans (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures; does not include succotash)	7510200 Lima Beans, raw 752040- Lima Beans, cooked 752041- Lima Beans, canned 75402- Lima Beans with sauce (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; does not include succotash)
Cabbage	4944- Fresh Cabbage (and home canned/froz.) 4958601 Sauerkraut, home canned or pkgd 5114801 Sauerkraut, comm. canned 5114904 Comm. Canned Cabbage 5114905 Comm. Canned Cabbage (no sauce; incl. baby) 5115501 Sauerkraut, low sodium., comm. canned 5312102 Sauerkraut Juice, comm. canned (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	7510300 Cabbage, raw 7510400 Cabbage, Chinese, raw 7510500 Cabbage, red, raw 7514100 Cabbage salad or coleslaw 7514130 Cabbage, Chinese, salad 75210- Chinese Cabbage, cooked 75211- Green Cabbage, cooked 75212- Red Cabbage, cooked 752130- Savoy Cabbage, cooked 75230- Sauerkraut, cooked 7540701 Cabbage, creamed 755025- Cabbage, pickled or in relish (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Lettuce	4945- Fresh Lettuce, French Endive (and home canned/froz.) (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	75113- Lettuce, raw 75143- Lettuce salad with other veg. 7514410 Lettuce, wilted, with bacon dressing 7522005 Lettuce, cooked (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Okra	4946- Fresh Okra (and home canned/froz.) 5114914 Comm. Canned Okra 5213720 Comm. Frozen Okra 5213721 Comm. Frozen Okra with Oth. Veg. & Sauce (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	7522000 Okra, cooked, NS as to fat 7522001 Okra, cooked, fat not added 7522002 Okra, cooked, fat added 7522010 Lufta, cooked (Chinese Okra) 7541450 Okra, fried 7550700 Okra, pickled (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Peas	4947- Fresh Peas (and home canned/froz.) 51147- Comm Canned Peas (incl. baby) 5115310 Low Sodium Green or English Peas (canned) 5115314 Low Sod. Blackeye, Gr. or Imm. Peas (canned) 5114205 Blackeyed Peas, comm. canned 52134- Comm. Frozen Peas 5412- Dried Peas and Lentils (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	7512000 Peas, green, raw 7512775 Snowpeas, raw 75223- Peas, cowpeas, field or blackeye, cooked 75224- Peas, green, cooked 75225- Peas, pigeon, cooked 75231- Snowpeas, cooked 7541650 Pea salad 7541660 Pea salad with cheese 75417- Peas, with sauce or creamed 76409- Peas, baby 76411- Peas, creamed, baby (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby foods except mixtures)

Appendix 12A. Food Codes and Definitinos Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Cucumbers	4952- Fresh Cucumbers (and home canned/froz.) (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	7511100 Cucumbers, raw 75142- Cucumber salads 752167- Cucumbers, cooked 7550301 Cucumber pickles, dill 7550302 Cucumber pickles, relish 7550303 Cucumber pickles, sour 7550304 Cucumber pickles, sweet 7550305 Cucumber pickles, fresh 7550307 Cucumber, Kim Chee 7550311 Cucumber pickles, dill, reduced salt 7550314 Cucumber pickles, sweet, reduced salt (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)
Beets	4954- Fresh Beets (and home canned/froz.) 51145- Comm. Canned Beets (incl. baby) 5115305 Low Sodium Beets (canned) 5213714 Comm. Frozen Beets 5312104 Beet Juice (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	7510250 Beets, raw 752080- Beets, cooked 752081- Beets, canned 7540501 Beets, harvard 7550021 Beets, pickled 76403- Beets, baby (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby foods except mixtures)
Strawberries	5022- Fresh Strawberries 5122801 Comm. Canned Strawberries with sugar 5122802 Comm. Canned Strawberries without sugar 5122803 Canned Strawberry Pie Filling 5222- Comm. Frozen Strawberries (does not include ready-to-eat dinners; includes baby foods except mixtures)	6322- Strawberries 6413250 Strawberry Juice (includes baby food; except mixtures)
Other Berries	5033- Fresh Berries Other than Strawberries 5122804 Comm. Canned Blackberries with sugar 5122805 Comm. Canned Blackberries without sugar 5122806 Comm. Canned Blueberries with sugar 5122807 Comm. Canned Blueberries without sugar 5122808 Canned Blueberry Pie Filling 5122809 Comm. Canned Gooseberries with sugar 5122810 Comm. Canned Gooseberries without sugar 5122811 Comm. Canned Raspberries with sugar 5122812 Comm. Canned Raspberries without sugar 5122813 Comm. Canned Cranberry Sauce 5122815 Comm. Canned Cranberry-Orange Relish 52233- Comm. Frozen Berries (not strawberries) 5332404 Blackberry Juice (home and comm. canned) 5423114 Dried Berries (not strawberries) (does not include ready-to-eat dinners; includes baby foods except mixtures)	6320- Other Berries 6321- Other Berries 6341101 Cranberry salad 6410460 Blackberry Juice 64105- Cranberry Juice (includes baby food; except mixtures)

Appendix 12A. Food Codes and Definitins Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Peaches	5036- Fresh Peaches 51224- Comm. Canned Peaches (incl. baby) 5223601 Comm. Frozen Peaches 5332405 Home Canned Peach Juice 5423105 Dried Peaches (baby) 5423106 Dried Peaches (does not include ready-to-eat dinners; includes baby foods except mixtures)	62116- Dried Peaches 63135- Peaches 6412203 Peach Juice 6420501 Peach Nectar 67108- Peaches,baby 6711450 Peaches, dry, baby (includes baby food; except mixtures)
Pears	5037- Fresh Pears 51225- Comm. Canned Pears (incl. baby) 5332403 Comm. Canned Pear Juice, baby 5362204 Fresh Pear Juice 5423107 Dried Pears (does not include ready-to-eat dinners; includes baby foods except mixtures)	62119- Dried Pears 63137- Pears 6341201 Pear salad 6421501 Pear Nectar 67109- Pears, baby 6711455 Pears, dry, baby (includes baby food; except mixtures)
EXPOSED/PROTECTED FRUITS/VEGETABLES, ROOT VEGETABLES		
Exposed Fruits	5022- Strawberries, fresh 5023101 Acerola, fresh 5023401 Currants, fresh 5031- Apples/Applesauce, fresh 5033- Berries other than Strawberries, fresh 5034- Cherries, fresh 5036- Peaches, fresh 5037- Pears, fresh 50381- Apricots, Nectarines, Loquats, fresh 5038305 Dates, fresh 50384- Grapes, fresh 50386- Plums, fresh 50387- Rhubarb, fresh 5038805 Persimmons, fresh 5038901 Sapote, fresh 51221- Apples/Applesauce, canned 51222- Apricots, canned 51223- Cherries, canned 51224- Peaches, canned 51225- Pears, canned 51228- Berries, canned 5122903 Grapes with sugar, canned 5122904 Grapes without sugar, canned 5122905 Plums with sugar, canned 5122906 Plums without sugar, canned 5122907 Plums, canned, baby 5122911 Prunes, canned, baby 5122912 Prunes, with sugar, canned 5122913 Prunes, without sugar, canned 5122914 Raisin Pie Filling 5222- Frozen Strawberries 52231- Apples Slices, frozen 52233- Berries, frozen 52234- Cherries, frozen 52236- Peaches, frozen 52239- Rhubarb, frozen 53321- Canned Apple Juice 53322- Canned Grape Juice	62101- Apple, dried 62104- Apricot, dried 62108- Currants, dried 62110- Date, dried 62116- Peaches, dried 62119- Pears, dried 62121- Plum, dried 62122- Prune, dried 62125- Raisins 63101- Apples/applesauce 63102- Wi-apple 63103- Apricots 63111- Cherries, maraschino 63112- Acerola 63113- Cherries, sour 63115- Cherries, sweet 63117- Currants, raw 63123- Grapes 6312601 Juneberry 63131- Nectarine 63135- Peach 63137- Pear 63139- Persimmons 63143- Plum 63146- Quince 63147- Rhubarb/Sapodillo 632- Berries 64101- Apple Cider 64104- Apple Juice 64105- Cranberry Juice 64116- Grape Juice 64122- Peach Juice 64132- Prune/Strawberry Juice 6420101 Apricot Nectar 64205- Peach Nectar 64215- Pear Nectar 67102- Applesauce, baby 67108- Peaches, baby

Appendix 12A. Food Codes and Definitinos Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Exposed Fruits (continued)	5332402 Canned Prune Juice 5332403 Canned Pear Juice 5332404 Canned Blackberry Juice 5332405 Canned Peach Juice 53421- Frozen Grape Juice 5342201 Frozen Apple Juice, comm. fr. 5342202 Frozen Apple Juice, home fr. 5352101 Apple Juice, asep. packed 5352201 Grape Juice, asep. packed 5362101 Apple Juice, fresh 5362202 Apricot Juice, fresh 5362203 Grape Juice, fresh 5362204 Pear Juice, fresh 5362205 Prune Juice, fresh 5421- Dried Prunes 5422- Raisins, Currants, dried 5423101 Dry Apples 5423102 Dry Apricots 5423103 Dates without pits 5423104 Dates with pits 5423105 Peaches, dry, baby 5423106 Peaches, dry 5423107 Pears, dry 5423114 Berries, dry 5423115 Cherries, dry (includes baby foods)	67109- Pears, baby 6711450 Peaches, baby, dry 6711455 Pears, baby, dry 67202- Apple Juice, baby 6720380 White Grape Juice, baby 67212- Pear Juice, baby (includes baby foods/juices except mixtures; excludes fruit mixtures)
Protected Fruits	501- Citrus Fruits, fresh 5021- Cantaloupe, fresh 5023201 Mangoes, fresh 5023301 Guava, fresh 5023601 Kiwi, fresh 5023701 Papayas, fresh 5023801 Passion Fruit, fresh 5032- Bananas, Plantains, fresh 5035- Melons other than Cantaloupe, fresh 50382- Avocados, fresh 5038301 Figs, fresh 5038302 Figs, cooked 5038303 Figs, home canned 5038304 Figs, home frozen 50385- Pineapple, fresh 5038801 Pomegranates, fresh 5038902 Cherimoya, fresh 5038903 Jackfruit, fresh 5038904 Breadfruit, fresh 5038905 Tamarind, fresh 5038906 Carambola, fresh 5038907 Longan, fresh 5121- Citrus, canned 51226- Pineapple, canned 5122901 Figs with sugar, canned 5122902 Figs without sugar, canned 5122909 Bananas, canned, baby 5122910 Bananas and Pineapple, canned, baby 5122915 Litchis, canned	61- Citrus Fr., Juices (incl. cit. juice mixtures) 62107- Bananas, dried 62113- Figs, dried 62114- Lychees/Papayas, dried 62120- Pineapple, dried 62126- Tamarind, dried 63105- Avocado, raw 63107- Bananas 63109- Cantaloupe, Carambola 63110- Cassaba Melon 63119- Figs 63121- Genip 63125- Guava/Jackfruit, raw 6312650 Kiwi 6312651 Lychee, raw 6312660 Lychee, cooked 63127- Honeydew 63129- Mango 63133- Papaya 63134- Passion Fruit 63141- Pineapple 63145- Pomegranate 63148- Sweetsop, Soursop, Tamarind 63149- Watermelon 64120- Papaya Juice 64121- Passion Fruit Juice 64124- Pineapple Juice 64133- Watermelon Juice 6420150 Banana Nectar

Appendix 12A. Food Codes and Definitins Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Protected Fruits (continued)	5122916 Mangos with sugar, canned 5122917 Mangos without sugar, canned 5122918 Mangos, canned, baby 5122920 Guava with sugar, canned 5122921 Guava without sugar, canned 5122923 Papaya with sugar, canned 5122924 Papaya without sugar, canned 52232- Bananas, frozen 52235- Melon, frozen 52237- Pineapple, frozen 5331- Canned Citrus Juices 53323- Canned Pineapple Juice 5332408 Canned Papaya Juice 5332410 Canned Mango Juice 5332501 Canned Papaya Concentrate 5341- Frozen Citrus Juice 5342203 Frozen Pineapple Juice 5351- Citrus and Citrus Blend Juices, asep. packed 5352302 Pineapple Juice, asep. packed 5361- Fresh Citrus and Citrus Blend Juices 5362206 Papaya Juice, fresh 5362207 Pineapple-Coconut Juice, fresh 5362208 Mango Juice, fresh 5362209 Pineapple Juice, fresh 5423108 Pineapple, dry 5423109 Papaya, dry 5423110 Bananas, dry 5423111 Mangos, dry 5423117 Litchis, dry 5423118 Tamarind, dry 5423119 Plantain, dry (includes baby foods)	64202- Cantaloupe Nectar 64203- Guava Nectar 64204- Mango Nectar 64210- Papaya Nectar 64213- Passion Fruit Nectar 64221- Soursop Nectar 6710503 Bananas, baby 6711500 Bananas, baby, dry 6720500 Orange Juice, baby 6721300 Pineapple Juice, baby (includes baby foods/juices except mixtures; excludes fruit mixtures)

Appendix 12A. Food Codes and Definitinos Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Exposed Veg.	491- Fresh Dark Green Vegetables 493- Fresh Tomatoes 4941- Fresh Asparagus 4943- Fresh Beans, Snap or Wax 4944- Fresh Cabbage 4945- Fresh Lettuce 4946- Fresh Okra 49481- Fresh Artichokes 49483- Fresh Brussel Sprouts 4951- Fresh Celery 4952- Fresh Cucumbers 4955- Fresh Cauliflower 4958103 Fresh Kohlrabi 4958111 Fresh Jerusalem Artichokes 4958112 Fresh Mushrooms 4958113 Mushrooms, home canned 4958114 Mushrooms, home frozen 4958118 Fresh Eggplant 4958119 Eggplant, cooked 4958120 Eggplant, home frozen 4958200 Fresh Summer Squash 4958201 Summer Squash, cooked 4958202 Summer Squash, home canned 4958203 Summer Squash, home frozen 4958402 Fresh Bean Sprouts 4958403 Fresh Alfalfa Sprouts 4958504 Bamboo Shoots 4958506 Seaweed 4958508 Tree Fern, fresh 4958601 Sauerkraut 5111- Dark Green Vegetables (all are exposed) 5113- Tomatoes 5114101 Asparagus, comm. canned 51144- Beans, green, snap, yellow, comm. canned 5114704 Snow Peas, comm. canned 5114801 Sauerkraut, comm. canned 5114901 Artichokes, comm. canned 5114902 Bamboo Shoots, comm. canned 5114903 Bean Sprouts, comm. canned 5114904 Cabbage, comm. canned 5114905 Cabbage, comm. canned, no sauce 5114906 Cauliflower, comm. canned, no sauce 5114907 Eggplant, comm. canned, no sauce 5114913 Mushrooms, comm. canned 5114914 Okra, comm. canned 5114918 Seaweeds, comm. canned 5114920 Summer Squash, comm. canned	721- Dark Green Leafy Veg. 722- Dark Green Nonleafy Veg. 74- Tomatoes and Tomato Mixtures 7510050 Alfalfa Sprouts 7510075 Artichoke, Jerusalem, raw 7510080 Asparagus, raw 75101- Beans, sprouts and green, raw 7510275 Brussel Sprouts, raw 7510280 Buckwheat Sprouts, raw 7510300 Cabbage, raw 7510400 Cabbage, Chinese, raw 7510500 Cabbage, Red, raw 7510700 Cauliflower, raw 7510900 Celery, raw 7510950 Chives, raw 7511100 Cucumber, raw 7511120 Eggplant, raw 7511200 Kohlrabi, raw 75113- Lettuce, raw 7511500 Mushrooms, raw 7511900 Parsley 7512100 Pepper, hot chili 75122- Peppers, raw 7512750 Seaweed, raw 7512775 Snowpeas, raw 75128- Summer Squash, raw 7513210 Celery Juice 7514100 Cabbage or cole slaw 7514130 Chinese Cabbage Salad 7514150 Celery with cheese 75142- Cucumber salads 75143- Lettuce salads 7514410 Lettuce, wilted with bacon dressing 7514600 Greek salad 7514700 Spinach salad 7520600 Algae, dried 75201- Artichoke, cooked 75202- Asparagus, cooked 75203- Bamboo shoots, cooked 752049- Beans, string, cooked 75205- Beans, green, cooked/canned 75206- Beans, yellow, cooked/canned 75207- Bean Sprouts, cooked 752085- Breadfruit 752090- Brussel Sprouts, cooked 75210- Cabbage, Chinese, cooked 75211- Cabbage, green, cooked

Appendix 12A. Food Codes and Definitins Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Exposed Veg. (cont.)	5114923 Chinese or Celery Cabbage, comm. canned 51152- Tomatoes, canned, low sod. 5115301 Asparagus, canned, low sod. 5115302 Beans, Green, canned, low sod. 5115303 Beans, Yellow, canned, low sod. 5115309 Mushrooms, canned, low sod. 51154- Greens, canned, low sod. 5115501 Sauerkraut, low sodium 5211- Dark Gr. Veg., comm. frozen (all exp.) 52131- Asparagus, comm. froz. 52133- Beans, snap, green, yellow, comm. froz. 5213407 Peapods, comm froz. 5213408 Peapods, with sauce, comm froz. 5213409 Peapods, with other veg., comm froz. 5213701 Brussel Sprouts, comm. froz. 5213702 Brussel Sprouts, comm. froz. with cheese 5213703 Brussel Sprouts, comm. froz. with other veg. 5213705 Cauliflower, comm. froz. 5213706 Cauliflower, comm. froz. with sauce 5213707 Cauliflower, comm. froz. with other veg. 5213708 Caul., comm. froz. with other veg. & sauce 5213709 Summer Squash, comm. froz. 5213710 Summer Squash, comm. froz. with other veg. 5213716 Eggplant, comm. froz. 5213718 Mushrooms with sauce, comm. froz. 5213719 Mushrooms, comm. froz. 5213720 Okra, comm. froz. 5213721 Okra, comm. froz., with sauce 5311- Canned Tomato Juice and Tomato Mixtures 5312102 Canned Sauerkraut Juice 5321- Frozen Tomato Juice 5371- Fresh Tomato Juice 5381102 Aseptically Packed Tomato Juice 5413101 Dry Algae 5413102 Dry Celery 5413103 Dry Chives 5413109 Dry Mushrooms 5413111 Dry Parsley 5413112 Dry Green Peppers 5413113 Dry Red Peppers 5413114 Dry Seaweed 5413115 Dry Tomatoes (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	75212- Cabbage, red, cooked 752130- Cabbage, savoy, cooked 75214- Cauliflower 75215- Celery, Chives, Christophine (chayote) 752167- Cucumber, cooked 752170- Eggplant, cooked 752171- Fern shoots 752172- Fern shoots 752173- Flowers of sesbania, squash or lily 7521801 Kohlrabi, cooked 75219- Mushrooms, cooked 75220- Okra/lettuce, cooked 7522116 Palm Hearts, cooked 7522121 Parsley, cooked 75226- Peppers, pimento, cooked 75230- Sauerkraut, cooked/canned 75231- Snowpeas, cooked 75232- Seaweed 75233- Summer Squash 7540050 Artichokes, stuffed 7540101 Asparagus, creamed or with cheese 75403- Beans, green with sauce 75404- Beans, yellow with sauce 7540601 Brussel Sprouts, creamed 7540701 Cabbage, creamed 75409- Cauliflower, creamed 75410- Celery/Chiles, creamed 75412- Eggplant, fried, with sauce, etc. 75413- Kohlrabi, creamed 75414- Mushrooms, Okra, fried, stuffed, creamed 754180- Squash, baked, fried, creamed, etc. 7541822 Christophine, creamed 7550011 Beans, pickled 7550051 Celery, pickled 7550201 Cauliflower, pickled 755025- Cabbage, pickled 7550301 Cucumber pickles, dill 7550302 Cucumber pickles, relish 7550303 Cucumber pickles, sour 7550304 Cucumber pickles, sweet 7550305 Cucumber pickles, fresh 7550307 Cucumber, Kim Chee 7550308 Eggplant, pickled 7550311 Cucumber pickles, dill, reduced salt 7550314 Cucumber pickles, sweet, reduced salt 7550500 Mushrooms, pickled 7550700 Okra, pickled 75510- Olives 7551101 Peppers, hot 7551102 Peppers,pickled 7551301 Seaweed, pickled 7553500 Zucchini, pickled 76102- Dark Green Veg., baby 76401- Beans, baby (excl. most soups & mixtures)

Appendix 12A. Food Codes and Definitinos Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Protected Veg.	4922- Fresh Pumpkin, Winter Squash 4942- Fresh Lima Beans 4947- Fresh Peas 49482- Fresh Soy Beans 4956- Fresh Corn 4958303 Succotash, home canned 4958304 Succotash, home frozen 4958401 Fresh Cactus (prickly pear) 4958503 Burdock 4958505 Bitter Melon 4958507 Horseradish Tree Pods 51122- Comm. Canned Pumpkin and Squash (baby) 51142- Beans, comm. canned 51143- Beans, lima and soy, comm. canned 51146- Corn, comm. canned 5114701 Peas, green, comm. canned 5114702 Peas, baby, comm. canned 5114703 Peas, blackeye, comm. canned 5114705 Pigeon Peas, comm. canned 5114919 Succotash, comm. canned 5115304 Lima Beans, canned, low sod. 5115306 Corn, canned, low sod. 5115307 Creamed Corn, canned, low sod. 511531- Peas and Beans, canned, low sod. 52122- Winter Squash, comm. froz. 52132- Lima Beans, comm. froz. 5213401 Peas, gr., comm. froz. 5213402 Peas, gr., with sauce, comm. froz. 5213403 Peas, gr., with other veg., comm. froz. 5213404 Peas, gr., with other veg., comm. froz. 5213405 Peas, blackeye, comm froz. 5213406 Peas, blackeye, with sauce, comm froz. 52135- Corn, comm. froz. 5213712 Artichoke Hearts, comm. froz. 5213713 Baked Beans, comm. froz. 5213717 Kidney Beans, comm. froz. 5213724 Succotash, comm. froz. 5411- Dried Beans 5412- Dried Peas and Lentils 5413104 Dry Corn 5413106 Dry Hominy 5413504 Dry Squash, baby 5413603 Dry Creamed Corn, baby (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	732- Pumpkin 733- Winter Squash 7510200 Lima Beans, raw 7510550 Cactus, raw 7510960 Corn, raw 7512000 Peas, raw 7520070 Aloe vera juice 752040- Lima Beans, cooked 752041- Lima Beans, canned 7520829 Bitter Melon 752083- Bitter Melon, cooked 7520950 Burdock 752131- Cactus 752160- Corn, cooked 752161- Corn, yellow, cooked 752162- Corn, white, cooked 752163- Corn, canned 7521749 Hominy 752175- Hominy 75223- Peas, cowpeas, field or blackeye, cooked 75224- Peas, green, cooked 75225- Peas, pigeon, cooked 75301- Succotash 75402- Lima Beans with sauce 75411- Corn, scalloped, fritter, with cream 7541650 Pea salad 7541660 Pea salad with cheese 75417- Peas, with sauce or creamed 7550101 Corn relish 76205- Squash, yellow, baby 76405- Corn, baby 76409- Peas, baby 76411- Peas, creamed, baby (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)

Appendix 12A. Food Codes and Definitins Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	**Household Code/Definition**	**Individual Code**
Root Vegetables	48- Potatoes, Sweetpotatoes 4921- Fresh Carrots 4953- Fresh Onions, Garlic 4954- Fresh Beets 4957- Fresh Turnips 4958101 Fresh Celeriac 4958102 Fresh Horseradish 4958104 Fresh Radishes, no greens 4958105 Radishes, home canned 4958106 Radishes, home frozen 4958107 Fresh Radishes, with greens 4958108 Fresh Salsify 4958109 Fresh Rutabagas 4958110 Rutabagas, home frozen 4958115 Fresh Parsnips 4958116 Parsnips, home canned 4958117 Parsnips, home frozen 4958502 Fresh Lotus Root 4958509 Ginger Root 4958510 Jicama, including yambean 51121- Carrots, comm. canned 51145- Beets, comm. canned 5114908 Garlic Pulp, comm. canned 5114910 Horseradish, comm. prep. 5114915 Onions, comm. canned 5114916 Rutabagas, comm. canned 5114917 Salsify, comm. canned 5114921 Turnips, comm. canned 5114922 Water Chestnuts, comm. canned 51151- Carrots, canned, low sod. 5115305 Beets, canned, low sod. 5115502 Turnips, low sod. 52121- Carrots, comm. froz. 5213714 Beets, comm. froz. 5213722 Onions, comm. froz. 5213723 Onions, comm. froz., with sauce 5213725 Turnips, comm. froz. 5312103 Canned Carrot Juice 5312104 Canned Beet Juice 5372102 Fresh Carrot Juice 5413105 Dry Garlic 5413110 Dry Onion 5413502 Dry Carrots, baby 5413503 Dry Sweet Potatoes, baby (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	71- White Potatoes and Puerto Rican St. Veg. 7310- Carrots 7311140 Carrots in sauce 7311200 Carrot chips 734- Sweetpotatoes 7510250 Beets, raw 7511150 Garlic, raw 7511180 Jicama (yambean), raw 7511250 Leeks, raw 75117- Onions, raw 7512500 Radish, raw 7512700 Rutabaga, raw 7512900 Turnip, raw 752080- Beets, cooked 752081- Beets, canned 7521362 Cassava 7521740 Garlic, cooked 7521771 Horseradish 7521850 Lotus root 752210- Onions, cooked 7522110 Onions, dehydrated 752220- Parsnips, cooked 75227- Radishes, cooked 75228- Rutabaga, cooked 75229- Salsify, cooked 75234- Turnip, cooked 75235- Water Chestnut 7540501 Beets, harvard 75415- Onions, creamed, fried 7541601 Parsnips, creamed 7541810 Turnips, creamed 7550021 Beets, pickled 7550309 Horseradish 7551201 Radishes, pickled 7553403 Turnip, pickled 76201- Carrots, baby 76209- Sweetpotatoes, baby 76403- Beets, baby (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)

Appendix 12A. Food Codes and Definitinos Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
USDA SUBCATEGORIES		
Dark Green Vegetables	491- Fresh Dark Green Vegetables 5111- Comm. Canned Dark Green Veg. 51154- Low Sodium Dark Green Veg. 5211- Comm. Frozen Dark Green Veg. 5413111 Dry Parsley 5413112 Dry Green Peppers 5413113 Dry Red Peppers (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures/dinners; excludes vegetable juices and dried vegetables)	72- Dark Green Vegetables all forms leafy, nonleafy, dk. gr. veg. soups
Deep Yellow Vegetables	492- Fresh Deep Yellow Vegetables 5112- Comm. Canned Deep Yellow Veg. 51151- Low Sodium Carrots 5212- Comm. Frozen Deep Yellow Veg. 5312103 Carrot Juice 54135- Dry Carrots, Squash, Sw. Potatoes (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures/dinners; excludes vegetable juices and dried vegetables)	73- Deep Yellow Vegetables all forms carrots, pumpkin, squash, sweetpotatoes, dp. yell. veg. soups
Other Vegetables	494- Fresh Light Green Vegetables 495- Fresh Other Vegetables 5114- Comm. Canned Other Veg. 51153- Low Sodium Other Veg. 51155- Low Sodium Other Veg. 5213- Comm. Frozen Other Veg. 5312102 Sauerkraut Juice 5312104 Beet Juice 5411- Dreid Beans 5412- Dried Peas, Lentils 541310- Dried Other Veg. 5413114 Dry Seaweed 5413603 Dry Cr. Corn, baby (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures/dinners; excludes vegetable juices and dried vegetables)	75- Other Vegetables all forms
Citrus Fruits	501- Fresh Citrus Fruits 5121- Comm. Canned Citrus Fruits 5331- Canned Citrus and Citrus Blend Juice 5341- Frozen Citrus and Citrus Blend Juice 5351- Aseptically Packed Citrus and Citr. Blend Juice 5361- Fresh Citrus and Citrus Blend Juice (includes baby foods; excludes dried fruits)	61- Citrus Fruits and Juices 6720500 Orange Juice, baby food 6720600 Orange-Apricot Juice, baby food 6720700 Orange-Pineapple Juice, baby food 6721100 Orange-Apple-Banana Juice, baby food (excludes dried fruits)

Appendix 12A. Food Codes and Definitins Used in Analysis of the 1987/88 USDA NFCS Data (continued)

Food Product	Household Code/Definition	Individual Code
Other Fruits	502- Fresh Other Vitamin C-Rich Fruits 503- Fresh Other Fruits 5122- Comm. Canned Fruits Other than Citrus 5222- Frozen Strawberries 5223- Frozen Other than Citr. or Vitamin C-Rich Fr. 5332- Canned Fruit Juice Other than Citrus 5342- Frozen Juices Other than Citrus 5352- Aseptically Packed Fruit Juice Other than Citr. 5362- Fresh Fruit Juice Other than Citrus 542- Dry Fruits (includes baby foods; excludes dried fruits)	62- Dried Fruits 63- Other Fruits 64- Fruit Juices and Nectars Excluding Citrus 671- Fruits, baby 67202- Apple Juice, baby 67203- Baby Juices 67204- Baby Juices 67212- Baby Juices 67213- Baby Juices 673- Baby Fruits 674- Baby Fruits

TABLE OF CONTENTS

Page No.

13. BREAST MILK INTAKE

13.1. BACKGROUND

Breast milk is a potential source of exposure to toxic substances for nursing infants. Lipid soluble chemical compounds accumulate in body fat and may be transferred to breast-fed infants in the lipid portion of breast milk. Because nursing infants obtain most (if not all) of their dietary intake from breast milk, they are especially vulnerable to exposures to these compounds. Estimating the magnitude of the potential dose to infants from breast milk requires information on the quantity of breast milk consumed per day and the duration (months) over which breast-feeding occurs. Information on the fat content of breast milk is also needed for estimating dose from breast milk residue concentrations that have been indexed to lipid content.

Several studies have generated data on breast milk intake. Typically, breast milk intake has been measured over a 24-hour period by weighing the infant before and after each feeding without changing its clothing (test weighing). The sum of the difference between the measured weights over the 24-hour period is assumed to be equivalent to the amount of breast milk consumed daily. Intakes measured using this procedure are often corrected for evaporative water losses (insensible water losses) between infant weighings (NAS, 1991). Neville et al. (1988) evaluated the validity of the test weight approach among bottle-fed infants by comparing the weights of milk taken from bottles with the differences between the infants' weights before and after feeding. When test weight data were corrected for insensible water loss, they were not significantly different from bottle weights. Conversions between weight and volume of breast milk consumed are made using the density of human milk (approximately 1.03 g/mL) (NAS, 1991). Recently, techniques for measuring breast milk intake using stable isotopes have been developed. However, few data based on this new technique have been published (NAS, 1991).

Studies among nursing mothers in industrialized countries have shown that intakes among infants average approximately 750 to 800 g/day (728 to 777 mL/day) during the first 4 to 5 months of life with a range of 450 to 1,200 g/day (437 to 1,165 mL/day) (NAS, 1991). Similar intakes have also been reported for developing countries (NAS, 1991). Infant birth weight and nursing frequency have been shown to influence the rate of intake (NAS, 1991). Infants who are larger at birth and/or nurse more frequently have been shown to have higher intake rates. Also, breast milk production among nursing mothers has been reported to be somewhat higher than the amount actually consumed by the infant (NAS, 1991).

The available studies on breast milk intake are summarized in the following sections. Studies on breast milk intake rates have been classified as either key studies or relevant studies based on the criteria described in the Introduction (Volume I, Section 1.3.1). Recommended intake rates are based on the results of key studies, but relevant studies are also presented to provide the reader with added perspective on the current state of knowledge pertaining to breast milk intake.

Relevant data on lipid content and fat intake, energy content and energy intake, breast-feeding duration and frequency, and the estimated percentage of the U.S. population that breast-feeds are also presented.

13.2. KEY STUDIES ON BREAST MILK INTAKE

Pao et al. - Milk Intakes and Feeding Patterns of Breast-fed Infants - Pao et al. (1980) conducted a study of 22 healthy breast-fed infants to estimate breast milk intake rates. Infants were categorized as completely breast-fed or partially breast-fed. Breast feeding mothers were recruited through LaLeche League groups. Except for one black infant, all other infants were from white middle-class families in southwestern Ohio. The goal of the study was to enroll infants as close to one month of age as possible and to obtain records near one, three, six, and nine months of age (Pao et al., 1980). However, not all mother/infant pairs participated at each time interval. Data were collected for these 22 infants using the test weighing method. Records were collected for three consecutive 24-hour periods at each test interval. The weight of breast milk was converted to volume by assuming a density of 1.03 g/mL. Daily intake rates were calculated for each infant based on the mean of the three 24-hour periods. Mean daily breast milk intake rates for the infants surveyed at each time interval are presented in Table 13-1. For completely breast-fed infants, the mean intake rates were 600 mL/day at 1 month of age and 833 mL/day at 3 months of age. Partially breast-fed infants had mean intake rates of 485 mL/day, 467 mL/day, 395 mL/day, and 554 mL/day at 1, 3, 6, and 9 months of age, respectively. Pao et al. (1980) also noted that intake rates for boys in both groups were slightly higher than for girls.

Table 13-1. Daily Intakes of Breast Milk

Age	Number of Infants Surveyed at Each Time Period	Mean Intake (mL/day) [a]	Range of Daily Intake (mL/day)
Completely Breast-fed			
1 month	11	600 ± 159	426 - 989
3 months	2	833	645 - 1,000
6 months	1	682	616 - 786
Partially Breast-fed			
1 month	4	485 ± 79	398 - 655
3 months	11	467 ± 100	242 - 698
6 months	6	395 ± 175	147 - 684
9 months	3	< 554	451 - 732

[a] Data expressed as mean ± standard deviation.
Source: Pao et al., 1980.

The advantage of this study is that data for both exclusively and partially breast-fed infants were collected for multiple time periods. Also, data for individual infants were collected over 3 consecutive days which would account for some individual variability. However, the number of infants in the study was relatively small and may not be entirely representative of the U.S. population based on race and socioeconomic status which may introduce some bias in the results. In addition, this study did not account for insensible water loss which may underestimate the amount of breast milk ingested.

Butte et al. - Human Milk Intake and Growth in Exclusively Breast-fed Infants - Breast milk intake was studied in exclusively breast-fed infants during the first 4 months of life (Butte et al., 1984). Breastfeeding mothers were recruited through the Baylor Milk Bank Program in Texas. Forty-five mother/infant pairs participated in the study. However, data for some time periods (i.e., 1, 2, 3, or 4 months) were missing for some mothers as a result of illness or other factors. The mothers were from the middle- to upper-socioeconomic stratum and had a mean age of 28.0 ± 3.1 years. A total of 41 mothers were white, 2 were Hispanic, 1 was Asian, and 1 was West Indian. Infant growth progressed satisfactorily over the course of the study. The amount of milk ingested over a 24-hour period was determined using the test weighing procedure. Test weighing occurred over a 24-hour period for most participants, but intake among several infants was studied over longer periods (48 to 96 hours) to assess individual variation in intake. The study did not indicate whether the data were corrected for insensible water loss. Mean breast milk intake ranged from 723 g/day (702 mL/day) at 3 months to 751 g/day (729 mL/day) at 1 month, with an overall mean of 733 g/day (712 mL/day) for the entire study period (Table 13-2). Intakes were also calculated on the basis of body weight (Table 13-2). Based on the results of test weighings conducted over 48 to 96 hours, the mean variation in individual daily intake was estimated to be 7.9±3.6 percent.

Table 13-2. Breast Milk Intake Among Exclusively Breast-fed Infants During the First 4 Months of Life

Age (months)	Number of Infants	Breast Milk Intake[a] (g/day)	Breast Milk Intake[a] (g/kg-day)	Body Weight[b] (kg)
1	37	751.0 ± 130.0	159.0 ± 24.0	4.7
2	40	725.0 ± 131.0	129.0 ± 19.0	5.6
3	37	723.0 ± 114.0	117.0 ± 20.0	6.2
4	41	740.0 ± 128.0	111.0 ± 17.0	6.7

[a] Data expressed as mean ± standard deviation.
[b] Calculated by dividing breastmilk intake (g/day) by breastmilk intake (g/kg-day).
Source: Butte et al., 1984.

The advantage of this study is that data for a larger number of exclusively breast-fed infants were collected than were collected by Pao et al. (1980). However, data were collected over a shorter time period (i.e., 4 months compared to 6 months) and day-to-day variability was not characterized for all infants. In addition, the population studied may not be representative of the U.S. population based on race and socioeconomic status.

Neville et al. - Studies on Human Lactation - Neville et al. (1988) studied breast milk intake among 13 infants during the first year of life. The mothers were all multiparous, nonsmoking, Caucasian women of middle- to upper-socioeconomic status living in Denver, Colorado (Neville et al., 1988). All women in the study practiced exclusive breast-feeding for at least 5 months. Solid foods were introduced at mean age of 7 months. Daily milk intake was estimated by the test weighing method with corrections for insensible weight loss. Data were collected daily from birth to 14 days, weekly from weeks 3 through 8, and monthly until the study period ended at 1 year after inception. The estimated breast milk intakes for this study are listed in Table 13-3. Mean breast milk intakes were 770 g/day (748 mL/day), 734 g/day (713 mL/day), 766 g/day (744 mL/day), and 403 g/day (391 mL/day) at 1, 3, 6, and 12 months of age, respectively.

Table 13-3. Breast Milk Intake During a 24-Hour Period

Age (days)	Number of Infants	Mean (g/day)	Standard Deviation (g/day)	Range (g/day)
1	7	44	71	-31-149 [a]
2	10	182	86	44-355
3	11	371	153	209-688
4	11	451	176	164-694
5	12	498	129	323-736
6	10	508	167	315-861
7	8	573	167	406-842
8	9	581	159	410-923
9	10	580	76	470-720
10	10	589	132	366-866
11	8	615	168	398-934
14	10	653	154	416-922
21	10	651	84	554-786
28	13	770	179	495-1144
35	12	668	117	465-930
42	12	711	111	554-896
49	10	709	115	559-922
56	13	694	98	556-859
90	12	734	114	613-942
120	13	711	100	570-847
150	13	838	134	688-1173
180	13	766	121	508-936
210	12	721	154	486-963
240	10	622	210	288-1002
270	12	618	220	223-871
300	11	551	234	129-894
330	9	554	240	120-860
360	9	403	250	65-770

[a] Negative value due to insensible water loss correction.
Source: Neville et al., 1988.

In comparison to the previously described studies, Neville et al. (1988) collected data on numerous days over a relatively long time period (12 months) and they were corrected for insensible weight loss. However, the intake rates presented in Table 13-3 are estimated based on intake during only a 24-hour period. Consequently, these intake rates are based on short-term data that do not account for day-to-day variability among individual infants. Also, a smaller number of subjects was included than in the previous studies, and the population studied may not be representative of the U.S. population based on race and socioeconomic status.

Dewey and Lönnerdal - Milk and Nutrient Intakes of Breast-fed Infants - Dewey and Lönnerdal (1983) monitored the dietary intake of 20 breast-fed infants between the ages of 1 and 6 months. Most of the infants in the study were exclusively breast-fed (five were given some formula, and several were given small amounts of solid foods after 3 months of age). According to Dewey and Lönnerdal (1983), the mothers were all well educated and recruited through Lamaze childbirth classes in the Davis area of California. Breast milk intake volume was estimated based on two 24-hour test weighings per month. Breast milk intake rates for the various age groups are presented in Table 13-4. Breast milk intake averaged 673, 782, and 896 mL/day at 1, 3, and 6 months of age, respectively.

Table 13-4. Breast Milk Intake for Infants Aged 1 to 6 Months

Age (months)	Number of Infants	Mean (mL/day)	SD (mL/day) [a]	Range (mL/day)
1	16	673	192	341-1,003
2	19	756	170	449-1,055
3	16	782	172	492-1,053
4	13	810	142	593-1,045
5	11	805	117	554-1,045
6	11	896	122	675-1,096

[a] Standard deviation.
Source: Dewey and Lönnerdal, 1983.

The advantage of this study is that it evaluated breast-fed infants for a period of 6 months based on two 24-hour observations per infant per month. Corrections for insensible water loss apparently were not made. Also, the number of infants in the study was relatively small and may not be representative of U.S. population based on race and socioeconomic status.

Dewey et al. - The DARLING Study - The Davis Area Research on Lactation, Infant Nutrition and Growth (DARLING) study was conducted in 1986 to evaluate growth patterns, nutrient intake, morbidity, and activity levels in infants who were breast-fed for at least the first 12 months of life (Dewey et al., 1991a; 1991b). Seventy-three infants aged 3 months were included in the study. The number of infants included in the study at subsequent time intervals was somewhat lower as a result of attrition. All infants in the study were healthy and of normal gestational age and weight at birth, and did not consume solid foods until after the first 4 months of age. The mothers were highly educated and of "relatively high socioeconomic status" from the Davis area of California (Dewey et al., 1991a; 1991b). Breast milk intake was estimated by weighing the infants before and after each feeding and correcting for insensible water loss. Test weighings were conducted over a 4-day period every 3 months. The results of the study indicate that breast milk intake declines over the first 12 months of life. Mean breast milk intake was estimated to be 812 g/day (788 mL/day) at 3 months and 448 g/day (435 mL/day) at 12 months (Table 13-5). Based on the estimated intakes at 3 months of age, variability between individuals (coefficient of variation (CV) = 16.3 percent) was higher than individual day-to-day variability (CV = 5.4 percent) for the infants in the study (Dewey et al., 1991a).

Table 13-5. Breast Milk Intake Estimated by the DARLING Study

Age (months)	Number of Infants	Mean Intake (g/day)	Standard Deviation (g/day)
3	73	812	133
6	60	769	171
9	50	646	217
12	42	448	251

Source: Dewey et al. (1991b).

The advantages of this study are that data were collected over a relatively long-time (4 days) period at each test interval which would account for some day-to-day infant variability, and corrections for insensible water loss were made. However, the population studied may not be representative of the U.S. population based on race and socioeconomic status.

13.3. OTHER RELEVANT STUDIES ON BREAST MILK INTAKE

Hofvander et al. - The Amount of Milk Consumed by 1- to 3-Month Old Infants - Hofvander et al. (1982) compared milk intake among breast-fed and bottle-fed infants at ages 1, 2, and 3 months of age. Intake of breast milk and breast milk substitutes was tabulated for 25 Swedish infants in each age group. Daily intake among breast-fed infants was estimated using the test weighing method. Test weighings were conducted over a 24-hour time period at each time interval. Daily milk intake among bottle-fed infants was estimated by measuring the volumetric differences in milk contained in bottles at the beginning and end of all feeding sessions in a 24-hour period. The mean intake rates for bottle-fed infants were slightly higher than for breast-fed infants for all age groups (Table 13-6). Also, boys consumed breast milk or breast milk substitutes at a slightly higher rate than girls (Table 13-7). Breast milk intake was estimated to be 656 g/day (637 mL/day) at 1 month and 776 g/day (753 mL/day) at 3 months.

Table 13-6. Milk Intake for Bottle- and Breast-fed Infants by Age Group

Age (months)	Breast Milk Substitutes Mean (g/day)[a]	Breast Milk Mean (g/day)[a]
1	713 (500-1,000)	656 (360-860)
2	811 (670-1,180)	773 (575-985)
3	853 (655-1,065)	776 (600-930)

[a] Range given in parentheses.
Source: Hofvander et al., 1982.

Table 13-7. Milk Intake for Boys and Girls

	Boys		Girls	
Age	Mean (g/day)	N	Mean (g/day)	N
Breast milk				
1	663	12	649	13
2	791	14	750	11
3	811	12	743	13
Breast milk substitute				
1	753	10	687	15
2	863	13	753	12
3	862	13	843	12

Source: Hofvander et al., 1982.

This study was conducted among a small number of Swedish infants, but the results are similar to those summarized previously for U.S. studies. Insensible water losses were apparently not considered in this study, and only short-term data were collected.

Köhler et al. - Food Intake and Growth of Infants - Köhler et al. (1984) evaluated breast milk and formula intake among normal infants between the ages of 6 and 26 weeks. The study included 25 fully breast-fed and 34 formula-fed infants from suburban communities in Sweden. Intake among breast-fed infants was estimated using the test weighing method over a 48-hour test period. Intake among formula-fed infants was estimated by feeding infants from bottles with known volumes of formula and recording the amount consumed over a 48-hour period. Table 13-8 presents the mean breast milk and formula intake rates for

Table 13-8. Intake of Breast Milk and Formula

	Breast Milk			Cow's Formula			Soy Formula		
Age (wks)	N	Mean (g/d)	SD (g/d)	N	Mean (g/d)	SD (g/d)	N	Mean (g/d)	SD (g/d)
6	26	746	101	20	823	111	13	792	127
14	21	726	143	19	921	95	13	942	78
22	13	722	114	18	818	201	13	861	196
26	12	689	120	18	722	209	12	776	159

Source: Köhler et al., 1984.

the infants studied. Data were collected for both cow's milk-based formula and soy-based formula. The results indicated that the daily intake for bottle-fed infants was greater than for breast-fed infants.

The advantages of this study are that it compares breast milk intake to formula intake and that test weightings were conducted over 2 consecutive days to account for variability in individual intake. Although the population studied was not representative of the U.S. population, similar intake rates were observed in the studies that were previously summarized.

Axelsson et al. - Protein and Energy Intake During Weaning - Axelsson et al. (1987) measured food consumption and energy intake in 30 healthy Swedish infants between the ages of 4 and 6 months. Both formula-fed and breast-fed infants were studied. All infants were fed supplemental foods (i.e., pureed fruits and vegetables after 4 months, and pureed meats and fish after 5 months). Milk intake among breast-fed infants was estimated by weighing the infants before and after each feeding over a 2-day period at each sampling interval. Breast milk intake averaged 765 mL/day at 4.5 months of age, and 715 mL/day at 5.5 months of age.

This study is based on short-term data, a small number of infants, and may not be representative of the U.S. population. However, the intake rates estimated by this study are similar to those generated by the U.S. studies that were summarized previously.

13.4. KEY STUDIES ON LIPID CONTENT AND FAT INTAKE FROM BREAST MILK

Human milk contains over 200 constituents including lipids, various proteins, carbohydrates, vitamins, minerals, and trace elements as well as enzymes and hormones (NAS, 1991). The lipid content of breast milk varies according to the length of time that an infant nurses. Lipid content increases from the beginning to the end of a single nursing session (NAS, 1991). The lipid portion accounts for approximately 4 percent of human breast milk (39 ± 4.0 g/L) (NAS, 1991). This value is supported by various studies that evaluated lipid content from human breast milk. Several studies also estimated the quantity of lipid consumed by breast-feeding infants. These values are appropriate for performing exposure assessments for nursing infants when the contaminant(s) have residue concentrations that are indexed to the fat portion of human breast milk.

Butte et al. - Human Milk Intake and Growth in Exclusively Breast-fed Infants - Butte et al., (1984) analyzed the lipid content of breast milk samples taken from women who participated in a study of breast milk intake among exclusively breast-fed infants. The study was conducted with over 40 women during a 4-month period. The mean lipid content of breast milk at various infants' ages is presented in Table 13-9. The overall lipid content for the 4-month study period was 34.3 ± 6.9 mg/g (3.4 percent). Butte et al. (1984) also calculated lipid intakes from 24-hour breast milk intakes and the lipid content of the human milk samples. Lipid intake was estimated to range from 23.6 g/day (3.8 g/kg-day) to 28.0 g/day (5.9 g/kg-day).

The number of women included in this study was small, and these women were selected primarily from middle- to upper-socioeconomic classes. Thus, data on breast milk lipid content from this study may not be entirely representative of breast milk lipid content among the U.S. population. Also, these estimates are based on short-term data and day-to-day variability was not characterized.

Maxwell and Burmaster - Simulation Model for Estimating a Distribution of Lipid Intake -Maxwell and Burmaster (1993) used a hypothetical population of 5,000 infants between birth and 1 year of age to simulate a distribution of daily lipid intake from breast milk. The hypothetical population represented both bottle-fed and breast-fed infants aged 1 to 365 days. A distribution of

Table 13-9. Lipid Content of Human Milk and Estimated Lipid Intake among Exclusively Breast-fed Infants

Age (months)	Number of Observations	Lipid Content (mg/g) [a]	Lipid Content (percent) [b]	Lipid Intake (g/day) [a]	Lipid Intake (g/kg-day) [a]
1	37	36.2 ± 7.5	3.6	28.0 ± 8.5	5.9 ± 1.7
2	40	34.4 ± 6.8	3.4	25.2 ± 7.1	4.4 ± 1.2
3	37	32.2 ± 7.8	3.2	23.6 ± 7.2	3.8 ± 1.2
4	41	34.8 ± 10.8	3.5	25.6 ± 8.6	3.8 ± 1.3

[a] Data expressed as means ± standard deviation.
[b] Percents calculated from lipid content reported in mg/g.

Source: Butte, et al., 1984.

daily lipid intake was developed based on data in Dewey et al. (1991b) on breast milk intake for infants at 3, 6, 9, and 12 months and breast milk lipid content, and survey data in Ryan et al. (1991) on the percentage of breast-fed infants under the age of 12 months (i.e., approximately 22 percent). A model was used to simulate intake among 1,113 of the 5,000 infants that were expected to be breast-fed. The results of the model indicated that lipid intake among nursing infants under 12 months of age can be characterized by a normal distribution with a mean of 26.8 g/day and a standard deviation of 7.4 g/day (Table 13-10). The model assumes that nursing infants are completely breast-fed and does not account for infants who are breast-fed longer than 1 year. Based on data collected by Dewey et al. (1991b), Maxwell and Burmaster (1993) estimated the lipid content of breast milk to be 36.7 g/L at 3 months (35.6 mg/g or 3.9%) and 40.2 g/L (39.0 mg/g or 3.9%) at 12 months.

Table 13-10. Predicted Lipid Intakes for Breast-fed Infants Under 12 Months of Age

Statistic	Value
Number of Observations in Simulation	1,113
Minimum Lipid Intake	1.0 g/day
Maximum Lipid Intake	51.5 g/day
Arithmetic Mean Lipid Intake	26.8 g/day
Standard Deviation Lipid Intake	7.4 g/day

Source: Maxwell and Burmaster, 1993.

The advantage of this study is that it provides a "snapshot" of daily lipid intake from breast milk for breast-fed infants. These results are, however, based on a simulation model and there are uncertainties associated with the assumptions made. The estimated mean lipid intake rate represents the average daily intake for nursing infants under 12 months of age. These data are useful for performing exposure assessments when the age of the infant cannot be specified (i.e., 3 months or 6 months). Also, because intake rates are indexed to the lipid portion of the breast milk, they may be used in conjunction with residue concentrations indexed to fat content.

13.5. OTHER FACTORS

Other factors associated with breast milk intake include: the energy intake from breast-feeding, the frequency of breast-feeding sessions per day, the duration of breast-feeding per event, the duration of breast-feeding during childhood, and the magnitude and nature of the population that breast-feeds.

Energy Intake and Energy Content of Breast Milk and Infant Formula - Several studies have estimated energy intakes among breast-feeding infants; therefore, based on the energy content of breast milk, intake rates can be calculated. The Food and Agriculture Organization/World Health Organization (FAO/WHO) recommends infant energy intakes of 116 kcal/kg/day for the first 3 months of life and 99 kcal/kg/day between the ages of 3 to 6 months (Butte et al., 1990). Similarly, the Food and Nutrition Board's Recommended Dietary Allowance (RDA) for energy intake is 115 kcal/kg/day during the first 6 months of life (Montandon et al., 1986; Butte et al., 1984), and USDA's Nutrition Research Board recommends 115 kcal/kg/day at birth and 105 kcal/kg/day by the end of the first year (Butte et al., 1990). However, Butte et al. (1984) observed energy intakes that were substantially less than the recommended values among healthy, well nourished, exclusively breast-fed infants (110 ± 24 kcal/kg-day at 1 month and 71 ± 17 kcal/kg/day at 4 months). In another study, Köhler et al. (1984) observed that energy intake for healthy breast-fed infants was lower than for healthy formula-fed infants (Table 13-11). According to Whitehead and Paul (1991), recent studies indicate that the energy

Table 13-11. Total Energy Intake

	Breast-fed			Formula-fed		
Age (wks)	Number of Infants	Mean (kcal/day)	SD (kcal/day)	Number of Infants	Mean (kcal/day)	SD (kcal/day)
6	26	525	71	33	594	131
14	21	595	100	32	715	108
22	13	638	98	31	699	141
26	12	663	85	30	695	124

Source: Köhler et al., 1984.

intake from formula averages about 90 kcal/kg-day and energy intake from breast milk averages about 85 kcal/kg-day. Based on several of these studies, Whitehead and Paul (1991) estimated the energy intake among exclusively breast-fed infants to be 114, 98, 92, and 86 kcal/kg-day at 1, 2, 3 and 4 months of age, respectively. Dewey and Lönnerdal (1983) estimated the energy intake from breast milk to be 113, 105, 93, 93, 85, and 89 kcal/kg-day (509, 564, 556, 596, 593, and 658 kcal/day) for infants 1, 2, 3, 4, 5, and 6 months of age, respectively. Table 13-12 presents energy intakes estimated by Dewey et al. (1991b) in a subsequent study. Using an assumed energy content of 65 kcal/mL for breast milk and measured breast milk intake rates, Axelsson et al. (1987) estimated energy intake among breast-fed infants to be 82.2±9.1 kcal/kg-day at 4 to 5 months of age and 76.9±9.4 kcal/kg-day at 5 to 6 months of age. Energy intake among bottle-fed infants was slightly higher. Bottle-fed infants consuming formula with an energy content of 72 kcal/mL had energy intakes of 104.3±12.4 kcal/kg-day at 4 to 5 months and 97.3±11.1 kcal/kg-day at 5 to 6 months. Bottle-fed infants consuming formula with an energy content of 69 kcal/mL had energy intakes of 95.6±13.2 kcal/kg-day at 4 to 5 months and 92.6± 15.0 kcal/kg-day at 5 to 6 months.

Prentice et al. (1988) estimated the energy requirements of 355 healthy children, ages 0 to 3 years of age, by using data on energy expenditure instead of energy intake. Data on measurements of energy expenditure using the doubly-labeled water method $^{2}H_2{}^{18}O$ from the published literature were used. This method measures total energy expenditure by following the disappearance of stable isotopes taken as an oral dose. The energy requirements estimated by Prentice et al. (1988) are 110, 95, 85, 83, 83, 84, and 85 kcal/kg-day at 1, 3 ,6, 9, 12, 24, and 36 months, respectively.

Table 13-12. Energy Intake from Human Milk

Age (months)	Number of Observations	Energy Intake kcal/day [a]	Energy Intake kcal/kg-day [a]
3	71	569 (86)	91.4 (11.7)
6	56	549 (120)	71.6 (15.2)
9	46	466 (152)	54.3 (17.3)
12	40	322 (181)	34.7 (19.9)

[a] Expressed as means with standard deviation in parentheses.
Source: Dewey et al., 1991b.

Dewey and Lönnerdal (1983) estimated the energy content in human milk samples at 1 to 6 months post partum based on analyses of fat, protein, and lactose content. Mean energy content averaged 74 to 79 kcal/mL. Dewey et al. (1991a) estimated that at 3 months the average energy content of breast milk is 72.8 ± 9.5 kcal/mL. Whitehead and Paul (1991) and Axelsson et al. (1987) assumed a breast milk energy content of 65 kcal/mL in their studies of the energy intake among breast-fed infants, and Köhler et al. (1984) estimated the energy contents of cow's milk-based and soy-based infant formulas to be 67 kcal/mL.

Frequency and Duration of Feeding - Hofvander et al. (1982) reported on the frequency of feeding among 25 bottle-fed and 25 breast-fed infants at ages 1, 2, and 3 months. The mean number of meals for these age groups was approximately 5 meals/day (Table 13-13). Neville et al. (1988) reported slightly higher mean feeding frequencies. The mean number of meals per day for exclusively breast-fed infants was 7.3 at ages 2 to 5 months and 8.2 at ages 2 weeks to 1 month. Neville et al. (1988) reported that for infants between the ages of 1 week and 5 months the average duration of a breast feeding session is 16-18 minutes.

Table 13-13. Number of Meals Per Day

Age (months)	Bottle-fed Infants (meals/day) [a]	Breast-fed (meals/day) [a]
1	5.4 (4-7)	5.8 (5-7)
2	4.8 (4-6)	5.3 (5-7)
3	4.7 (3-6)	5.1 (4-8)

[a] Data expressed as mean with range in parentheses.
Source: Hofvander et al., 1982.

Population of Nursing Infants and Duration of Breast-Feeding During Infancy - According to NAS (1991), the percentage of breast-feeding women has changed dramatically over the years. Between 1936 and 1940, approximately 77 percent of infants were breast fed, but the incidence of breast-feeding fell to approximately 22 percent in 1972. The duration of breast-feeding also dropped from about 4 months in the early 1930s to 2 months in the late 1950s. After 1972, the incidence of breast-feeding began to rise again, reaching its peak at approximately 61 percent in 1982. The duration of breast-feeding also increased between 1972 and 1982. Approximately 10 percent of the mothers who initiated breast-feeding continued for at least 3 months in 1972; however, in 1984, 37 percent continued breast-feeding beyond 3 months. In 1989, breast-feeding was initiated among 52.2 percent of newborn infants, and 40 percent continued for 3 months or longer (NAS, 1991). Based on the data for 1989, only about 20 percent of infants were still breast fed by age 5 to 6 months (NAS, 1991). Data on the actual length of time that infants continue to breast-feed beyond 5 or 6 months are limited (NAS, 1991). However, Maxwell and Burmaster (1993) estimated that approximately 22 percent of infants under 1 year of age are breast-fed. This estimate is based on a reanalysis of survey data in Ryan et al. (1991) collected by Ross Laboratories (Maxwell and Burmaster, 1993). Studies have also indicated that breast-feeding practices may differ among ethnic and socioeconomic groups and among regions of the United States. The percentages of mothers who breast feed, based on ethnic background and demographic variables, are presented in Table 13-14 (NAS, 1991).

Intake Rates Based on Nutritional Status - Information on differences in the quality and quantity of breast milk consumed based on ethnic or socioeconomic characteristics of the population is limited. Lönnerdal et al. (1976) studied breast milk volume and composition (nitrogen, lactose, proteins) among underprivileged and privileged Ethiopian mothers. No significant differences were observed between the data for these two groups; and similar data for well-nourished Swedish mothers were observed. Lönnerdal et al. (1976) stated that these results indicate that breast milk quality and quantity are not affected by maternal malnutrition. However, Brown et al. (1986a; 1986b) noted that the lactational capacity and energy concentration of marginally-nourished women in Bangladesh were "modestly less than in better nourished mothers." Breast milk intake rates for infants of marginally-nourished women in this study were 690±122 g/day at 3 months, 722±105 g/day at 6 months, and 719±119 g/day at 9 months of age (Brown et al., 1986a). Brown et al. (1986a) observed that breast milk from women with larger measurements of arm circumference and triceps skinfold thickness had higher concentrations of fat and energy than mothers with less body fat. Positive correlations between maternal weight and milk fat concentrations were also observed. These results suggest that milk composition may be affected by maternal nutritional status.

13.6. RECOMMENDATIONS

The key studies described in this section were used in selecting recommended values for breast milk intake, fat content and fat intake, and other related factors. Although different survey designs, testing periods, and populations were utilized by the key and relevant studies to estimate intake, the mean and standard deviation estimates reported in these studies are relatively consistent. The general designs of both key and relevant studies and their limitations are summarized in Table 13-15. Table 13-16 presents the confidence rating for breast milk intake recommendations.

Breast Milk Intake - The breast milk intake rates for nursing infants that have been reported in the key studies described in this section are summarized in Table 13-17. Based on the combined results of these studies, 742 mL/day is recommended to represent an average breast milk intake rate, and 1,033 mL/day represents an upper-percentile intake rate (based on the middle range of the mean plus 2

Table 13-14. Percentage of Mothers Breast-feeding Newborn Infants in the Hospital and Infants at 5 or 6 Months of Age in the United States in 1989[a], by Ethnic Background and Selected Demographic Variables[b]

	Total		White		Black		Hispanic[c]	
Category	Newborns	5-6 Mo Infants	Newborns	5-6 Mo Infants	Newborns	5-6 Mo Infants	Newborns	5-6 Mo Infants
All mothers	52.2	19.6	58.5	22.7	23.0	7.0	48.4	15.0
Parity								
Primiparous	52.6	16.6	58.3	18.9	23.1	5.9	49.9	13.2
Multiparous	51.7	22.7	58.7	26.8	23.0	7.9	47.2	16.5
Marital status								
Married	59.8	24.0	61.9	25.3	35.8	12.3	55.3	18.8
Unmarried	30.8	7.7	40.3	9.8	17.2	4.6	37.5	8.6
Maternal age								
< 20 yr	30.2	6.2	36.8	7.2	13.5	3.6	35.3	6.9
20-24 yr	45.2	12.7	50.8	14.5	19.4	4.7	46.9	12.6
25-29 yr	58.8	22.9	63.1	25.0	29.9	9.4	56.2	19.5
30-34 yr	65.5	31.4	70.1	34.8	35.4	13.6	57.6	23.4
≥35 yr	66.5	36.2	71.9	40.5	35.6	14.3	53.9	24.4
Maternal education								
No college	42.1	13.4	48.3	15.6	17.6	5.5	42.6	12.2
College[d]	70.7	31.1	74.7	34.1	41.1	12.2	66.5	23.4
Family income								
< $7,000	28.8	7.9	36.7	9.4	14.5	4.3	35.3	10.3
$7,000-$14,999	44.0	13.5	49.0	15.2	23.5	7.3	47.2	13.0
$15,000-$24,999	54.7	20.4	57.7	22.3	31.7	8.7	52.6	16.5
≥$25,000	66.3	27.6	67.8	28.7	42.8	14.5	65.4	23.0
Maternal employment								
Full time	50.8	10.2	54.8	10.8	30.6	6.9	50.4	9.5
Part time	59.4	23.0	63.8	25.5	26.0	6.6	59.4	17.7
Not employed	51.0	23.1	58.7	27.5	19.3	7.2	46.0	16.7
U.S. census region								
New England	52.2	20.3	53.2	21.4	35.6	5.0	47.6	14.9
Middle Atlantic	47.4	18.4	52.4	21.8	30.6	9.7	41.4	10.8
East North Central	47.6	18.1	53.2	20.7	21.0	7.2	46.2	12.6
West North Central	55.9	19.9	58.2	20.7	27.7	7.9	50.8	22.8
South Atlantic	43.8	14.8	53.8	18.7	19.6	5.7	48.0	13.8
East South Central	37.9	12.4	45.1	15.0	14.2	3.7	23.5	5.0
West South Central	46.0	14.7	56.2	18.4	14.5	3.8	39.2	11.4
Mountain	70.2	30.4	74.9	33.0	31.5	11.0	53.9	18.2
Pacific	70.3	28.7	76.7	33.4	43.9	15.0	58.5	19.7

[a] Mothers were surveyed when their infants were 6 months of age. They were asked to recall the method of feeding the infant when in the hospital, at age 1 week, at months 1 through 5, and on the day preceding completion of the survey. Numbers in the columns labeled "5-6 Mo Infants" are an average of the 5-month and previous day responses.
[b] Based on data from Ross Laboratories.
[c] Hispanic is not exclusive of white or black.
[d] College includes all women who reported completing at least 1 year of college.

Source: NAS, 1991.

standard deviations) for infants between the ages of 1 and 6 months of age. This value is the mean of the average intakes at 1, 3, and 6 months from the key studies listed in Table 13-17. It is consistent with the average intake rate of 718 to 777 mL/day estimated by NAS (1991) for infants during the first 4 to 5 months of life. Intake among older infants is somewhat lower, averaging 413 mL/day for 12-month olds (Neville et al. 1988; Dewey et al. 1991; 1991b). When a time weighted average is calculated for the 12-month period, average breast milk intake is approximately 688 mL/day, and upper-percentile intake is approximately 980 mL/day. Table 13-18 summarizes these recommended intake rates.

Lipid Content and Lipid Intake - Recommended lipid intake rates are based on data from Butte et al. (1984) and Maxwell and Burmaster (1993). Butte et al. (1984) estimated that average lipid intake ranges from 23.6 ± 7.2 g/day (22.9 ± 7.0 mL/day) to 28.0 ± 8.5 g/day (27.2 ± 8.3 mL/day) between 1 and 4 months of age. These intake rates are consistent with those observed by Burmaster and Maxwell (1993) for infants under 1 year of age [(26.8 ± 7.4 g/day (26.0 ± 7.2 mL/day)]. Therefore, the recommended breast milk lipid intake rate for infants under 1 year of age is 26.0 mL/day and the upper-percentile value is 40.4 mL/day (based on the mean plus 2 standard deviations). The recommended value for breast milk fat content is 4.0 percent based on data from NAS (1991), Butte et al. (1984), and Maxwell and Burmaster (1993).

13.7 REFERENCES FOR CHAPTER 13

Axelsson, I.; Borulf, S.; Righard, L.; Räihä, N. (1987) Protein and energy intake during weaning: effects and growth. Acta Paediatr. Scand. 76:321-327.

Brown, K.H.; Akhtar, N.A.; Robertson, A.D.; Ahmed, M.G. (1986a) Lactational capacity of marginally nourished mothers: relationships between maternal nutritional status and quantity and proximate composition of milk. Pediatrics. 78: 909-919.

Brown, K.H.; Robertson, A.D.; Akhtar, N.A. (1986b) Lactational capacity of marginally nourished mothers: infants' milk nutrient consumption and patterns of growth. Pediatrics. 78: 920-927.

Butte, N.F.; Garza, C.; Smith, E.O.; Nichols, B.L. (1984) Human milk intake and growth in exclusively breast-fed infants. Journal of Pediatrics. 104:187-195.

Butte, N.F.; Wong, W.W.; Garza, C.; Klein, P.D. (1990) Adequacy of human milk for meeting energy requirements during early infancy. In: Atkinson, S.A.; Hanson, L.A.; Chandra, R.K., eds. Breastfeeding, nutrition, infection and infant growth in developed and emerging countries.. ARTS Biomedical Publ., Newfoundland, Canada.

Dewey, K.G.; Lönnerdal, B. (1983) Milk and nutrient intake of breast-fed infants from 1 to 6 months:relation to growth and fatness. Journal of Pediatric Gastroenterology and Nutrition. 2:497-506.

Dewey, K.G.; Heinig, J.; Nommsen, L.A.; Lönnerdal, B. (1991a) Maternal versus infant factors related to breast milk intake and residual volume: the DARLING study. Pediatrics. 87:829-837.

Dewey, K.G.; Heinig, J.; Nommsen, L.; Lönnerdal, B. (1991b) Adequacy of energy intake among breast-fed infants in the DARLING study: relationships to growth, velocity, morbidity, and activity levels. The Journal of Pediatrics. 119:538-547.

Hofvander, Y.; Hagman, U.; Hillervik, C.; Sjolin, S. (1982) The amount of milk consumed by 1-3 months old breast- or bottle-fed infants. Acta Paediatr. Scand. 71:953-958.

Köhler, L.; Meeuwisse, G.; Mortensson, W. (1984) Food intake and growth of infants between six and twenty-six weeks of age on breast milk, cow's milk formula, and soy formula. Acta Paediatr. Scand. 73:40-48.

Lönnerdal, B.; Forsum, E.; Gebre-Medhim, M.; Hombraes, L. (1976) Breast milk composition in Ethiopian and Swedish mothers: lactose, nitrogen, and protein contents. The American Journal of Clinical Nutrition. 29:1134-1141.

Maxwell, N.I.; Burmaster, D.E. (1993) A simulation model to estimate a distribution of lipid intake from breast milk during the first year of life. Journal of Exposure Analysis and Environmental Epidemiology. 3:383-406.

Montandon, C.M.; Wills, C.; Garza, C.; Smith, E.O.; Nichols, B.L. (1986) Formula intake of 1- and 4-month-old infants. Journal of Pediatric Gastroenterology and Nutrition. 5:434-438.

National Academy of Sciences (NAS). (1991) Nutrition during lactation. Washington, DC National Academy Press.

Neville, M.C.; Keller, R.; Seacat, J.; Lutes, V.; Neifert, M.; et al. (1988) Studies in human lactation: milk volumes in lactating women during the onset of lactation and full lactation. American Journal of Clinical Nutrition. 48:1375-1386.

Pao, E.M.; Hines, J.M.; Roche, A.F. (1980) Milk intakes and feeding patterns of breast-fed infants. Journal of the American Dietetic Association. 77:540-545.

Prentice, A.M.; Lucas, A.; Vasquez-Velasquez, L.; Davies, P.S.; Whitehead, R.G. (1988) Are current dietary guidelines for young children a prescription for over feeding? Lancet. 1988:1066-1068.

Ryan, A.S.; Rush, D.; Krieger, F.W.; Lewandowski, G.E. (1991) Recent declines in breastfeeding in the United States, 1984-1989. Pediatrics. 88:719-727.

Whitehead, R.G.; Paul, A.A. (1991) Dietary energy needs from 6 to 12 months of age. In: Heird, W.C. ed., Nutritional Needs of the Six to Twelve Month Old Infant. New York, Raven Press Ltd. pp. 135-148.

Table 13-15. Breast Milk Intake Studies

Study	Relevance	Number of Individuals	Type of Feeding	Sampling Time and Interval	Population Studied	Comments
KEY STUDIES						
Butte et al., 1984	Key	45	Exclusively breast-fed for first 4 months	Most infants studied over 1 day only, at 1, 2, 3, 4 months some studied over 48 to 96 hours to study individual variability	Mid- to upper-socioeconomic stratum	Estimated breast milk intake and energy intake; corrected for insensible water loss
Dewey et al., 1991a; 1991b	Key	73	Breast-fed for 12 months; exclusively breast-fed for at least first 4 months	Test weighing over 4-day period every 3 months for 1 year	Highly educated, high-socioeconomic class from Davis area of California	Estimated breast milk intake; corrected for insensible water loss
Dewey and Lönnerdal, 1983	Key	20	Most infants exclusively breast-fed	Two test weighings per month for 6 months	Mid to upper class from Davis area of California	Estimated brest milk intake and energy intake; did not correct for insensible water loss
Neville et al., 1988	Key	13	Exclusively breast-fed infants	Infants studied over 24-hour period at each sampling interval; numerous sampling intervals over first year of life	Nonsmoking Caucasian mothers; middle- to upper-socioeconomic status	Estimated breast milk intake and lipid intake; corrected for insensible water loss; estimated frequency and duration of feeding
Pao et al., 1980	Key	22	Completely or partially breast-fed infants	Three consecutive days at 1, 3, 6, and 9 months	White middle class from southeastern Ohio	Estimated breast milk intake; did not correct for insensible water loss

Table 13-15. Breast Milk Intake Studies

Study	Relevance	Number of Individuals	Type of Feeding	Sampling Time and Interval	Population Studied	Comments
RELEVANT STUDIES						
Axelsson et al., 1987	Relevant	30	Breast-fed infants and infants fed formula with two different energy contents	Studied over 2-day periods at 4.5 and 5.5 months of age	Swedish infants	Energy intake calculated from analysis of milk composition and measured intake rates; not corrected for insensible water loss
Brown et al., 1986a; 1986b	Relevant	58, 60	Breast-fed infants	Studied over 3 days at each interval	Bangledeshi infants; marginally nourished mothers	Measured milk and nutrient intake; not corrected for insensible water loss
Köhler et al., 1984	Relevant	59	25 fully breast-fed and 34 formula-fed infants	Studied over 48-hour periods at 6, 14, 22, and 26 weeks of age	Swedish infants	Estimated breast milk and formula intake; no corrections for insensible water loss among breast-fed infants; estimated energy intake
Maxwell and Burmaster, 1993	Relevant	1,113	Population of 1,113 breast-fed infants based on a hypothetical population of 5,000 breast-fed and bottle-fed infants	NA	NA	Simulated distribution of breast milk intake based on data from Dewey 1991a; estimated percent of breast-fed infants under 12 months of age
NAS, 1991	Relevant	NA	Breast-fed infants	NA	NA	Summarizes current state-of-knowledge on breast milk volume, composition and breast-feeding populations
Hofvander et al., 1982	Relevant	50	25 breast-fed and 25 formula-fed infants	Studied 24-hour period at 1, 2, and 3 months	Swedish infants	Estimated breast milk and formula intake; no corrections for insensible water loss among breast-fed infants; estimated frequency of feeding

Table 13-16. Confidence in Breast Milk Intake Recommendations

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	All key studies are from peer review literature	High
• Accessibility	Papers are widely available from peer review journals	High
• Reproducibility	Methodology used was clearly presented	High
• Focus on factor of interest	The focus of the studies was on estimating breast milk intake	High
• Data pertinent to U.S.	Subpopulations of the U.S. were the focus of all the key studies	High
• Primary data	All the studies were based on primary data	High
• Currency	Studies were conducted between 1980-1986. Although incidence of breast feeding may change with time, breast milk intake among breastfed infants may not.	Medium
• Adequacy of data collection period	Infants were not studied long enough to fully characterize day to day variability.	Medium
• Validity of approach	Methodology uses changes in body weight as a surrogate for total ingestion. This is the best methodology there is to estimate breast milk ingestion. Mothers were instructed in the use of infant scales to minimize measurement errors. Three out of the 5 studies corrected data for insensible water loss.	Medium
• Study size	The sample sizes used in the key studies were fairly small (range 13-73).	
• Representativeness of the population	Population is not representative of the U.S.; only mid-upper class, well nourished mothers were studied. Socioeconomic factors may affect the incidence of breastfeeding. Mother's nourishment may affect milk production.	Low
• Characterization of variability	Not very well characterized	Low
• Lack of bias in study design (high rating is desirable)	Bias in the studies was not characterized; Three out of 5 studies corrected for insensible water loss; Not correcting for insensible water loss may underestimate intake; Mothers selected for the studies were volunteers; therefore response rate does not apply; population studied may introduce some bias in the results (see above)	Low
• Measurement error	All mothers were well educated and trained in the use of the scale which helped minimize measurement error.	Medium
Other Elements		
• Number of studies	There are 5 key studies	High
• Agreement between researchers	There is good agreement among researchers	High
Overall Rating	Studies were well designed; results were consistent; sample size was fairly low and not representative of U.S. population or population of nursing mothers; variability cannot be characterized due to limitations in data collection period.	Medium

Table 13-17. Breast Milk Intake Rates Derived From Key Studies

Mean (mL/day)	N	Upper Percentile (mL/day) (mean plus 2 standard deviations)	Reference
Age: 1 Month			
600	11	918	Pao et al., 1980
729	37	981	Butte et al., 1984
747	13	1,095	Neville et al., 1988
673	16	1,057	Dewey and Lönnerdal, 1983
weighted avg = 702		1,007[a]	
Age: 3 Months			
833	2	---	Pao et al., 1980
702	37	923	Butte et al., 1984
712	12	934	Neville et al., 1988
782	16	1,126	Dewey and Lönnerdal, 1983
788	73	1,046	Dewey et al., 1991b
weighted avg = 759		1,025[a]	
Age: 6 Months			
682	1	---	Pao et al., 1980
744	13	978	Neville et al., 1988
896	11	1,140	Dewey and Lönnerdal, 1983
747	60	1,079	Dewey et al., 1991b
weighted avg = 765		1,059[a]	
Age: 9 Months			
600	12	1,027	Neville et al., 1988
627	50	1,049	Dewey et al., 1991b
avg = 622		1,038	
Age: 12 Months			
391	9	877	Neville et al., 1988
435	42	923	Dewey et al., 1991a; 1991b
weighted avg = 427		900	
12-MONTH TIME WEIGHTED AVERAGE			
688		Range 900-1,059 (middle of the range 980)	

[a] Middle of the range.

Table 13-18. Summary of Recommended Breast Milk and Lipid Intake Rates

Age	Mean	Upper Percentile
Breask Milk		
1-6 Months	742 mL/day	1,033 mL/day
12 Month Average	688 mL/day	980 mL/day
Lipids[a]		
<1 Year	26.0 mL/day	40.4 mL/day

[a] The recommended value for the lipid content of breaskmilk is 4.0 percent.

TABLE OF CONTENTS

14. ACTIVITY FACTORS

In calculating exposure, a person's average daily dose is determined from a combination of variables including the pollutant concentration, exposure duration, and frequency of exposure (Sexton and Ryan, 1987). These variables can be dependent on human activity patterns and time spent at each activity and/or location. A person's total exposure can be predicted using indirect approaches such as computerized mathematical models. This indirect approach of predicting exposure also requires activity patterns (time use) data. Thus, individual or group activities are important determinants of potential exposure because toxic chemicals introduced into the environment may not cause harm to an individual until an activity is performed subjecting the individual to contact with those contaminants. An individual's choice on how to spend time will vary according to their occupation, hobbies, culture, location, gender, age, and personal preferences. Educational level attained and socioeconomic status also influence chosen activities and their duration.

The purpose of this section is to describe published time use studies that provide information on activities in which various individuals engage, length of time spent performing various activities, locations in which individuals spend time and length of time spent by individuals within those various environments. Information on time spent in specific occupations and residing in specific areas also is included in this section.

This section summarizes data on how much time individuals spend doing various activities and in various microenvironments. These data cover a wide scope of activities and populations. The following table (Table 14-1) should be used as a guide to locating the information relevant to activities and microenvironments of concern. Assessors can consider using these data to develop exposure duration estimates for specific exposure scenarios. Available studies are grouped as key or relevant studies. The classifications of these studies are based on the applicability of their data to exposure assessments. All tables that provide data from these studies are presented at the back of this chapter.

14.1. ACTIVITY PATTERNS

The purpose of this section is to describe published time use studies that provide information on time-activity patterns of the national population and various sub-populations in the U.S. The studies involve survey designs where time diaries were used to collect information on the time spent at various activities and locations for children, adolescents, and adults, and to collect certain demographic and socioeconomic data. Available studies on time-activity data are summarized in the following sections. It should be noted that other site-limited studies, based on small sample sites, are available, but are not presented in this section. The studies presented in this section are ones believed to be the most appropriate for the purpose of the Handbook. Activity pattern studies are presented in Sections 14.1.1 and 14.1.2.

14.1.1. Key Activity Pattern Studies

Timmer et al. - How Children Use Time - Timmer et al. (1985) conducted a study using the data obtained on children's time use from a 1981-1982 Panel study. This study was a follow-up of households from a previous survey conducted in 1975-76. The 922 respondents in the 1981-82 study were those who had completed at least three out of four waves of interview in the 1975 - 1976 survey. Timmer et al. (1985) conducted the survey during February through December 1981, and households were contacted four times during a 3 month interval of the survey period. The first contact was a personal interview, followed by subsequent telephone interviews for most of the respondents. However, families with children were contacted personally and questionnaires were administered to a maximum of three children per household.

The children surveyed were between the ages of 3 and 17 years and were interviewed twice. The questionnaires administered to children had two components: a time diary and a standardized interview. The time diary involved children reporting their activities beginning at 12.00 a.m. the previous night; the duration and location of each activity; the presence of another individual; and whether they were performing other activities at the same time. The standardized interview administered to the children was to gather information about their psychological, intellectual (using reading comprehension tests), and emotional well-being; their hopes and goals; their family environment; and their attitudes and beliefs.

For preschool children, parents provided information about the child's previous day's activities. Children in first through third grades completed the time diary with their parents assistance and, in addition, completed reading tests. Children in fourth grade and above provided their own diary information and participated in the interview. Parents were asked to assess their children's socioemotional and intellectual development. A survey form was sent to a teacher of each school-age child to evaluate each child's socioemotional and intellectual development. The activity descriptor codes used in this study were developed by Juster et al. (1983). The activity codes and descriptors used for the adult time diaries in both surveys are presented in Appendix Table 14A-1.

The mean time spent performing major activities on weekdays and weekends by age and sex, and type of day is presented in Table 14-2. On weekdays, children spend about 40 percent of their time sleeping, 20 percent in school, and 10 percent eating, washing, dressing, and performing other personal activities (Timmer et al., 1985). The data in Table 14-2 indicates that girls spend more time than boys performing household work and personal care activities, and less time playing sports. Also, children spend most of their free time watching television. Table 14-3 presents the mean time children spend during weekdays and weekends performing major activities by five different age groups. Also, the significant effects of each variable (i.e., age, sex) are shown in Table 14-3. Older children spend more time performing household and market work, studying and watching television, and less time eating, sleeping, and playing. Timmer et al. (1985) estimated that on the average, boys spend 19.4 hours a week watching television and girls spend 17.8 hours per week performing the same activity.

A limitation associated with this study is that the data do not provide overall annual estimates of children's time use since the data were collected only during the time of the year when children attend school and not during school vacation. Another limitation is that a distribution pattern of children's time use was not provided. In addition, the survey was conducted in 1981 so there is a potential that activity patterns in children may have changed significantly from that period to the present. Therefore, application of these data for current exposure situations may bias exposure assessments results. An advantage of this survey is that diary recordings of activity patterns were kept and the data obtained were not based completely on recall. Another advantage is that because parents assisted younger children with keeping their diaries and with interviews, any bias that may have been created by having younger children record their data should have been minimized.

Robinson and Thomas - Time Spent in Activities, Locations, and Microenvironments: A California-National Comparison - Robinson and Thomas (1991) reviewed and compared data from the 1987-88 California Air Resources Board (CARB) time activity study and from a similar 1985 national study, *American's Use of Time*. Data from the national study were recorded similarly to the CARB code categories, in order to make data comparisons (Robinson and Thomas, 1991).

The CARB study involved residents who lived in the state of California. One adult 18 years or older was randomly sampled in each household and was asked to complete a diary with entries for the previous day's activities and the location of each activity. Time use patterns for other individuals 12 years and older in the households contacted were also included in the diaries. Telephone interviews based on the random-digit-dialing (RDD) procedure were conducted for approximately 1,762 respondents in the CARB survey. These interviews were distributed across all days of the week and across different months of the year (between October 1987-August 1988).

In the 1985 National study, single day diaries were collected from over 5,000 respondents across the U.S., 12 years of age and older. The study was conducted during January through December 1985. Three modes of time diary collection were employed for this survey: mailback, telephone interview, and personal interview. Data obtained from the personal interviews were not used in this study (Robinson and Thomas, 1991). The sample population for the mail-back and telephone interview was selected based on a RDD method. The RDD was designed to represent all telephone households in the contiguous United States (Robinson and Thomas, 1991). In addition to estimates of time spent at various activities and locations, the survey design provided information on the employment status, age, education, race, and gender for each member of the respondent's household. The mail-back procedure was based on a "tomorrow" approach, and the telephone interview was based on recall. In the "tomorrow" approach, respondents know, and agree ahead of time, that they will be keeping a diary (Robinson and Thomas, 1991).

Data comparisons by Robinson and Thomas (1991) were based on 10 major activity categories (100 sub-category codes) and 3 major locations (44 sub-location codes) employed in both the CARB and the 1985 national study. In order to make data comparisons, Robinson and Thomas (1991) excluded responses from individuals of ages 65 years and older and 18 years or younger in both surveys. In addition, only mail-back responses were analyzed for the 1985 national study. The data were then weighted to project both the California and national population in terms of days of the week, region, numbers of respondents per household, and 3 monthly seasons of the year (Robinson and Thomas, 1991).

Table 14-4 shows the mean time spent in the 10 major activities by gender and for all respondents between the ages of 18-64 years (time use data for the individual activities are presented in Appendix Table 14A-2). In both studies respondents spent most of their time (642 mins/day) on personal needs and care (i.e., sleep). Californians spent more time on paid work, education and training, obtaining goods and services, and communication, and less time on household work, child care, organizational activities, entertainment/social activities, and recreation than the national population. The male and female population closely followed the same trends as the general population. Table 14-5 shows the mean time spent at 3 major locations for the CARB and national study grouped by total sample and gender, ages 18-64 years (time use data for the 44 detailed microenvironments are presented in Appendix Table 14A-3). Respondents spent most of their time at home, 892 minutes/day for the CARB and 954 minutes/day for the national study. Californians spent more of their time away from home and traveling compared to the national population.

In addition, Robinson and Thomas (1991) defined a set of 16 microenvironments based on the activity and location codes employed in both studies. The analysis included data for adolescents (12-17 years) and adults (65 years and older) in both the CARB study and the mail-back portion of the 1985 national study (Robinson and Thomas, 1991). The mean duration of time spent in locations for total sample population, 12 years and older, across three types of locations is presented in Table 14-6 for both studies. Respondents spent most of their time indoors, 1255 and 1279 minutes/day for the CARB and national study, respectively.

Table 14-7 presents the mean duration of time and standard mean error for the 16 microenvironments grouped by total sample population and gender. Also included is the mean time spent for respondents (“Doers”) who reported participating in each activity. Table 14-7 shows that in both studies men spend more time in autoplaces (garages), automobiles and other vehicles, physical outdoor activities, outdoor sites, and work locations. In contrast, women spend more time cooking, engaging in other kitchen activities, performing other chores, and shopping. The same trends also occur on a per participant basis.

Table 14-8 shows the mean time spent in various microenvironments grouped by type of the day (weekday or weekend) in both studies. Generally, respondents spent most of their time during the weekends in restaurants/bars (CARB study), motor vehicles, outdoor activities, social-cultural settings, leisure/communication activities, and sleeping. Microenvironmental differences by age are presented in Table 14-9. Respondents in the age groups 18-24 years and 25-44 years spent most of their time in restaurants/bars and traveling. The oldest age group, 65 years and older, spent most of their time in the kitchen (cooking and other kitchen related activities) and in communication activities.

Limitations associated with the Robinson and Thomas (1991) study are that the CARB survey was based on recall and the survey was performed in California only. This may somewhat bias the CARB data set. Another limitation is that time distribution patterns (statistical analysis) were not provided for both studies. Also, the data are based on short term studies. An advantage of this study is that the 1985 national study represents the general U.S. population. Also, the 1985 national study provides time estimates by activities, locations, and microenvironments grouped by age, gender, and type of day. Another advantage is that the data were compared and that, overall, both data sets showed similar patterns of activity (Robinson and Thomas, 1991).

California Air Resources Board (CARB) - Study of Children's Activity Patterns - The California children's activity pattern survey design provided time estimates of children (under 12 years old) in various activities and locations (microenvironments) on a typical day (CARB, 1991). The sample population, which consisted of 1,200 respondents (including children under 12 years of age and adult informants residing in the child's household), was selected using Waksberg RDD methods from English-speaking households. One child was selected from each household. If the selected child was 8 years old or less, the adult in the same household who spent the most time with the child responded. However, if the selected child was between 9 and 11 years old, that child responded. The population was also stratified to provide representative estimates for major regions of the state. The survey questionnaire included a time diary which provided information on the children's activity and location patterns based on a 24-hour recall period. In addition, the survey questionnaire included questions about potential exposure to sources of indoor air pollution (i.e., presence of smokers) on the diary day and the socio-demographic characteristics (i.e., age, gender, marital status of adult) of children and adult respondents. The questionnaires and the time diaries were administered via a computer-assisted telephone interviewing (CATI) technology (CARB, 1991). The telephone interviews were conducted during April 1989 to February 1990 over four seasons: Spring (April-June 1989), Summer (July-September 1989), Fall (October-December 1989), and Winter (January-February 1990).

The data obtained from the survey interviews resulted in ten major activity categories, 113 detailed activity codes, 6 major categories of locations, and 63 detailed location codes. The average time respondents spent during the 10 activity categories for all children are presented in Table 14-10. Also included in this table are the detailed activity, including its code, with the highest mean duration of time; the percentage of respondents who reported participating in any activity (percent doing); and the mean, median, and maximum time duration for "doers." The dominant activity category, personal care (night sleep being the highest contributor), had the highest time expenditure of 794 mins/day (13.2 hours/day). All respondents reported sleeping at night, resulting in a mean daily time per participant of 794 mins/day spent sleeping. The activity category "don't know" had a duration of about 2 mins/day and only 4 percent of the respondents reported missing activity time.

Table 14-11 presents the mean time spent in the 10 activity categories by age and gender. Differences in activity patterns for boys and girls tended to be small. Table 14-12 presents the mean time spent in the 10 activity categories grouped by seasons and California regions. There were seasonal differences for 5 activity categories: personal care, educational activities, social/entertainment, recreation, and communication/passive leisure. Time expenditure differences in various regions of the State were minimal for childcare, work-related activities, shopping, personal care, education, social life, and recreation.

Table 14-13 presents the distribution of time across six location categories. The participation rates (percent) of respondents, the mean, median, and maximum time for "doers." The detailed location with the highest average time expenditure are also shown. The largest amount of time spent was at home (1,078 minutes/day); 99 percent of respondents spent time at home (1,086 minutes/participant/day). Tables 14-14 and 14-15 show the average time spent in the six locations grouped by age and gender, and season and region, respectively. There are age differences in time expenditure in educational settings for boys and girls (Table 14-14). There are no differences in time expenditure at the six locations by regions, and time spent in school decreased in the summer months compared to other seasons (Table 14-15). Table 14-16 shows the average potential exposure time children spent in proximity to tobacco smoke, gasoline fumes, and gas oven fumes grouped by age and gender. The sampled children spent more time closer to tobacco smoke (77 mins/day) than gasoline fumes (2 mins/day) and gas oven fumes (11 mins/day).

A limitation of this study is that the sampling population was restricted to only English-speaking households; therefore, the data obtained does not represent the diverse population group present in California. Another limitation is that time use values obtained from this survey were based on short-term recall data; therefore, the data set obtained may be biased. Other limitations are: the survey was conducted in California and is not representative of the national population, and the significance of the observed differences in the data obtained (i.e., gender, age, seasons, and regions) were not tested statistically. An advantage of this study is that time expenditure in various activities and locations were presented for children grouped by age, gender, and seasons. Also, potential exposures of respondents to pollutants were explored in the survey. Another advantage is the use of the CATI program in obtaining time diaries, which allows automatic coding of activities and locations onto a computer tape, and allows activities forgotten by respondents to be inserted into its appropriate position during interviewing (CARB, 1991).

U.S. EPA - Dermal Exposure Assessment: Principles and Applications - U.S. EPA (1992) addressed the variables of exposure time, frequency, and duration needed to calculate dermal exposure as related to activity. The reader is referred to the document for a detailed discussion of these variables in relation to soil and water related activities. The suggested values that can be used for dermal exposure are presented in Table 14-17. Limitations of this study are that the values are based on small data sets and a limited number of studies. An advantage is that it presents default values for frequency and duration for use in exposure assessments when specific data are not available.

James and Knuiman - An Application of Bayes Methodology to the Analysis of Diary Records from a Water Use Study - In 1987, James and Knuiman provided a distribution of the amount of time spent showering by individuals in households located in Australia. This distribution was based on diary records of 2,500 households. Using these data, a cumulative frequency distribution was derived and is presented in Table 14-18. Based on these results, the mean shower length is approximately 8 minutes, the median shower length is approximately 7 minutes and the 90th percentile is approximately 12 minutes.

A limitation of the study is that the data are from households in Australia and may not be representative of U.S. households. An advantage is that it presents cumulative distribution data.

Tsang and Klepeis (1996) - National Human Activity Pattern Survey (NHAPS) - The National Human Activity Pattern Survey was conducted by the U.S. EPA (Tsang and Klepeis, 1996). It is the largest and most current human activity pattern survey available (Tsang and Klepeis, 1996). Data for 9,386 respondents in the 48 contiguous United States were collected via minute-by-minute 24-hour diaries between October 1992 and September 1994. Detailed data were collected for a maximum of 82 different possible locations, and a maximum of 91 different activities. Participants were selected using a Ramdon Digit Dial (RDD) method and Computer Assisted Telephone Interviewing (CATI). The response rate was 63 percent, overall. If the chosen respondent was a child too young to interview, an adult in the household gave a proxy interview. Each participant was asked to recount their entire daily routine from midnight to midnight immediately previous to the day that they were interviewed. The survey collected information on duration and frequency of selected activities and of the time spent in selected microenvironments. In addition, demographic information was collected for each respondent to allow for statistical summaries to be generated according to specific subgroups of the U.S. population (i.e., by gender, age, race, employment status, census region, season, etc.). The participants' responses were weighted according to geographic, socioeconomic, time/season, and other demographic factors to ensure that results were representative of the U.S. population. The weighted sample matches the 1990 U.S. census population for each gender, age group, census region, and the day-of-week and seasonal responses are equally distributed. Saturdays and Sundays were oversampled to ensure an adequate weekend sample.

The data presented are a compilation of 24-hour diary locations, activities, and follow-up exposure questions based on exposure-related events (personal, exposure, household characteristics, medical background) (Tsang and Klepeis, 1996). Data presented are reported in the form of means, percentages of time spent, and percentages of respondent occurrences. The diary data are useful for obtaining national representative distributions of time spent in a large variety of activities and locations in a single day (Tsang and Klepeis, 1996). According to Tsang and Klepeis (1996), the 24-hour diaries in the NHAPS are useful in probabilistic modeling (Monte-Carlo) that provides frequency distributions of exposure. Overall survey results indicate that for time spent in microenvironments, the largest overall percentage of time was spent in residential-indoors (67 percent), followed by time spent outdoors (8 percent), and then time spent in vehicles (5 percent) (Tsang and Klepeis, 1996). NHAPS data on the time spent in selected activities are presented in Tables 14-19 through 14-92. NHAPS data on the time spent in selected microenvironments are presented in Tables 14-93 to 14-139.

Tables 14-19 through 14-30 provide information on the frequency and duration of taking baths, frequency of taking showers, and on the amount of time spent in the shower or bathroom after completion of the activity. Table 14-31 provides the frequency for washing the hand in a day. Tables 14-32 through 14-34 present information on time spent by persons working with or being near foods while being grilled or barbecued, working with or near open flames, and working or being near excessive dust in the air. Tables 14-35 through 14-37 provide data for the number of times a vehicle was started in a garage or carport and started with the door closed, and time spent at a gas station or repair shop. Tables 14-38 through 14-40 present information on the number of times windows and doors were opened and the number of minutes left open at home in a day. Tables 14-41 through 14-45 provide data for time spent in heavy traffic either running, walking, standing, or in a vehicle, and time spent in indoor and outdoor parking lots and garages. Tables 14-46 through 14-48 present information for time spent working for pay and for time spent working outdoors. Tables 14-49 through 14-54 provide information for frequency of performing household tasks such as vacuuming, washing dishes, and clothes in the home. Tables 14-55 through 14-62 present data for frequency and duration on playing in sand, gravel, and dirt; and working in circumstances where one comes in contact with soil such as a garden. Tables 14-63 through 14-65 provide information on the number of times the respondent went swimming in a fresh water pool and the time spent in the water during 1 month.

Tables 14-66 through 14-85 present 24-hour cumulative statistics for time spent in various major categories. They are as follows: Paid Work (main job); Household Work (food preparation and cleanup, cleaning house, clothes care); Child Care (indoor and outdoor playing); Obtaining Goods and Services (car repair); Personal Needs and Care (sleeping/napping); Free Time and Education (school); and Recreation (active sports, exercise, outdoor recreation).

Tables 14-86 through 14-92 prvide 24-hour cumulative statistics for time spent in various activities that are the results of regrouping/combining activities described in Tables 14-66 through 14-85. They were regrouped into broader categories in order to present categories with a larger number of occurrences in an attempt to create useful exposure activities from the available data (Tsang and Klepeis, 1996).

Tables 14-93 through 14-101 provide statistics for time spent in various indoor microenvironments such as repair shops/gas stations; bar/ night club/bowling alley; and at school. Tables 14-102 through 14-110 present statistical data for time spent in various outdoor locations. These tables include locations such as school grounds/playground; parking lots; construction sites; parks and golf courses; and farms.

Statistics for time spent in various locations in the home are presented in Tables 14-111 through 14-118. Data are presented for the 24-hour cumulative number of minutes spent in the kitchen, bathroom, bedroom, garage, basement, utility room or laundry room, in the outdoor pool or spa; and in the yard or other areas outside the house. Tables 14-119 through 14-128 provide data on time spent traveling and in various types of vehicles, and on time spent walking.

Tables 14-129 through 14-138 present information on locations/microenvironments that have been regrouped/combined based on various data described in Tables 14-93 through 14-128. Tables 14-129 through 14-138 provide statistics for total time spent indoors at home, including all rooms; outdoors at home; traveling inside a vehicle; outdoors near a vehicle; outdoors other than near a residence; in an office or factors; in malls and other stores; in various public buildings, in bars, restaurants, etc.; and outdoor locations such as auto repair shops and laundromats. Table 14-139 provides the statistics for the cumulative number of minutes spent in an activity or microenvironment where a smoker was present.

Advantages of the NHAPS dataset are that it is representative of the U.S. population and it has been adjusted to be balanced geographically, seasonally, and for day/time. Also, it is representative for all ages, gender, and race.

14.1.2. Relevant Activity Pattern Studies

Robinson - Changes in Americans' Use of Time: 1965-1975 - Robinson (1977) compared time use data obtained from two national surveys that were conducted in 1965-1966 and in 1975. Each survey used the time-diary method to collect data. The 1965-66 survey excluded people in the following categories: (a) Non-Standard Metropolitan Statistical Area (non-SMSA) (designation of Census Bureau areas having no city with more than 50,000 population); (b) households where no adult members were in the labor force for at least 10 hours per week; (c) age 65 and over; and (d) farm-related occupations (Robinson, 1977). The 1,244 respondents in the 1965-66 study included either employed men and women or housewives (Robinson, 1977). The survey was conducted between November-December 1965 and March-April 1966. Respondents recorded their daily activities in time diaries by using the "tomorrow" approach. In this approach, diaries were kept on the day following the interviewer's initial contact. The interviewer then made a second call to the respondent to determine if the information in diaries were correct and to obtain additional data. Only one person per household was interviewed. The survey was designed to obtain information on time spent with family members, time spent at various locations during activities, and performing primary and secondary activities.

A similar study was conducted in 1975 from October through December. Unlike the 1965-1966 survey, the 1975 survey included rural areas, farmers, the unemployed, students, and retirees. Time diary data were collected using the "yesterday" approach. In this approach, interviewers made only one contact with respondents (greater than 1500) and the diaries were filled out based on a 24-hour recall (Robinson, 1977). Time diary data were also collected from the respondents' spouses.

In both surveys, the various activities were coded into 96 categories, and then were combined into five major categories. Free-time activities were grouped into 5 sub-categories (Appendix Table 14A-2). In order to compare data obtained from both surveys, Robinson (1977) excluded the same population groups in the 1975 survey that were excluded in the 1965-66 survey (i.e., farmers, rural residents).

Results obtained from the surveys were presented by gender, age, marital and employment status, race, and education. Robinson (1977) reported the data collected in hours/week; however, the method for converting daily activities to hours/week were not presented. Table 14-140 shows the differences in time use by gender, employment, and marital status for five major activity categories and five subcategories for 1965 and 1975. Time spent on work related activities (i.e., work for pay and family care) was lower in 1975 than in 1965 for employed men and women. Table 14-140 also shows that there was an overall increase in free time activities for all the six groups. The difference in time use in 1965 and 1975 are presented by age, education, and race in Tables 14-141, 14-142, and 14-143, respectively. These tables include data for students and certain employed respondents that were excluded in Table 14-40 (Robinson, 1977). In 1975, the eldest group (ages 56-65 years) showed a decline in paid work, and an increase in family care, personal care and sleep (Table 14-141). Education level comparisons across the ten-year interval indicated that the less educated had a decrease in paid work and an increase in sleep and personal care; the most educated had an increase in work time and a decrease in other leisure (Table 14-142). For racial comparisons, Blacks spent less time at paid work than Whites across the ten-year interval (Table 14-143). Table 14-144 also shows that Blacks spent more time than Whites at free time activities in 1975.

A limitation of the study survey design is that time use data were gathered as social indicators. Therefore, the activity categories presented may not be relevant in exposure assessments. Another limitation is that statistical analysis of the data set was not provided. Additional limitations are that the time use data are old and the data may not reflect recent changes in time use. The 1965 and 1975 data sets excluded certain population groups and, therefore, may not be entirely representative of the U.S. population. Another limitation is that these are short-term studies and may not necessarily represent long-term activity patterns. An advantage of this study is that time use data were presented by age, gender, race, education level, and employment and marital status. Another advantage is that earlier investigations on the study method (24-hr recall) employed in the 1965 study revealed no systematic biases in reported activities (Robinson, 1977). Robinson (1977) also noted that the time-diary method provides a "zero-sum" measure (i.e., since there are only 24 daily hours or 168 weekly hours, if time on one activity increases then time on another activity must decrease).

Juster et al. - 1975-1981 Time Use Longitudinal Panel Study - The Time Allocation longitudinal study of the U.S. population began as part of a multinational project with the first survey conducted in 1965-66. A second national time use survey was conducted in 1975-1976 and another in 1981 (Juster et al. 1983). Juster et al. (1983) provided study descriptions of the second and third surveys. The surveys included a probability sample of the adult population (18 years and older) and children between the ages of 3 and 17 years in the United States. In both surveys, time use was measured from 24-hour recall diaries administered to respondents and their spouses. The 1975-1976 survey involved four waves of interview: wave 1, October-November 1975; wave 2, February 1976; wave 3, May-June 1976; wave 4, September 1976. The first wave was a personal interview and the other three waves were telephone interviews. The 1975-1976 survey sample consisted of 2,300 individuals, and of that sample, 1,519 respondents. Four recall diaries (one from each wave of interviews) were obtained from 947 respondents, with data on time use measures for two weekdays, one Saturday and one Sunday. The survey was designed to gather information for: employment status; earnings and other income; "consumption benefits for activities of respondents and their spouses;" health, friendships and associations of the respondents; stock technology available to the household, house repair, and maintenance activities of the family; division of labor in household work and related attitudes; physical characteristics of the respondents housing structure, net worth and housing values; job characteristics; and characteristics of mass media usage on a typical day (Juster et al., 1983).

The 1981 survey was a follow-up of respondents and spouses who had completed at least three waves of interview in the 1975-1976 survey. For the 1981 survey, 920 individuals were eligible. The survey design was similar to the 1975-1976 survey, however in this survey, the adult population was 25 years and older and consisted of 620 respondents. Four waves of interviews were conducted between February - March 1981 (wave 1), May - June 1981 (wave 2), September 1981 (wave 3), and November - December (wave 4). The 1981 survey included the respondents' children between the ages of 3 and 17 years. The survey design for children provided information on time use measures from two time diary reports: one school day and one non-school day. In addition, information for academic achievement measures, school and family life measures, and ratings from the children's teachers were gathered during the survey.

Juster et al. (1983) did not report the time use data obtained for the 1975-1976 survey or the 1981 survey. These data are stored in four tape files and can be obtained from the Inter-university Consortium for Political and Social Research (ICPSR) in Michigan. The response rate for the first wave of interview (1975-76 survey) based on the original sample population was 66 percent, and response rates for the subsequent waves ranged from 42 percent (wave 4) to 50 percent (wave 2). In the 1981 survey, the response rate based on eligible respondents was 67 percent for the first interview, and ranged from 54 percent (wave 4) to 60 percent (wave 2) in the subsequent interviews (Juster et al., 1985). The 1975-1976 survey included 87 activities. In the 1981 survey, these 87 activities were broken down into smaller components, resulting in 223 activities (Juster et al., 1985). The activity codes and descriptors used for the adult time diaries in both surveys are presented in Appendix Table 14A-3.

A limitation of this study is that the surveys were not designed for exposure assessment purposes. Therefore, the time use data set may be biased. Another limitation is that time use data collected were based on a 24-hour diary recall. This may somewhat bias the data set obtained from this survey. An advantage associated with this survey is that it provides a database of information on various human activities. This information can be used to assess various exposure pathways and scenarios associated with these activities. Also, some of the data from these surveys were used in the studies conducted by Timmer et al. (1985) and Hill (1985). In addition, the activity descriptor codes developed in these studies were used by Timmer et al (1985), Hill (1985), and Robinson and Thomas (1991). These studies are presented in Sections 14.1.1 and 14.1.2. Another advantage of this survey is that the data are based on a national survey and conducted over a one year period, resulting in a seasonally balanced survey and one representative of the U.S. population.

Hill - Patterns of Time Use - Hill (1985) investigated the total amount of time American adults spend in one year performing various activities and the variation in time use across three different dimensions: demographic characteristics, geographical location, and seasonal characteristics. In this study, time estimates were based on data collected from time diaries in four waves (1 per season) of a survey conducted in the fall of 1975 through the fall of 1976 for the 1975-1976 Time Allocation Study. The sampling periods included two weekdays, one Saturday and one Sunday. The 1975-1976 Time Allocation Study provided information on the amount of time spent performing primary activities. The information gathered were responses to the survey question "What were you doing?" The survey also provided information on secondary activities (i.e., respondents performing more than one activity at the same time). Hill (1985) analyzed time estimates for 10 broad categories of activities based on data collected from 87 activities. These estimates included seasonal variation in time use patterns and comparisons of time use patterns for different days of the week. The 10 major categories and ranges of activity codes are listed in Appendix Table 14A-4. Hill (1985) collected data on time use for the major activity patterns in four different age groups (18-24, 25-44, 45-64, and 65 years and older). However, the time use data were summarized in graphs rather than in tables.

Analysis of the 1975-76 survey data revealed very small regional differences in time use among the broad activity patterns (Hill, 1985). The weighted mean hours per week spent performing the 10 major activity categories presented by region are shown in Table 14-144. In all regions, adults spent more time on personal care (included night sleep). Adults in the North Central region of the country spent more time on market work activities than adults in other regions of the country. Adults in the South spent more time on leisure activities (passive and active combined) than adults elsewhere (Table 14-144). Table 14-145 presents the time spent per day, by the day of the week for the 10 major activity categories. Time spent on the 87 activities (components of the 10 major categories) are presented in Appendix Table 14A-5. Adult time use was dominated in descending order by personal care (including sleep), market work, passive leisure, and house work. Collectively, these activities represent about 80 percent of available time (Hill, 1985).

According to Hill (1985), sleep was the single most dominant activity averaging about 56.3 hours per week. Television watching (passive leisure) averaged about 21.8 hours per week, and housework activities averaged about 14.7 hours per week. Weekdays were predominantly market-work oriented. Weekends (Saturday and Sunday) were predominantly devoted to household tasks ("sleeping in," socializing, and active leisure) (Hill, 1985). Table 14-146 presents the mean time spent performing these 10 groups of activities during each wave of interview (fall, winter, spring, and summer). Adjustments were made to the data to assure equal distributions of weekdays, Saturdays, and Sundays (Hill, 1985). The data indicates that the time periods adults spent performing market work, child care, shopping, organizational activities, and active leisure were fairly constant throughout the year (Hill, 1985). The mean hours spent per week in performing the 10 major activity patterns are presented by gender in Table 14-147 (time use patterns for all 87 activities are presented in Appendix Table 14A-6). Table 14-147 indicates that time use patterns determined by data collected for the mid-1970's survey show gender differences. Men spent more time on activities related to labor market work and education, and women spent more time on household work activities.

A limitation associated with this study is that the time data were obtained from an old survey conducted in the mid-1970s. Because of fairly rapid changes in American society, applying these data to current exposure assessments may result in some biases. Another limitation is that time use data were not presented for children. An advantage of this study is that time diaries were kept and data were not based on recall. The former approach may result in a more accurate data set. Another advantage of this study is that the survey is seasonally balanced since it was conducted throughout the year and the data are from a large survey sample.

Sell - The Use of Children's Activity Patterns in the Development of a Strategy for Soil Sampling in West Central Phoenix - In a report prepared for the Arizona Department of Environmental Quality, Sell (1989) investigated the activity patterns of preschool and school age children in the west central portion of Phoenix known as Maryvale. The survey was conducted in two parts: (1) most of the school age children were interviewed personally from May through June, 1989 in three schools; and (2) survey questionnaires were mailed to parents of preschool children.

In the first survey, 15 percent of the total school population (2,008) was sampled with 111 children in grades K-6 participating (response rate of 37 percent). The surveyed population was 53.2 percent male and 46.8 percent female. Of this population, 41 percent were Hispanics, 49.5 percent Anglos, 7.2 percent Blacks, and 1.7 percent Asians. The children interviewed were between the ages of 5 and 13 years. Within each school, the children in grades K-6 were stratified into two groups, primary (grades K-3) and intermediate (grades 4-6), and children were selected randomly from each group. Children in grades K-2 were either interviewed in school or at home in the presence of a parent or an adult care-provider. In the course of the interview, children were asked to identify locations of activity areas, social areas (i.e., places they went with friends), favorite areas, and locations of forts or clubhouses. Aerial photographs were used to mark these areas.

The second survey involved only preschool children. Parents completed questionnaires which provided information on the amount of time their children spent outdoors, outdoor play locations, favorite places, digging areas, use of park or playgrounds, and swimming or wading locations. This survey was conducted between June-July 1989. One thousand (1,000) parents were sampled, but only 211 questionnaires were usable out of 886 questionnaires received resulting in a response rate for the preschool's survey of about 24 percent. The sample population consisted of children 1 month and up to preschool age. Of this population, 53 percent were Anglos, 18 percent Hispanics, 2 percent Blacks, and 3 percent Asians.

The survey design considered the kinds of activities children engaged in, but not the amount of time children spent in each activity. Therefore, Sell (1989) presented the data obtained from the survey in terms of percent of respondents who engaged in specific activities or locations. A summary of percent responses of the preschool and school-age children's activities at various locations in the Maryvale study areas are presented in Table 14-148. Also included in this table is a ranking of children's play locations based on other existing research works. Based on the survey data, Sell (1989) reported that the median time preschool children spent outdoors on weekdays was 1-2 hours, and on weekends the median time spent outdoors was 2-5 hours. Most of these children played outside in their own yards, and some played in other people's yards or parks and playgrounds (Sell, 1989).

Limitations associated with this study are that the survey design did not report the time spent in various activities or locations and the response rates obtained from the surveys were low and, therefore, may result in biased data. In addition, because the survey was conducted in Arizona, the surveyed population does not represent the children's population on a national basis. Advantages of this study are that it provides data on various activities children engage in and locations of these activities, and provides for time spent outdoors. This information is useful in determining exposure pathways to toxic pollutants for children.

Tarshis - The Average American Book - Tarshis (1981) compiled a book addressing the habits, tastes, lifestyles, and attitudes of the American people in which he reported data on time spent in personal grooming. The data presented are gathered from small surveys, the Newspaper Advertising Bureau, and magazines. Tarshis reported frequency and percentage data by gender and age for grooming activities such as showering and bathing as follows:

- 90 percent take some sort of a bath in an average 24-hour period;
- 5 percent average more than 1 shower or bath a day;
- 75 percent of men shower, 25 percent take baths;

- 50 percent of women take showers, 50 percent take baths;
- 65 percent of teenage girls 16-19 shower daily;
- 55 percent of teenage girls take at least one bath a week;
- 50 percent of women use an additive in their bath every time they bathe;
- People are more likely to shower than bathe if they are young and have higher income; and
- Showering is more popular than bathing in large cities.

Limitations of this study are that the data are compiled from other sources, and that the data are old; it is possible that these data may not reflect the current trends of the general population. An advantage of the study is that it presents frequency data that are useful in exposure assessment, especially concerning volatilization of chemicals from water.

AIHC (1994) - Exposure Factors Sourcebook - The activity factors data presented in the Sourcebook are similar to that in this handbook. The AIHC Sourcebook uses tenure data from the Bureau of Labor Statistics (1987), while this handbook uses more recent data (Carey, 1988) and provides general and specific recommendations for various age groups. Distributions were derived using data presented in U.S. EPA (1989) version of this handbook, he Bureau of Labor Statistics (1984), and various other references. Distribution data and/or recommendations are presented for time in one residence, residential occupancy, time spent indoors/outdoors, hours at home/away from home for adults and children, hours at work for adults, working tenure, and shower duration. For each distribution, the @Risk formula is provided for direct use in the @Risk software (Palisade, 1992). The Sourcebook has been classified as a relevant rather than a key study becuase it is not the primary source for the data used to make recommendations. It is a relevant source of alterntive information.

14.2. OCCUPATIONAL MOBILITY

14.2.1. Background

The amount of time spent in different types of occupations may affect the duration and/or magnitude of exposures to contaminants specific to those occupations. For example, an individual who spends an entire lifetime as a farmer may experience a longer duration of exposure to certain contaminants, especially pesticides, than individuals who leave farming for indoor occupations. Also, individual exposures to specific chemicals in the work place may be significantly reduced when individuals change jobs. Work place exposures among women may be of shorter duration than among men because women's careers may be interrupted by home and family responsibilities. The key studies presented in the following section provide occupational tenure for workers grouped by age, race, gender, and employment status.

14.2.2. Key Occupational Mobility Studies

Carey (1988) - Occupational Tenure in 1987: Many Workers Have Remained in Their Fields - Carey (1988) presented median occupational and employer tenure for different age groups, gender, earnings, ethnicity, and educational attainment. Occupational tenure was defined as "the cumulative number of years a person worked in his or her current occupation, regardless of number of employers, interruptions in employment, or time spent in other occupations" (Carey, 1988). The information presented was obtained from supplemental data to the January 1987 Current Population Study, a U.S. Bureau of the Census publication. Carey (1988) did not present information on the survey design.

The median occupational tenure by age and gender, ethnicity, and employment status are presented in Tables 14-149, 14-150, and 14-151, respectively. The median occupational tenure of the working population (109.1 million people) 16 years of age and older in January of 1987, was 6.6 years (Table 14-149). Table 14-149 also shows that median occupational tenure increased from 1.9 years for workers ages 16-24 to 21.9 for workers 70 years and older. The median occupational tenure for men 16 years and older was higher (7.9 years) than for women of the same age group (5.4 years). Table 14-150 indicates that whites had longer occupational tenure (6.7 years) than blacks (5.8 years), and Hispanics (4.5 years). Full-time workers had more occupational tenure than part-time workers 7.2 years and 3.1 years, respectively (Table 14-151).

Table 14-152 presents the median occupational tenure among major occupational groups. The median tenure ranged from 4.1 years for service workers to 10.4 years for people employed in farming, forestry, and fishing. In addition, median occupational tenure among detailed occupations ranged from 24.8 years for barbers to 1.5 years for food counter and fountain workers (Appendix Table 14A-7).

The strength of an individual's attachment to a specific occupation has been attributed to the individual's investment in education (Carey, 1988). Carey (1988) reported the median occupational tenure for the surveyed working population by age and educational level. Workers with 5 or more years of college had the highest median occupational tenure of 10.1 years. Workers that were 65 years and older with 5 or more years of college had the highest occupational tenure level of 33.8 years. The median occupational tenure was 10.6 years for self-employed workers and 6.2 years for wage and salary workers (Carey, 1988).

A limitation associated with this study is that the survey design employed in the data collection was not presented. Therefore, the validity and accuracy of the data set cannot be determined. Another limitation is that only median values were reported in the study. An advantage of this study is that occupational tenure (years spent in a specific occupation) was obtained for various age groups by gender, ethnicity, employment status, and educational level. Another advantage of this study is that the data were based on a survey population which appears to represent the general U.S. population.

Carey - Occupational Tenure, Employer Tenure, and Occupational Mobility - Carey (1990) conducted another study that was similar in scope to the study of Carey (1988). The January 1987 Current Population Study (CPS) was used. This study provided data on occupational mobility and employer tenure in addition to occupational tenure. Occupational tenure was defined in Carey (1988) as the "the cumulative number of years a person worked in his or her current occupation, regardless of number of employees, interruptions in employment, or time spent in other locations." Employer tenure was defined as "the length of time a worker has been with the same employer," while occupational mobility was defined as "the number of workers who change from one occupation to another" (Carey, 1990). Occupational mobility was measured by asking individuals who were employed in both January 1986 and January 1987 if they were doing the same kind of work in each of these months (Carey, 1990). Carey (1990) further analyzed the occupational mobility data and obtained information on entry and exit rates for occupations. These rates were defined as "the percentage of persons employed in an occupation who had voluntarily entered it from another occupation" and an exit rate was defined as "the percentage of persons employed in an occupation who had voluntarily left for a new occupation" (Carey, 1990).

Table 14-153 shows the voluntary occupational mobility rates in January 1987 for workers 16 years and older. For all workers, the overall voluntary occupational mobility rate was 5.3 percent. These data also show that younger workers left occupations at a higher rate than older workers. Carey (1990) reported that 10 million of the 100.1 million individuals employed in January 1986 and in January 1987 had changed occupations during that period, resulting in an overall mobility rate of 9.9 percent. Executive, administrative, and managerial occupations had the highest entry rate of 5.3 percent, followed by administrative support (including clerical) at 4.9 percent. Sales had the highest exit rate of 5.3 percent and service had the second highest exit rate of 4.8 percent (Carey, 1990). In January 1987, the median employer tenure for all workers was 4.2 years. The median employee tenure was 12.4 years for those workers that were 65 years of age and older (Carey, 1990).

Because the study was conducted by Carey (1990) in a manner similar to that of the previous study (Carey, 1988), the same advantages and disadvantages associated with Carey (1988) also apply to this data set.

14.3. POPULATION MOBILITY

14.3.1. Background

An assessment of population mobility can assist in determining the length of time a household is exposed in a particular location. For example, the duration of exposure to site-specific contamination, such as a polluted stream from which a family fishes or contaminated soil on which children play or vegetables are grown, will be directly related to the period of time residents live near the contaminated site.

Information regarding population mobility is compiled and published by the U.S. Bureau of the Census (BOC). Banks, insurance companies, credit card companies, real estate and housing associations use residence history information. However, usually this information is confidential. Information compiled by the BOC provides information about population mobility; however, it is difficult to determine the average residence time of a homeowner or apartment dweller from this information. Census data provide representations of a cross-section of the population at specific points in time, but the surveys are not designed to follow individual families through time. The most current BOC information about annual geographical mobility and mobility by State is summarized in Appendix 14B. Figure 14-1 graphically displays the distribution of movers by type of move.

Available information was provided by the Oxford Development Corporation, the National Association of Realtors (NAR), and the BOC. According to Oxford Development Corporation, a property management firm, the typical residence time for an apartment dweller for their corporation has been estimated to range from 18 to

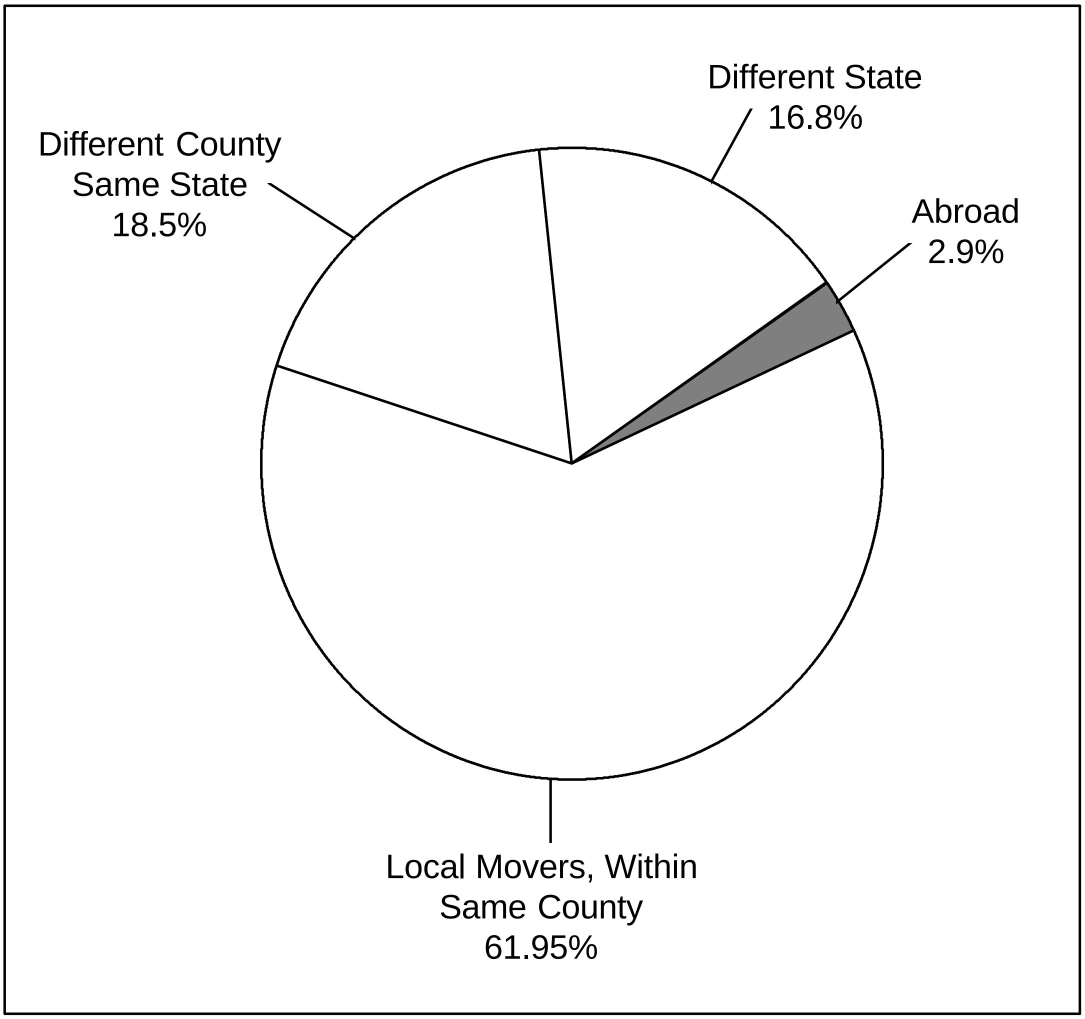


Figure 14-1. Distribution of Individuals Moving by Type of Move: 1991-92

Source: U.S. Bureau of the Census, 1993

Figure 14-1. Distribution of Individuals Moving by Type of Move: 1991-92.

Source: U.S Bureau of the Census, 1993

30 months (S. Cameron Hendricks, Sales Department, Oxford Development Corporation, Gaithersburg, MD, personal communication with P. Wood (Versar) August 10, 1992).

14.3.2. Key Population Mobility Studies

Israeli and Nelson (1992) - Distribution and Expected Time of Residence for U.S. Households - In risk assessments, the average current residence time (time since moving into current residence) has often been used as a substitute for the average total residence time (time between moving into and out of a residence) (Israeli and Nelson, 1992). Israeli and Nelson (1992) have estimated distributions of expected time of residence for U.S. households. Distributions and averages for both current and total residence times were calculated for several housing categories using the 1985 and 1987 BOC housing survey data. The total residence time distribution was estimated from current residence time data by modeling the moving process (Israeli and Nelson, 1992). Israeli and Nelson (1992) estimated the average total residence time for a household to be approximately 4.6 years or 1/6 of the expected life span (see Table 14-154). The maximal total residence time that a given fraction of households will live in the same residence is presented in Table 14-155. For example, only 5 percent of the individuals in the "All Households" category will live in the same residence for 23 years and 95 percent will move in less than 23 years.

The authors note that the data presented are for the expected time a household will stay in the same residence. The data do not predict the expected residence time for each member of the household, which is generally expected to be smaller (Israeli and Nelson, 1992). These values are more realistic estimates for the individual total residence time, than the average time a household has been living at its current residence. The expected total residence time for a household is consistently less than the average current residence time. This is the result of greater weighting of short residence time when calculating the average total residence time than when calculating the average current residence time (Israeli and Nelson, 1992).

When averaging total residence over a time interval, frequent movers may appear several times, but when averaging current residence times, each household appears only once (Israeli and Nelson, 1992). According to Israeli and Nelson (1992), the residence time distribution developed by the model is skewed and the median values are considerably less than the means (T), which are less than the average current residence times.

U.S. Bureau of the Census (1993) - American Housing Survey for the United States in 1991 - This survey is a national sample of 55,000 interviews in which collected data were presented owners, renters, Black householders, and Hispanic householders. The data reflect the number of years a unit has been occupied and represent all occupied housing units that the residents' rented or owned at the time of the survey.

The results of the survey pertaining to residence time of owner/renter occupied units in the U.S. are presented in Table 14-156. Using the data in Table 14-156, the percentages of householders living in houses for specified time ranges were determined and are presented in Table 14-157. Based on the BOC data in Table 14-156, the 50th percentile and the 90th percentile values were calculated for the number of years lived in the householder's current house. These values were calculated by apportioning the total sample size (93,147 households) to the indicated percentile associated with the applicable range of years lived in the current home. Assuming an even distribution within the appropriate range, the 50th and 90th percentile values for years living in current home were determined to be 9.1 and 32.7 years, respectively. These were then rounded to 9 and 33 years. Based on the above data, the range of 9 to 33 years is assumed to best represent a central tendency estimate of length of residence and upper percentile estimate of residence time, respectively.

A limitation associated with the above analysis is the assumption that there is an even distribution within the different ranges. As a result, the 50th and 90th percentile values may be biased.

Johnson and Capel (1992) - A Monte Carlo Approach to Simulating Residential Occupancy Periods and It's Application to the General U.S. Population - Johnson and Capel developed a methodology to estimate the distribution of the residential occupancy period (ROP) in the national population. ROP denotes the time (years) between a person moving into a residence and the time the person moves out or dies. The methodology used a Monte Carlo approach to simulate a distribution of ROP for 500,000 persons using data on population, mobility, and mortality.

The methodology consisted of six steps. The first step defined the population of interest and categorized them by location, gender, age, sex, and race. Next the demographic groups were selected and the fraction of the specified population that fell into each group was developed using U.S. BOC data. A mobility table was developed based on census data, which provided the probability that a person with specified demographics did not move during the previous year. The fifth step used data on vital statistics published by the National Center for Health Statistics and developed a mortality table which provided the probability that individuals with specific demographic characteristics would die during the upcoming year. As a final step, a computer based algorithm was used to apply a Monte Carlo approach to a series of persons selected at random from the population being analyzed.

Table 14-158 presents the results for residential occupancy periods for the total population, by gender. The estimated mean ROP for the total population was 11.7 years. The distribution was skewed (Johnson and Capel, 1992): the 25th, 50th, and 75th percentiles were 4, 9, and 16 years, respectively. The 90th, 95th, and 99th percentiles were 26, 33, and 47 years, respectively. The mean ROP was 11.1 years for males and 12.3 years for females, and the median value was 8 years for males and 9 years for females.

Descriptive statistics for subgroups defined by current ages were also calculated. These data, presented by gender, are shown in Table 14-159. The mean ROP increases from age 3 to age 12 and there is a noticeable decrease at age 24. However, there is a steady increase from age 24 through age 81.

There are a few biases within this methodology that have been noted by the authors. The probability of not moving is estimated as a function only of gender and age. The Monte Carlo process assumes that this probability is independent of (1) the calendar year to which it is applied, and (2) the past history of the person being simulated. These assumptions, according to Johnson and Capel (1992), are not entirely correct. They believe that extreme values are a function of sample size and will, for the most part, increase as the number of simulated persons increases.

14.3.3. Relevant Population Mobility Studies

National Association of Realtors (NAR) (1993) The Home Buying and Selling Process - The NAR survey was conducted by mailing a questionnaire to 15,000 home buyers throughout the U.S. who purchased homes during the second half of 1993. The survey was conducted in December 1993 and 1,763 usable responses were received, equaling a response rate of 12 percent. Of the respondents, forty-one percent were first time buyers. Home buyer names and addresses were obtained from Dataman Information Services (DIS). DIS compiles information on residential real estate transactions from more than 600 counties throughout the United States using courthouse deed records. Most of the 250 Metropolitan Statistical Areas are also covered in the DIS data compilation.

The home buyers were questioned on the length of time they owned their previous home. A typical repeat buyer was found to have lived in their previous home between four and seven years. The survey results indicate that the average tenure of home buyers is 7.1 years based on an overall residence history of the respondents. These results are presented in Table 14-160. In addition, the median length of residence in respondents' previous homes was found to be 6 years (see Table 14-161).

The distances the respondents moved to their new homes were typically short distances. Data presented in Table 14-162 indicate that the median distances range from 11 miles for new home buyers and repeat buyers to 8 years for first time buyers and existing home buyers. Seventeen (17) percent of respondents purchased homes over 100 miles from their previous homes and 49 percent purchased homes less than 10 miles away.

Lehman - Homeowners Relocating at Faster Pace - Lehman (1994) presents data gathered by the Chicago Title and Trust Family Insurers. The data indicate that, in 1993, average U.S. homeowners moved every 12 years. In 1992, homeowners moved every 13.4 years and in 1991, every 14.3 years. Data from the U.S. Bureau of the Census indicate that 7 percent of the owner population moved in 1991. Based on this information, Lehman has concluded that it would take 12 years for 100 percent of owners to move. According to Lehman, Bill Harriett of the U.S. Bureau of the Census has been said that 14 years is a closer estimate for the time required for 100 percent of home owners to move. An advantage of this study is that it provides percentile data for the residential occupancy period.

14.4. RECOMMENDATIONS

Assessors are commonly interested in a number of specific types of time use data including time/frequencies for bathing, showering, gardening, residence time, indoor versus outdoor time, swimming, occupational tenure, and population mobility. Recommendations for each of these are discussed below.

14.4.1. Recommendations for Activity Patterns

Following are recommendations for selected activities known to increase an individual's exposure to certain chemicals. These activities are time spent indoors versus outdoors and gardening, bathing and showering, swimming, residential time spent indoors and outdoors, and traveling inside a vehicle.

Time Spent Indoors Versus Outdoors and Gardening - Assessors often require knowledge of time individuals spend indoors versus outdoors. Ideally, this issue would be addressed on a site-specific basis since the times are likely to vary considerably depending on the climate, residential setting (i.e., rural versus urban), personal traits (i.e., age, health) and personal habits. The following general recommendation is offered in lieu of site-specific information. The key study by Robinson and Thomas (1991) compares the time use values derived in the CARB and National Studies; data are presented only for persons 12 years and older. The time use values did not differ significantly between the two studies and were averaged to provide the following recommended values. These values are applicable to individuals 12 years and older. Approximately 21 hrs/day are spent indoors; 1.5 hrs/day are spent outdoors, and 1.5 hrs/day are spent in a vehicle.

Activities can vary significantly with differences in age. Special attention should be given to the activities of populations under the age of 12 years. Timmer et al. (1985) presented data on time spent in various activities for boys and girls ages 3-11 years. The study focused on activities performed indoors such as household work, personal care, eating, sleeping, school, studying, attending church, watching television, and engaging in household conversations. The average times spent in each indoor activity (and half the times spent in each activity which could have occurred indoors or outdoors) were summed. This procedure resulted in the following recommendations:

- Indoor activities accounted for about 78 percent of the total time in weekdays and 70 percent total time in weekend days. The corresponding times spent indoors are 19 hrs/day for weekdays and 17 hrs/day on weekends.

- Outdoor activities accounted for about 22 percent of children's time during weekdays and 30 percent during the weekend. The corresponding times spent outdoors are 5 hrs/day for weekdays and 7 hrs/day on weekends.

Assessors evaluating soil exposures are commonly interested in data on gardening times and frequencies. No data specific to time spent gardening could be found; thus, no firm recommendation could be made. However, two sets of data were found which indirectly relate to this issue which the assessor can consider in deriving time estimates for gardening:

- Robinson and Thomas (1991) estimated the time spent in "other outdoor activities" (Table 14-8) as 1 hr/day. These data apply to populations 12 years and older.

- Hill (1985) estimated that time spent in "house work and/or yard work" (Table 14-144) as 2 hr/day. These data apply to adult populations.

U.S. EPA's Dermal Exposure Assessment Document (1992) recommends, on the basis of judgement, an event frequency for the adult gardener, working outside: 1 to 2 events/week during warmer months or about 40 events/year.

Baths and Showers - In the NHAPS study, 649 (~ 7 percent) of the total participants indicated either taking or giving at least one bath in a day. Those 649 respondents were subsequently asked the number of times they took or gave a bath in one day. The majority, 459 of 649 respondents, recorded taking or giving one bath in a day. These results are presented in Table 14-22. The recommended bathing duration is 20 minutes. This is a 50th percentile value based on the NHAPS distribution shown on Table 14-24; the reported 90th percentile value is 45 minutes.

The recommended shower frequency of one shower per day is based on the NHAPS data summarized in Table 14-19. This table showed that 3,594 of the 9,386 total participants indicated taking at least one shower the previous day. When asked the number of actual showers taken the previous day, the reported results ranged from one to ten showers; a majority (76 percent), of those 3,549 responsents, reported taking one shower the previous day. The NHAPS data shown on Table 14-19, Table 14-22, and Table 14-24 provide information grouped according to gender, age, race, employment, education, day of the week, seasonal conditions, and health conditions such as asthma, angina, and bronchitis/emphysema.

Recommendations for showering duration are based on the key study conducted by James and Knuiman (1987). Although the study pertains to showering activities of the Australian population, it is assumed that bathing activities are similar in the U.S. population. The recommended average showering time is 8 minutes per day and 12 minutes per day is the reported 90th percentile value. A complete set of percentiles are listed in Table 14-18 and recommended for deriving distributions of showering time.

Swimming - Data for swimming frequency is taken from the NHAPS Study (Tsang ad Klepeis, 1996). Of 9,386 participants, 653 (about 7 percent), answered yes to the question "in the past month, did you swim in a freshwater pool?". The results to this question are summarized in Table 14-63. The recorded number of times respondents swam in the past month ranged from 1 to 60 with the greatest number of respondents, 147 (23 percent), reporting they swam one time per month. Thus, the recommended swimming frequency is one event/ month for the general population. The recommended swimming duration, 60 minutes per swimming event, is based on the NHAPS distribution shown on Table 14-65. Sixty minutes is based on the 50th percentile value and the 90th percentile value is 180 minutes per swimming event.

In addition, users can obtain frequency and duration data grouped according to gender, age, race, employment, education, day of the week, and season. Frequency and duration data is also available in Table 14-63 and Table 14-65, for swimmer respondents reporting health conditions such as asthma, angina, and bronchitis/ emphysema.

Residential Time Spent Indoors and Outdoors - The recommendations for time spent indoors at one's residence is 16.4 hours/day. This is based on the NHAPS data summarized in Table 14-129 which records the 50th percentile value of 985.0 minutes per day (16.4 hours/day) and 90th percentile value of 1,395 minutes per day (23.3 hours/day).

The recommended value for time spent outdoors at one's residence is 2 hours per day based on Table 14-100 (generated by the NHAPS data). Values of 105 minutes per day for the 50th percentile and 362 minutes per day for the 90th percentile are shown in Table 14-100.

Traveling Inside a Vehicle - The recommendation for time spent in a vehicle is 1 hour and 20 minutes per day. This recommendation is based on two studies and (1) Robinson and Thomas (1991) and (2) The NHAPS data. The Robinson and Thomas study evaluated two independent studies, the CARB and the National Study. They respectively reported mean durations for time spent in a vehicle as 98 and 87 minutes per day which averages to 92 minutes per day or about 1.5 hours per day. The NHAPS data, as summarized on Table 14-131, provide a 50th percentile value of 70 minutes per day (or 1 hour and 10 minutes) and a 90th percentile value of 190 minutes per day. Thus, the averaged value from these two studies is about 1 hour and 20 minutes. NHAPS data is grouped according to gender, race, age, employment status, census region, day of the week, season, and health condition of respondents.

14.4.2. Recommendations: Occupational Mobility

The median occupational tenure of the working population (109.1 million people) ages 16 years of age and older in January 1987 was 6.6 years (Carey, 1988). Since the occupational tenure varies significantly according to age it is recommended to use the age dependent values presented in Carey's 1988 study (Table 14-149). When age cannot be determined, it is recommended to use the median tenure value of 6.6 years for working men and women 16 years and older. For persons 70 years and older, a tenure value of 21.9 years is recommended for a working lifetime. A value of 30.5 years and 18.8 years is recommended for men and women, respectively. Part-time employment, race and the position held are important to consider in determining occupational tenure. The ratings indicating confidence in the occupational mobility recommendations are presented in Table 14-164.

14.4.3. Recommendations: Population Mobility

There are three key studies from which the population mobility recommendations were derived: Israeli and Nelson (1992), U.S. Bureau of the Census (1993) - and Johnson and Capel (1992). Each study used a unique approach to estimate the length of time a person resides in a household. The respective approaches were to (1) average current and total residence time; (2) model current residence time; and (3) determine the residential occupancy period. Below is a summary of the approaches used and values recommended by each of these studies.

Study	Value	Method
Israeli and Nelson, 1992	4.6 yr (averge) 1/6 a person's lifetime (70 yr) = 11.7 (modeled)	Average of current and total residence times
US Bureau of the Census, 1993	9 yr (50th percentile) 33 yr (90th percentile)	Current residence time
Johnson and Capel, 1992	26 yr (90th percentile) 33 yr (95th percentile) 47 yr (99th percentile) 12 yr (mean)	Residential occupancy period

The three studies provide residence time estimates that are very similar to the 9 year (50th percentile) and 30 year (95th percentile). Tables 14-154 and 14-155 show residence times for different types of residences and are recommended where assessors are interested in specific types of residences. The ratings indicating confidence in the population mobility recommendations is presented in Table 14-165.

14.4.4. Summary of Recommended Activity Factors

Table 14-166 includes a summation of the recommended activity pattern factors presented in this section and the studies which provided data on the specific activities. The type of activities include indoor activities, outdoor activities, time inside a vehicle, taking a bath or shower, swimming, working at a specific occupation, and residing in a particular location.

14.5. REFERENCES FOR CHAPTER 1

AIHC. (1994) Exposure factors sourcebook. Washington, DC. American Industrial Health Council.

California Air Resources Board (CARB). (1991) California Environmental Protection Agency, Air Resources Board Research Division.

Carey, M. (1988) Occupational tenure in 1987: Many workers have remained in their fields. Monthly Labor Review. October 1988. 3-12.

Carey, M. (1990) Occupational tenure, employer tenure, and occupational mobility. Occupational Outlook Quarterly. Summer 1990: 55-60.

Hill, M.S. (1985) Patterns of time use. In: Juster, F.T.; Stafford, F.P., eds. Time, goods, and well-being. Ann Arbor, MI: University of Michigan, Survey Research Center, Institute for Social Research, pp. 133-166.

Israeli, M; Nelson, C.B. (1992) Distribution and expected time of residence for U.S. households. Risk Anal. 12(1):65-72.

James, I.R.; Knuiman, M.W. (1987) An application of Bayes methodology to the analysis of diary records from a water use study. J. Am. Sta. Assoc. 82(399):705-711.

Johnson, T. and Capel, J. (1992) A monte carlo approach to simulating residential occupancy periods and its application to the general U.S. population. Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Air Quality and Standards.

Juster, F.T.; Hill, M.S.; Stafford, F.P.; Parsons, J.E. (1983) Study description. 1975-1981 time use longitudinal panel study. Ann Arbor, MI: The University of Michigan, Survey Research Center, Institute for Social Research.

Juster, F.T. (1985) A note on recent changes in time use. In: Juster, F.T.; Stafford, F.P.; eds. Time, goods, and well-being. Ann Arbor, MI: University of Michigan, Survey Research Center, Institute for Social Research. pp. 313-330.

Lehman, H.J. (1994) Homeowners relocating at faster pace. Virginia Homes Newspaper, Saturday, June 15, P. E1.

National Association of Realtors (NAR). (1993) The homebuying and selling process: 1993. The Real Estate Business Series. Washington, DC: NAR.

Robinson, J.P. (1977) Changes in Americans' use of time: 1965-1975. A progress report. Cleveland, OH: Cleveland State University, Communication Research Center.

Robinson, J.P; Thomas, J. (1991) Time spent in activities, locations, and microenvironments: a California-National Comparison Project report. Las Vegas, NV: U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory.

Sell, J. (1989) The use of children's activity patterns in the development of a strategy for soil sampling in West Central Phoenix. The Arizona Department of Environmental Quality, Phoenix, Arizona.

Sexton, K; Ryan, P.B. (1987) Assessment of human exposure to air pollution: methods, measurements, and models. In: Watson, A.; Bates, R.R.; Kennedy, D., eds. Air pollution, the automobile and public health: research opportunities for quantifying risk. Washington, DC: National Academy of Sciences Press.

Spencer, G. (1989) Projections of the populations of the United States by age, sex, and race: 1988 to 2080. Washington, DC: U.S. Department of Commerce, Bureau of the Census. Series, P-25, No. 1018.

Tarshis, B. (1981) The "Average American" book. New York, NY: New American Library, p. 191.

Timmer, S.G.; Eccles, J.; O'Brien, K. (1985) How children use time. In: Juster, F.T.; Stafford, F.P.; eds. Time, goods, and well-being. Ann Arbor, MI: University of Michigan, Survey Research Center, Institute for Social Research, pp. 353-380.

Tsang, A.M.; Klepeis, N.E. (1996) Results tables from a detailed analysis of the National Human Activity Pattern Survey (NHAPS) response. Draft Report prepared for the U.S. Environmental Protection Agency by Lockheed Martin, Contract No. 68-W6-001, Delivery Order No. 13.

U.S. Bureau of the Census. (1993) American Housing Survey for the United States in 1991. Washington, DC: U.S. Government Printing Office.

U.S. Bureau of the Census. (1993) Geographical mobility: March 1991 to March 1992. Current population reports P.20-473.

U.S. EPA. (1992) Dermal exposure assessment: principles and applications. Washington, DC: Office of Health and Environmental Assessment. EPA No. 600/8-91-011B. Interim Report.

Table 14-1. Time Use Table Locator Guide

Percentile	Basis	Population	Application	Study	Table
Averages	Activity	Children 3-17 yrs	National	Timmer et al., 1985	14-2
Distribution	Activity	Children and Teens	National	Timmer et al., 1985	14-3
Averages	Activity	Adults 18-64 yrs	National	Robinson and Thomas, 1991	14-4
Averages	Activity	Adults 18-64 yrs	Regional-CA	Robinson and Thomas, 1991	14-5
Averages	Microenvironment	Adults 18-64 yrs	National/Regional-CA	Robinson and Thomas, 1991	14-6
Averages	Microenvironment	Children and Adult	Regional-California	Robinson and Thomas, 1991	14-6 to 14-9
Averages	Microenvironment	Children and Adults	National	Robinson and Thomas, 1991	14-6 to 14-9
Averages	Activity	Infants and Children	Regional-California	CARB, 1991	14-10
Distribution	Activity	Infants and Children	Regional-California	CARB, 1991	14-11
Averages	Activity by season	Infants and Children	Regional-California	CARB, 1991	14-12
Averages	Microenvironment	Infants and Children	Regional-California	CARB, 1991	14-13
Distribution	Microenvironment	Infant and Children	Regional-California	CARB, 1991	14-14
Averages	Microenvironment by season	Infants and Children	Regional-California	CARB, 1991	14-15
Distribution	Microenvironment near pollutant	Infant and Children	Regional-California	CARB, 1991	14-16
Averages	Bathing and swimming	Adults	Regional-National	USEPA, 1992 Tsang and Klepeis, 1996	14-17 14-22, 14-63
Distribution	Showering	Adults	Foreign-Australia	James and Knuiman, 1987 Tsang and Klepeis, 1996	14-18 14-24
Average	Activity by employment	Adults	National	Robinson, 1977	14-19
Averages	Occupational Tenure by race and gender	Teens and Adults	National	Carey, 1988	14-29
Averages	Occupational Tenure by employment and gender	Teens and Adults	National	Carey, 1988	14-30
Distribution	Occupational Tenure by employment	Teens and Adults	National	Carey, 1988	14-31
Distribution	Occupational Mobility by age	Teens and Adults	National	Carey, 1990	14-32
Distribution	Population Mobility by locale	All ages	National	Census, 1993	Figure 14-1
Averages	Residence Time by region, setting	All ages	National	Israeli and Nelson, 1992	14-33
Distribution	Residence Time by region, setting	All ages	National	Israeli and Nelson, 1992	14-34
Distribution	Residence Time by year moved in	All ages	National	Census, 1993	14-35
Distribution	Residence Time by years in current home	All ages	National	Census, 1993	14-36
Distribution	Residence Time by gender	All ages	National	Johnson and Capel, 1992	14-37
Distribution	Residence Time by age	All ages	National	Johnson and Capel, 1992	14-38
Distribution	Residence Time by years in previous house	All ages	National	NAR, 1993	14-39
Distribution	Residence Time by tenure in previous home	All ages	National	NAR, 1993	14-40
Distribution	Relocation Distance	All ages	National	NAR, 1993	14-41

Table 14-2. Mean Time Spent (Minutes) Performing Major Activities Grouped by Age, Sex and Type of Day

Activity	Age (3-11 years) Duration of Time (mins/day)				Age (12-17 years) Duration of Time (mins/day)			
	Weekdays		Weekends		Weekdays		Weekends	
	Boys (n=118)	Girls (n=111)	Boys (n=118)	Girls (n=111)	Boys (n=77)	Girls (n=83)	Boys (n=77)	Girls (n=83)
Market Work	16	0	7	4	23	21	58	25
Household Work	17	21	32	43	16	40	46	89
Personal Care	43	44	42	50	48	71	35	76
Eating	81	78	78	84	73	65	58	75
Sleeping	584	590	625	619	504	478	550	612
School	252	259	--	--	314	342	--	--
Studying	14	19	4	9	29	37	25	25
Church	7	4	53	61	3	7	40	36
Visiting	16	9	23	37	17	25	46	53
Sports	25	12	33	23	52	37	65	26
Outdoors	10	7	30	23	10	10	36	19
Hobbies	3	1	3	4	7	4	4	7
Art Activities	4	4	4	4	12	6	11	9
Playing	137	115	177	166	37	13	35	24
TV	117	128	181	122	143	108	187	140
Reading	9	7	12	10	10	13	12	19
Household Conversations	10	11	14	9	21	30	24	30
Other Passive Leisure	9	14	16	17	21	14	43	33
NA[a]	22	25	20	29	14	17	10	4
Percent of Time Accounted for by Activities Above	94%	92%	93%	89%	93%	92%	88%	89%

[a] NA = Unknown
Source: Timmer et al., 1985.

Table 14-3. Mean Time Spent in Major Activities Grouped by Type of Day for Five Different Age Groups

	Time Duration (mins)										Significant Effects[a]
	Weekday					Weekend					
Age (years)	3-5	6-8	9-11	12-14	15-17	3-5	6-8	9-11	12-14	15-17	
Activities											
Market Work	--	14	8	14	28	--	4	10	29	48	
Personal Care	41	49	40	56	60	47	45	44	60	51	A,S,AxS (F > M)
Household Work	14	15	18	27	34	17	27	51	72	60	A,S, AxS (F > M)
Eating	82	81	73	69	67	81	80	78	68	65	A
Sleeping	630	595	548	473	499	634	641	596	604	562	A
School	137	292	315	344	314	--	--	--	--	--	
Studying	2	8	29	33	33	1	2	12	15	30	A
Church	4	9	9	9	3	55	56	53	32	37	A
Visiting	14	15	10	21	20	10	8	13	22	56	A (Weekend only)
Sports	5	24	21	40	46	3	30	42	51	37	A,S (M > F)
Outdoor activities	4	9	8	7	11	8	23	39	25	26	
Hobbies	0	2	2	4	6	1	5	3	8	3	
Art Activities	5	4	3	3	12	4	4	4	7	10	
Other Passive Leisure	9	1	2	6	4	6	10	7	10	18	A
Playing	218	111	65	31	14	267	180	92	35	21	A,S (M > F)
TV	111	99	146	142	108	122	136	185	169	157	A,S, AxS (M > F)
Reading	5	5	9	10	12	4	9	10	10	18	A
Being read to	2	2	0	0	0	3	2	0	0	0	A
NA	30	14	23	25	7	52	7	14	4	9	A

[a] Effects are significant for weekdays and weekends, unless otherwise specified A = age effect, $P < 0.05$, for both weekdays and weekend activities; S = sex effect $P < 0.05$, F > M, M > F = females spend more time than males, or vice versa; and AxS = age by sex interaction, $P < 0.05$.

Source: Timmer et al., 1985.

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries

WORK AND OTHER INCOME-PRODUCING ACTIVITIES

Paid Work

01 - Normal work: activities at the main job including work brought home, travel that is part of the job, and overtime; "working," "at work"
- Work at home; work activities for pay done in the home when home is the main workplace (include travel as above)

02 - Job search; looking for work, including visits to employment agencies, phone calls to prospective employers, answering want ads
- Unemployment benefits; applying for or collecting unemployment compensation
- Welfare, food stamps; applying for or collecting welfare, food stamps

05 - Second job; paid work activities that are not part of the main job (use this code only when R* clearly indicates a second job or "other" job); paid work for those not having main job; garage sales, rental property

06 - Lunch at the workplace; lunch eaten at work, cafeteria, lunchroom when "where" = work (lunch at a restaurant, code 44; lunch at home, code 43)
- Eating, smoking, drinking coffee as a secondary activity while working (at workplace)

07 - Before and/or after work at the workplace; activities at the workplace before starting or after stopping work; include "conversations," other work. Do not code secondary activities with this primary activity
- Other work-related

08 - Coffee breaks and other breaks at the workplace; unscheduled breaks and other nonwork during work hours at the workplace; "took a break"; "had coffee" (as a primary activity). Do not code secondary activities with this primary activity

09 - Travel; to and from the workplace when R's travel to and from work were both interrupted by stops; waiting for related travel
- Travel to and from the workplace, including time spent awaiting transportation

HOUSEHOLD ACTIVITIES

Indoor

10 - Meal preparation: cooking, fixing lunches
- Serving food, setting table, putting groceries away. unloading car after grocery shopping

11 - Doing dishes, rinsing dishes, loading dishwasher
- Meal cleanup, clearing table, unloading dishwasher

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

HOUSEHOLD ACTIVITIES (continued)

Indoor (continued)

12 - Miscellaneous, "worked around house." NA if indoor or outdoor - Routine indoor cleaning and chores, picking up, dusting, making beds, washing windows, vacuuming, "cleaning," "fall/spring cleaning," "housework"

14 - Laundry and clothes care - wash
- Laundry and clothes care - iron, fold, mending, putting away clothes ("Sewing" code 84)

16 - Repairs indoors; fixing, repairing appliances
- Repairs indoors; fixing, repairing furniture
- Repairs indoors; fixing, repairing furnace, plumbing, painting a room

17 - Care of houseplants

19 - Other indoor, NA whether cleaning or repair; "did things in house"

Outdoor

13 - Routine outdoor cleaning and chores; yard work, raking leaves, mowing grass, garbage removal, snow shoveling, putting on storm windows, cleaning garage, cutting wood

16 - Repair, maintenance, exterior; fixing repairs outdoors, painting the house, fixing the roof, repairing the driveway (patching)
- Home improvements: additions to and remodeling done to the house, garage; new roof
- Improvement to grounds around house; repaved driveway

17 - Gardening; flower or vegetable gardening; spading, weeding, composting, picking, worked in garden"

19 - Other outdoor; "worked outside," "puttering in garage

MISCELLANEOUS HOUSEHOLD CHORES

16 - Car care; necessary repairs and routine care to cars; tune up
- Car maintenance; changed oil, changed tires, washed cars; "worked on car" except when clearly as a hobby - (code 83)

17 - Pet care; care of household pets including activities with pets; playing with the dog; walking the dog; (caring for pets of relatives, friends, code 42)

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

MISCELLANEOUS HOUSEHOLD CHORES (continued)

19 - Household paperwork; paying bills, balancing the checkbook, making lists, getting the mail, working on the budget
- Other household chores; (no travel), picking up things at home, e.g., "picked up deposit slips" (relate travel to purpose)

CHILD CARE

<u>Child Care for Children of Household</u>

20 - Baby care; care to children aged 4 and under

21 - Child care; care to children aged 5*-17
- Child care; mixed ages or NA ages of children

22 - Helping/teaching children learn, fix, make things; helping son bake cookies; helping daughter fix bike
- Help with homework or supervising homework

23 - Giving children orders or instructions; asking them to help; telling the*i*n to behave

- Disciplining child; yelling at kids, spanking children; correcting children's behavior
- Reading to child
- Conversations with household children only; listening to children

24 - Indoor playing; other indoor activities with children (including games ("playing") unless obviously outdoor games)

25 - Outdoor playing; outdoor activities with children including sports, walks, biking with, other outdoor games
- Coaching/leading outdoor, nonorganizational activities

26 - Medical care at home or outside home; activities associated with children's health; "took son to doctor," "gave daughter medicine"

<u>Other Child Care</u>

27 - Babysitting (unpaid) or child care outside R's home or for children not residing in HH
- Coordinating or facilitating child's social or instructional nonschool activities; (travel related, code 29)
- Other child care, including phone conversations relating to child care other than medical

29 - Travel related to child's social and instructional nonschool activities
- Other travel related to child care activities; waiting for related travel

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

OBTAINING GOODS AND SERVICES

Goods (include phone calls to obtain goods)

30 - Groceries; supermarket, shopping for food
- All other shopping for goods; including for clothing, small appliances; at drugstores, hardware stores, department stores, "downtown" or "uptown," "shopping," "shopping center," buying gas, "window shopping"

31 - Durable household goods; shopping for large appliances, cars, furniture
- House, apartment: activities connected to buying, selling, renting, looking for house, apartment, including phone calls; showing house, including traveling around looking at real estate property (for own use)

Services (include phone conversations to obtain services)

32 - Personal care; beauty, barber shop; hairdressers

33 - Medical care for self; visits to doctor, dentist, optometrist, including making appointments

34 - Financial services; activities related to taking care of financial business; going to the bank, paying utility bills (not by mail), going to accountant, tax office, loan agency, insurance office
- Other government services: post office, driver's license, sporting licenses, marriage licenses, police station

35 - Auto services; repair and other auto services including waiting for such services
- Clothes repair and cleaning; cleaners, laundromat, tailor
- Appliance repair: including furnace, water heater, electric or battery operated appliances; including watching repair person
- Household repair services: including furniture; other repair services NA type; including watching repair person

37 - Other professional services; lawyer, counseling (therapy)
- Picking up food at a takeout place - no travel
- Other services, "going to the dump"

38 - Errands; "running errands," NA whether for goods or services; borrowing goods

39 - Related travel; travel related to obtaining goods and services and/or household activities except 31; waiting for related travel

PERSONAL NEEDS AND CARE

Care to Self

40 - Washing, showering, bathing
- Dressing; getting ready, packing and unpacking clothes, personal hygiene, going to the bathroom

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

PERSONAL NEEDS AND CARE (continued)

Care to Self (continued)

41 - Medical care at home to self

43 - Meals at home; including coffee, drinking, smoking, food from a restaurant eaten at home, "breakfast," "lunch"

44 - Meals away from home; eaten at a friend's home (including coffee, drinking, smoking)
- Meals away from home, except at workplace (06) or at friend's home (44); eating at restaurants, out for coffee

45 - Night sleep; longest sleep for day; (may occur during day for night shift workers) including "in bed," but not asleep

46 - Naps and resting; rest periods, "dozing," "laying down" (relaxing code 98)

48 - Sex, making out
- Personal, private; "none of your business"
- Affection between household members; giving and getting hugs, kisses, sitting on laps

Help and Care to Others

41 - Medical care to adults in household (HH)

42 - Nonmedical care to adults in HH; routine nonmedical care to adults in household; "got my wife up," "ran a bath for my husband"
- Help and care to relatives not living in HH; helping care for, providing for needs of relatives; (except travel) helping move, bringing food, assisting in emergencies, doing housework for relatives; visiting when sick
- Help and care to neighbors, friends
- Help and care to others, NA relationship to respondent

Other Personal and Helping

48 - Other personal; watching personal care activities

49 - Travel (helping); travel related to code 42, including travel that is the helping activity; waiting for related travel
- Other personal travel; travel related to other personal care activities; waiting for related travel; travel, NA purpose of trip - e.g., "went to Memphis" (no further explanation given)

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

EDUCATION AND PROFESSIONAL TRAINING

50 - Student (full-time); attending classes, school if full-time student; includes daycare, nursery school for children not in school

51 - Other classes, courses, lectures, academic or professional; R not a full-time student or NA whether a student; being tutored

54 - Homework, studying, research, reading, related to classes or profession, except for current job (code 07); "went to the library"

56 - Other education

59 - Other school-related travel; travel related to education coded above; waiting for related travel; travel to school not originating from home

ORGANIZATIONAL ACTIVITIES

Volunteer, Helping Organizations: hospital volunteer group, United Fund, Red Cross, Big Brother/Sister

63 - Attending meetings of volunteer, helping organizations
- Officer work; work as an officer of volunteer, helping organizations; R must indicate he/she is an officer to be coded here
- Fund raising activities as a member of volunteer helping organization, collecting money, planning a collection drive

- Direct help to individuals or groups as a member of volunteer helping organizations; visiting, bringing food, driving

- Other activities as a member of volunteer helping organizations, including social events and meals

Religious Practice

65 - Attending services of a church or synagogue, including participating in the service; ushering, singing in choir, leading youth group, going to church, funerals
- Individual practice; religious practice carried out as an individual or in a small group; praying, meditating, Bible study group (not a church), visiting graves

Religious Groups

64 - Meetings: religious helping groups; attending meetings of helping - oriented church groups -ladies aid circle, missionary society, Knights of Columbus
- Other activities; religious helping groups; other activities as a member of groups listed above, including social activities and meals

(continued on the following page)

ORGANIZATIONAL ACTIVITIES (continued)

Religious Groups (continued)

- Meetings: other church groups; attending meetings of church group, not primarily helping-oriented, or NA if helping-oriented
- Other activities, other church groups; other activities as a member of church groups that are not helping-oriented or NA if helping, including social activities and meals; choir practice; Bible class

Professional/Union Organizations: State Education Association; AFL-CIO; Teamsters

60 - Meetings; professional/union; attending meetings of professional or union groups
- Other activities, professional/union; other activities as a member of professional or union group including social activities and meals

Child/Youth/Family Organizations: PTA, PTO; Boy/Girl Scouts; Little Leagues; YMCA/YWCA; school volunteer

67 - Meetings, family organizations; attending meetings of child/youth/family*-oriented organizations
- Other activities, family organizations; other activities as a member of child/youth/family-oriented organizations including social activities and meals

Fraternal Organizations: Moose, VFW, Kiwanis, Lions, Civitan, Chamber of Commerce, Shriners, American Legion

66 - Meetings, fraternal organizations; attending meetings of fraternal organizations
- Other activities, fraternal organizations; other activities as a member of fraternal organizations including social activities and helping activities and meals

Political Party and Civic Participation: Citizens' groups, Young Democrats, Young Republicans, radical political groups, civic duties

62 - Meetings, political/citizen organizations; attending meetings of a political party or citizen group, including city council
- Other activities, political/citizen organizations; other participation in political party and citizens' groups, including social activities, voting, jury duty, helping with elections, and meals

Special Interest/Identity Organizations (including groups based on sex, race, national origin); NOW; NAACP; Polish-American Society; neighborhood, block organizations; CR groups; senior citizens; Weight Watchers

61 - Meetings: identify organizations; attending meetings of special interest, identity organizations
- Other activities, identity organizations; other activities as a member of a special interest, identity organization, including social activities and meals

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

ORGANIZATIONAL ACTIVITIES (continued)

Other Miscellaneous Organizations, do not fit above

68 - Other organizations; any activities as a member of an organization not fitting into above categories; (meetings and other activities included here) Travel Related to Organizational Activities

69 - Travel related to organizational activities as a member of a volunteer (helping) organization (code 63); including travel that is the helping activity, waiting for related travel
- Travel (other organization-related); travel related to all other organization activities; waiting for related travel

ENTERTAINMENT/SOCIAL ACTIVITIES

Attending Spectacles, Events

70 - Sports; attending sports events - football, basketball, hockey, etc.

71 - Miscellaneous spectacles, events: circus, fairs, rock concerts, accidents

72 - Movies; "went to the show"

73 - Theater, opera, concert, ballet

74 - Museums, art galleries, exhibitions, zoos

Socializing

75 - Visiting with others; socializing with people other than R's own HH members either at R's home or another home (visiting on the phone, code 96); talking/chatting in the context of receiving a visit or paying a visit

76 - Party; reception, weddings

77 - At bar; cocktail lounge, nightclub; socializing or hoping to socialize at bar, lounge
- Dancing

78 - Other events; other events or socializing, do not fit above

79 - Related travel; waiting for related travel

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

SPORTS AND ACTIVE LEISURE

Active Sports

80 - Football, basketball, baseball, volleyball, hockey. soccer, field hockey
- Tennis, squash, racquetball, paddleball
- Golf, miniature golf
- Swimming, waterskiing
- Skiing, ice skating, sledding, roller skating
- Bowling; pool, ping-pong, pinball
- Frisbee, catch
- Exercises, yoga (gymnastics - code 86)
- Judo, boxing, wrestling

Out of Doors

81 - Hunting
- Fishing
- Boating, sailing, canoeing
- Camping, at the beach
- Snowmobiling, dune-buggies
- Gliding, ballooning, flying
- Excursions, pleasure drives (no destination), rides with the family
- Picnicking

Walking, Biking

82 - Walking for pleasure
- Hiking
- Jogging, running
- Bicycling
- Motorcycling
- Horseback riding

Hobbies

83 - Photography
- Working on cars - not necessarily related to their running; customizing, painting
- Working on or repairing leisure time equipment (repairing the boat, "sorting out fishing tackle")
- Collections, scrapbooks
- Carpentry and woodworking (as a hobby)

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

SPORTS AND ACTIVE LEISURE (continued)

Domestic Crafts

84 - Preserving foodstuffs (canning, pickling)
- Knitting, needlework, weaving, crocheting (including classes), crewel, embroidery, quilting, quilling, macrame
- Sewing
- Care of animals/livestock when R is not a farmer (pets, code 17; "farmer", code 01, work)

Art and Literature

85 - Sculpture, painting, potting, drawing
- Literature, poetry, writing (not letters), writing a diary

Music/Theater/Dance

86 - Playing a musical instrument (include practicing), whistling
- Singing
- Acting (rehearsal for play)
- Nonsocial dancing (ballet, modern dance, body movement)
- Gymnastics (lessons - code 88)

Games

87 - Playing card games (bridge, poker)
- Playing board games (Monopoly, Yahtzee, etc.), bingo, dominoes
- Playing social games (scavenger hunts), "played games" - NA kind
- Puzzles

Classes/Lessons for Active Leisure Activity

88 - Lessons in sports activities: swimming, golf, tennis. skating, roller skating
- Lessons in gymnastics, dance, judo, body movement
- Lessons in music, singing, instruments
- Other lessons, not listed above

Travel

89 - Related travel; travel related to sports and active leisure; waiting for related travel: vacation travel

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

PASSIVE LEISURE

90 - Radio

91 - TV

92 - Records, tapes, "listening to music," listening to others playing a musical instrument

93 - Reading books (current job related, code 07; professionally or class related, code 54)

94 - Reading magazines, reviews, pamphlets
- Reading NA what; or other

95 - Reading newspapers

96 - Phone conversations - not coded elsewhere, including all visiting by phone
- Other talking/conversations; face-to-face conversations, not coded elsewhere (if children in HH only, code 23); visiting other than 75
- Conversations with HH members only - adults only or children and adults
- Arguing or fighting with people other than HH members only, household and nonhousehold members, or NA
- Arguing or fighting with HH members only

97 - Letters (reading or writing); reading mail

98 - Relaxing
- Thinking, planning; reflecting
- "doing nothing," "sat"; just sat;
- Other passive leisure, smoking dope, pestering, teasing, joking around, messing around; laughing

99 - Related travel: waiting for related travel

MISSING DATA CODES

- Activities of others reported - R's activity not specified
- NA activities; a time gap of greater than 10 minutes.

EXAMPLES OF ACTIVITIES IN "OTHER" CATEGORIES

<u>Other Work Related</u>

07 - Foster parent activities

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

EXAMPLES OF ACTIVITIES IN "OTHER" CATEGORIES (continued)

Other Household

19 - Typing
- Wrapping presents
- Checked refrigerator for shopping list
- Unpacked gifts from shower
- Packing/unpacking car
- "Settled in" after trip
- Hooked up boat to car
- Showed wife car (R was fixing)
- Packing to move
- Moved boxes
- Looking/searching for things at home (inside or out)

Other Child Care

27 - Waited for son to get hair cut
- Picked up nephew at sister's house
- "Played with kids" (R's children from previous marriage not living with R)
- Called babysitter

Other Services

37 - Left clothing at Goodwill
- Unloaded furniture (just purchased)
- Returned books (at library)
- Brought clothes in from car (after laundromat)
- Delivered some stuff to a friend
- Waited for father to pick up meat
- Waited for stores to open
- Put away things from swap meet
- Sat in car waiting for rain to stop before shopping
- Waiting for others while they are shopping
- Showing mom what I bought

Other Personal

48 - Waiting to hear from daughter
- Stopped at home, NA what for
- Getting hysterical
- Breaking up a fight (not child care related)
- Waited for wife to get up

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

EXAMPLES OF ACTIVITIES IN "OTHER" CATEGORIES (continued)

Other Personal (continued)

- Waiting for dinner at brother's house
- Waiting for plane (meeting someone at airport)
- Laughing
- Crying
- Moaning - head hurt
- Watching personal care activities ("watched dad shave")

Other Education

56
- Watched a film
- In discussion group

Other Organization

68
- Attending "Club House coffee klatch"
- Waited for church activities to begin
- "Meeting" NA kind
- Cleanup after banquet
- Checked into swap meet - selling and looking

Other Social, Entertainment

78
- Waiting for movies, other events
- Opening presents (at a party)
- Looking at gifts
- Decorating for party
- Tour of a home (friends or otherwise)
- Waiting for date
- Preparing for a shower (baby shower)
- Unloaded uniforms (for parade)

Other Active Leisure

88
- Fed birds, bird watching
- Astrology
- Swinging
- At park
- Showing slides
- Showing sketches

(continued on the following page)

Table 14A-1. Activity Codes and Descriptors Used For Adult Time Diaries (continued)

EXAMPLES OF ACTIVITIES IN "OTHER" CATEGORIES (continued)

Other Active Leisure (continued)

- Recording music
- Hung around airport (NA reason)
- Picked up fishing gear
- Inspecting motorcycle
- Arranging flowers
- Work on model airplane
- Picked asparagus
- Picked up softball equipment
- Registered to play golf
- Toured a village or lodge (coded 81)

Other Passive Leisure

98
- Lying in sun
- Listening to birds
- Looking at slides
- Stopped at excavating place
- Looking at pictures
- Walked around outside
- Waiting for a call
- Watched plane leave
- Girl watching/boy watching
- Watching boats
- Wasted time
- In and out of house
- Home movies

* R = Respondent
HH = Household.

Source: Juster et al., 1983.

Table 14A-2. Differences in Average Time Spent in Different Activities Between California and National Studies (Minutes Per Day for Age 18-64 years)

00-49	NON-FREE TIME	California 1987-88 (1359)	National 1985 (1980)	50-59	Free Time	California 1987-88 (1359)	National 1985 (1980)
00-09	PAID WORK			50-99	EDUCATION AND TRAINING		
00	(not used)			50	Students' Classes	9	5
01	Main Job	224	211	51	Other Classes	1	3
02	Unemployment	1	1	52	(not used)	-	-
03	Travel during work	8	NR	53	(not used)	-	-
04	(not used)	-	-	54	Homework	8	7
05	Second job	3	3	55	Library	*	1
06	Eating	6	8	56	Other Education	1	1
07	Before/after work	1	2	57	(not used)	-	-
08	Breaks	2	2	58	(not used)	-	-
09	Travel to/from work	28	25	59	Travel, Education	3	2
10-19	HOUSEHOLD WORK			60-69	ORGANIZATIONAL ACTIVITIES		
10	Food Preparation	29	36	60	Professional/Union	0	1
11	Meal Cleanup	10	11	61	Special Interest	*	1
12	Cleaning House	21	24	62	Political/Civic	0	*
13	Outdoor Cleaning	9	7	63	Volunteer/Helping	1	1
14	Clothes Care	7	11	64	Religious Groups	1	2
15	Car Repair/Maintenance (by R)	5	5	65	Religious Practice	5	7
16	Other Repairs (by R)	8	6	66	Fraternal	0	*
17	Plant Care	3	5	67	Child/Youth/Family	1	*
18	Animal Care	3	5	68	Other Organizations	2	1
19	Other Household	7	8	69	Travel Organizations	2	4
20-29	CHILD CARE			70-79	ENTERTAINMENT/ SOCIAL ACTIVITIES		
20	Baby Care	3	8	70	Sports Events	2	2
21	Child Care	7	5	71	Entertainment Events	5	1
22	Helping/Teaching	2	1	72	Movies	2	3
23	Talking/Reading	1	1	73	Theatre	1	1
24	Indoor Playing	2	3	74	Museums	1	*
25	Outdoor Playing	2	1	75	Visiting	26	25
26	Medical care - Care	*	1	76	Parties	6	7
27	Other Child Care	2	1	77	Bars/Lounges	4	6
28	(At Dry Cleaners)	*	NR	78	Other Social	*	1
29	Travel, Child care	4	4	79	Travel, Events/Social	13	16

Table 14A-2. Differences in Average Time Spent in Different Activities Between California and National Studies (Minutes Per Day for Age 18-64 years) (continued)

00-49	NON-FREE TIME	California 1987-88 (1359)	National 1985 (1980)	50-59	Free Time	California 1987-88 (1359)	National 1985 (1980)
30-39	OBTAINING GOODS AND SERVICES			80-89	RECREATION		
30	Everyday Shopping	8	5	80	Active Sports	15	13
31	Durable/House Shop	19	20	81	Outdoor	3	7
32	Personal Services	1	1	82	Walking/Hiking	5	4
33	Medical Appointments	2	2	83	Hobbies	1	1
34	Gov't/Financial Service	3	2	84	Domestic Crafts	3	6
35	Car Repair services	2	1	85	Art	*	1
36	Other Repair services	*	1	86	Music/Drama/Dance	3	2
37	Other Services	2	2	87	Games	5	7
38	Errands	*	1	88	Computer Use/Other	3	3
39	Travel, Goods and Services	24	20	89	Travel, Recreation	5	6
40-49	PERSONAL NEEDS AND CARE			90-99	COMMUNICATION		
40	Washing, Etc.	21	25	90	Radio	1	3
41	Medical Care	3	1	91	TV	130	126
42	Help and Care	3	4	92	Records/Tapes	3	1
43	Meals At Home	44	50	93	Read Books	4	7
44	Meals Out	27	20	94	Reading Magazines/Other	16	10
45	Night Sleep	480	469	95	Reading Newspaper	11	9
46	Naps/Day Sleep	16	16	96	Conversations	15	25
47	Dressing, Etc.	24	32	97	Writing	8	9
48	NA Activity	2	12	98	Think, Relax	9	6
49	Travel, Personal Care/NA	22	13	99	Travel, Communication	5	*
NR =	Not Recorded in National Survey				Total Travel	108	90
* =	Less than 0.5 Min. per day				(Codes 09, 29, 39, 49, 59, 69, 79, 89, 99)		

Source: Robinson and Thomas, 1991.

Table 14A-3. Time Spent in Various Micro-environments

	Mean duration					
		Men		Women		Total[a]
Code Description	N = 639 California	N = 914 National	N = 720 California	N = 1059 National	N = 1980 California	N = 1359 National
AT HOME						
Kitchen	46	56	98	135	72	104
Living Room	181	136	98	180	189	158
Dining Room	18	10	22	18	19	15
Bathroom	27	27	38	43	33	38
Bedroom	481	478	534	531	508	521
Study	8	10	6	7	7	8
Garage	14	5	6	1	19	2
Basement	<0.5	4	<0.5	6	<0.5	5
Utility Room	1	0	3	5	2	4
Pool, Spa	1	NR	1	NR[b]	1	NR[b]
Yard	33		21		27	37
Room to Room	9	160[c]	34	116	21	40
Other NR Room	3		4		3	22
Total at home	822	888	963	1022	892	954
AWAY FROM HOME						
Office	78	261	94	155	86	193
Plant	73	--	12	--	42	--
Grocery Store	12	18	14	33	13	30
Shopping Mall	30	--	40	--	35	--
School	25	13	29	11	27	15
Other Public Places	18	--	10	--	14	12
Hospital	9	NR	24	NR	17	3
Restaurant	35	22	25	18	30	23
Bar-Night Club	15	--	5	--	10	--
Church	7	8	5	11	6	10
Indoor Gym	4	NR	4	NR	4	NR
Other's Home	60	42	61	45	61	43
Auto Repair	18	NR	4	NR	11	NR
Playground	16	27	8	16	12	NR
Hotel-Motel	7	NR	8	NR	8	NR
Dry Cleaners	<0.5	NR	1	NR	1	NR
Beauty Parlor	<0.5	NR	4	NR	2	NR
Other Locations	3	NR	1	NR	2	NR
Other Indoor	17	41	7	24	12	24
Other Outdoor	60	NR	13	NR	37	6
Total away from home	487	445	371	324	430	383

Table 14A-3. Time Spent in Various Micro-environments (continued)

	Mean duration					
	Men		Women		Total[a]	
Code Description	N = 639 California	N = 914 National	N = 720 California	N = 1059 National	N = 1980 California	N = 1359 National
TRAVEL						
Car	76	--	77	--	76	--
Van/Truck	30	86	11	77	20	88
Walking	10	--	8	--	9	2
Bus Stop	<0.5	--	1	--	1	--
Bus	6	--	2	--	4	3
Rapid Train	1	--	--	--	1	1
Other Travel	2	--	1	--	1	<0.5
Airplane	1	15	<0.5	10	1	1
Bicycle	1	--	<0.5	--	1	NR
Motorcycle	2	--	<0.5	--	1	NR
Other or Missing	1	--	<0.5	--	1	NR
Total travel	130	101	102	87	116	94
Not ascertained	1	8	4	7	2	9
Total Time Outdoors	--	--	--	--	88	70

[a] Totals do not necessarily reflect exact averages presented for each gender. Totals were revised, but revisions for each gender were not provided.
[b] NR = Not Reported
[c] Is total mean duration for those categories; breakdowns per category were not reported.

Source: Robinson and Thomas, 1991.

Note:	National			California		
Percent at home	men	=	62	men	=	57
	women	=	71	women	=	67
	total	=	67	total	=	62
Percent away from home	men	=	31	men	=	34
	women	=	23	women	=	26
	total	=	27	total	=	30
Percent in travel	men	=	7	men	=	9
	women	=	6	women	=	7
	total	=	7	total	=	8

Table 14A-4. Major Time Use Activity Categories[a]

Activity code	Activity
01-09	Market work
10-19	House/yard work
20-29	Child care
30-39	Services/shopping
40-49	Personal care
50-59	Education
60-69	Organizations
70-79	Social entertainment
80-89	Active leisure
90-99	Passive leisure

[a] Appendix Table 14A-3 presents a detailed explanation of the coding and activities.
Source: Hill, 1985.

Table 14A-5. Mean Time Spent (mins/day) for 87 Activities Grouped by Day of the Week						
	Weekday N=831		Saturday N=831		Sunday N=831	
Activity	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
01-Normal Work	240.54	219.10	82.43	184.41	46.74	139.71
02-Unemployment Acts	0.98	9.43	0.00	0.00	0.00	0.00
05-Second Job	3.76	25.04	2.84	32.64	2.65	27.30
06-Lunch At Work	10.00	15.81	1.82	7.88	1.43	8.29
07-Before/After Work	3.51	10.05	1.45	9.79	1.66	13.76
08-Coffee Breaks	5.05	11.53	1.59	7.32	0.93	8.52
09-Travel: To/From Work	24.03	30.37	7.74	22.00	4.60	17.55
10-Meal Preparation	42.18	46.59	40.37	59.82	42.38	57.42
11-Meal Cleanup	12.48	19.25	12.07	22.96	13.97	25.85
12-Indoor Cleaning	26.37	43.84	38.88	80.39	21.73	48.70
13-Outdoor Cleaning	7.48	25.45	15.71	58.00	9.01	39.39
14-Laundry	13.35	30.39	11.48	31.04	7.79	25.43
16-Repairs/Maintenance	9.61	35.43	17.36	72.50	13.56	62.12
17-Garden/Pet Care	8.52	25.15	14.75	49.17	8.47	37.54
19-Other Household	6.26	20.62	9.82	37.58	7.60	32.17
20-Baby Care	6.29	22.91	5.89	30.72	6.26	33.78
21-Child Care	6.26	16.34	5.38	21.58	7.09	23.15
22-Helping/Teaching	1.36	8.28	0.23	3.64	0.76	6.52
23-Reading/Talking	2.47	8.65	1.71	10.84	1.53	9.97
24-Indoor Playing	1.75	8.72	0.90	7.82	2.45	15.11
25-Outdoor Playing	0.73	6.33	1.23	13.03	0.91	10.30
26-Medical Care-Child	0.64	7.42	0.16	2.79	0.44	7.20
27-Babysitting/Other	2.93	14.56	2.16	19.11	3.28	24.89
29-Travel: Child Care	4.18	10.97	1.71	8.72	2.08	10.56
30-Everyday Shopping	19.73	30.28	33.52	61.38	10.13	30.18
31-Durable/House Shop	0.58	4.83	1.46	14.04	1.65	17.92
32-Personal Care Services	1.93	10.04	3.42	18.94	0.02	0.69
33-Medical Appointments	3.43	14.49	0.60	6.63	0.00	0.00
34-Gov't/Financial Services	1.90	6.07	0.66	4.34	0.03	0.43
35-Repair Services	1.33	7.14	1.25	10.24	0.52	5.61
37-Other Services	1.13	7.17	1.55	9.57	0.72	4.34
38-Errands	0.74	8.03	0.35	5.27	0.04	1.04
39-Travel: Goods/Services	17.93	23.58	21.61	36.35	8.45	21.64
40-Washing/Dressing	44.03	29.82	44.25	41.20	47.54	40.15
41-Medical Care R/HH Adults	0.77	6.19	1.29	15.90	1.45	29.18
42-Help & Care	8.43	28.17	12.19	52.58	14.32	55.13
43-Meals At Home	53.45	35.57	57.86	49.25	61.84	49.27
44-Meals Out	19.55	31.20	31.13	56.03	25.95	47.60
45-Night Sleep	468.49	79.42	498.40	115.55	528.86	115.84
46-Naps/Resting	22.07	43.92	30.67	74.98	27.56	66.01
48-N.A. Activities	7.52	22.32	11.72	41.61	8.18	35.79
49-Travel: Personal	14.87	27.76	19.33	50.42	18.58	46.36
50-Students' Classes	6.33	33.79	0.96	18.17	0.96	20.07
51-Other Classes	2.65	17.92	0.40	11.52	0.27	5.63

Table 14A-5. Mean Time Spent (mins/day) for 87 Activities Grouped by Day of the Week (continued)						
	Weekday N=831		Saturday N=831		Sunday N=831	
Activity	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
54-Homework	4.56	24.35	3.48	27.98	5.40	38.68
56-Other Education	0.53	5.91	0.15	2.75	0.45	9.85
59-Travel: Education	2.29	10.36	0.35	4.26	0.21	3.14
60-Professional/Union Orgs.	0.51	7.27	0.13	3.64	0.44	8.34
61-Identity Organizations	1.53	11.19	1.24	35.63	0.48	7.58
62-Political/Citizen Orgs	0.14	1.25	0.07	1.91	0.19	5.55
63-Volunteer/Helping Orgs	1.08	10.08	0.02	0.45	0.41	7.09
64-Religious Groups	2.96	17.33	3.05	27.73	8.59	33.31
65-Religious Practice	4.98	19.92	7.13	30.12	34.05	62.06
66-Fraternal Organizations	0.85	9.28	1.73	27.71	0.31	6.67
67-Child/Family Organizations	1.70	11.69	1.04	17.83	0.26	7.63
68-Other Organizations	3.91	22.85	1.31	20.28	1.71	17.52
69-Traves: Organizations	3.41	9.83	2.66	12.22	12.07	37.64
70-Sport Events	2.22	13.45	6.29	42.05	3.44	27.78
71-Miscellaneous Events	0.32	4.89	1.94	19.90	1.96	19.75
72-Movies	1.65	11.03	4.74	27.04	3.35	22.65
73-Theater	0.69	7.13	2.66	27.79	0.77	10.37
74-Museums	0.19	3.32	0.90	13.62	0.72	11.17
75-Visiting w/Others	33.14	51.69	56.78	95.61	69.65	114.58
76-Parties	2.81	16.49	12.63	56.11	7.16	39.02
77-Bars/Lounges	3.62	18.07	7.23	35.09	3.91	26.95
78-Other Events	1.39	11.55	1.33	15.52	1.00	10.80
79-Travel: Events/Social	8.90	16.19	19.55	43.38	18.02	34.45
80-Active Sports	5.30	19.60	9.23	43.69	11.39	48.66
81-Outdoors	5.11	33.00	11.58	55.07	15.52	62.68
82-Walking/Biking	2.08	9.70	5.87	36.38	5.92	32.28
83-Hobbies	1.78	11.73	3.20	32.43	4.10	31.55
84-Domestic Crafts	11.18	37.03	8.67	40.49	6.41	34.82
85-Art/Literature	0.99	10.84	0.86	13.59	1.13	15.07
86-Music/Drama/Dance	0.45	4.91	0.83	8.83	0.63	8.32
87-Games	5.06	22.91	10.14	45.11	7.89	40.45
88-Classes/Other	2.65	15.83	2.56	29.92	3.37	23.60
89-Travel: Active Leisure	3.31	14.77	8.50	48.72	8.19	38.11
90-Radio	2.89	12.19	3.53	23.42	2.88	18.50
91-TV	113.01	103.89	118.99	131.24	149.67	141.43
92-Records/Tapes	2.58	20.26	2.40	16.09	2.03	16.08
93-Reading Books	4.41	18.09	2.76	17.85	5.23	30.13
94-Reading Magazines/N.A.	13.72	31.73	16.33	46.24	17.18	51.01
95-Reading Newspapers	12.03	22.65	12.19	34.96	26.01	44.47
96-Conversations	18.68	28.59	15.45	35.27	14.57	34.60
97-Letters	2.83	12.23	1.61	10.80	1.96	12.59
98-Other Passive Leisure	9.72	25.02	17.24	57.21	15.28	47.86
99-Travel: Passive Leisure	1.26	5.44	1.32	6.80	1.72	9.87
Source: Hill, 1985.						

Table 14A-6. Weighted Mean Hours Per Week by Gender: 87 Activities and 10 Subtotals

	Men N=410		Women N=561		Men and women N=971	
Activity	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
01 - Normal work	29.78	20.41	14.99	17.62	21.82	20.33
02 - Unemployment acts	0.14	1.06	0.08	0.75	0.11	0.90
05 - Second job	0.73	3.20	0.17	1.62	0.43	2.49
06 - Lunch at work 1.08	1.43	0.65	1.21	0.85	1.33	
07 - Before/after work	0.51	1.27	0.23	0.69	0.36	1.01
08 - Coffee breaks 0.57	1.05	0.36	1.03	0.46	1.04	
09 - Travel: to/from work	2.98	2.87	1.45	2.17	2.16	2.63
10 - Meal preparation	1.57	2.61	7.25	5.04	4.63	4.98
11 - Meal cleanup	0.33	0.83	2.30	2.19	1.39	1.97
12 - Indoor cleaning	0.85	2.01	5.03	5.05	3.10	4.46
13 - Outdoor cleaning	1.59	3.59	0.56	1.59	1.03	2.75
14 - Laundry	0.13	0.72	2.44	3.34	1.38	2.75
16 - Repairs/maintenance	2.14	4.29	0.68	3.43	1.35	3.92
17 - Gardening/pet care	0.94	2.78	1.00	2.19	0.97	2.48
19 - Other household	0.92	2.42	0.72	1.84	0.81	2.13
20 - Baby care	0.24	1.20	0.90	3.04	0.60	2.40
21 - Child care	0.24	0.78	0.99	2.11	0.64	1.68
22 - Helping/teaching	0.07	0.61	0.15	0.76	0.11	0.70
23 - Reading/talking	0.07	0.35	0.30	0.86	0.19	0.68
24 - Indoor playing 0.13	0.69	0.18	0.82	0.16	0.76	
25 - Outdoor playing	0.06	0.37	0.12	0.72	0.09	0.58
26 - Medical care - child	0.01	0.09	0.09	0.67	0.05	0.50
27 - Babysitting/other	0.14	0.78	0.64	2.58	0.41	1.98
29 - Travel: child care	0.23	0.67	0.50	1.21	0.38	1.00
30 - Everyday shopping	1.45	2.18	2.78	3.25	2.17	2.89
31 - Durables/house shopping	0.19	1.39	0.08	0.51	0.13	1.01
32 - Personal care services	0.06	0.42	0.35	1.14	0.22	0.90
33 - Medical appointments	0.15	0.75	0.37	1.63	0.27	1.31
34 - Govt/financial services	0.15	0.44	0.19	0.61	0.17	0.54
35 - Repair services 0.11	0.45	0.17	0.78	0.14	0.65	
37 - Other services 0.11	0.61	0.13	0.61	0.12	0.61	
38 - Errands	0.04	0.41	0.06	0.68	0.05	0.57
39 - Travel: goods/services	1.60	2.02	2.14	2.17	1.89	2.12

(Continued on the following page)

Table 14A-6. Weighted Mean Hours Per Week by Gender: 87 Activities and 10 Subtotals (continued)

	Men N=410		Women N=561		Men and women N=971	
Activity	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
40 - Washing/dressing	4.33	2.39	5.43	3.24	4.92	2.93
41 - Medical care - adults	0.09	0.67	0.18	1.00	0.14	0.86
42 - Help and care	1.02	2.84	1.30	3.04	1.17	2.95
43 - Meals at home	6.59	3.87	6.32	3.53	6.44	3.69
44 - Meals out	2.72	3.48	2.24	2.73	2.46	3.10
45 - Night sleep	55.76	8.43	56.74	8.49	56.29	8.47
46 - Naps/resting	2.94	5.18	3.19	4.70	3.08	4.93
48 - N.A. activities	1.77	6.12	1.99	5.70	1.89	5.89
49 - Travel: personal	2.06	2.59	1.61	2.51	1.82	2.56
50 - Students' classes	0.92	4.00	0.38	2.51	0.63	3.29
51 - Other classes	0.23	1.68	0.15	1.05	0.18	1.38
54 - Homework	0.76	3.48	0.38	1.87	0.56	2.74
56 - Other education	0.11	0.86	0.02	0.22	0.06	0.61
59 - Travel: education	0.29	1.07	0.16	1.06	0.22	1.07
60 - Professional/union organizations	0.04	0.46	0.04	0.62	0.04	0.55
61 - Identity organizations	0.14	0.97	0.18	1.55	0.16	1.31
62 - Political/citizen organizations	0.01	0.08	0.02	0.15	0.01	0.12
63 - Volunteer/helping organizations	0.02	0.32	0.14	1.05	0.09	0.80
64 - Religious groups	0.38	1.82	0.41	1.61	0.40	1.71
65 - Religious practice	0.89	2.05	1.31	2.97	1.12	1.60
66 - Fraternal organizations	0.16	1.17	0.05	0.66	0.10	0.93
67 - Child/family organizations	0.10	0.88	0.21	1.33	0.16	1.15
68 - Other organizations	0.34	2.40	0.32	1.53	0.32	1.98
69 - Travel: organizations	0.43	1.04	0.52	1.02	0.48	1.03
70 - Sports events	0.30	1.31	0.26	1.28	0.28	1.29
71 - Miscellaneous events	0.07	0.52	0.08	0.59	0.07	0.56
72 - Movies	0.31	1.25	0.26	1.13	0.28	1.19
73 - Theatre	0.13	0.93	0.06	0.48	0.09	0.72
74 - Museums	0.04	0.37	0.03	0.35	0.03	0.36
75 - Visiting with others	4.24	5.72	5.84	6.42	5.10	6.16
76 - Parties	0.64	2.05	0.44	1.65	0.53	1.84
77 - Bars/lounges 0.71	2.21	0.46	2.09	0.57	2.15	
78 - Other events	0.12	0.72	0.18	1.18	0.15	0.99
79 - Travel: events/social	1.40	1.82	1.26	1.67	1.32	1.74

(Continued on the following page)

Table 14A-6. Weighted Mean Hours Per Week by Gender: 87 Activities and 10 Subtotals (continued)

	Men N=410		Women N=561		Men and women N=971	
Activity	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
80 - Active sports	1.05	2.62	0.50	1.68	0.76	2.18
81 - Outdoors	1.49	4.59	0.48	1.67	0.94	3.39
82 - Walking/biking	0.52	1.31	0.23	0.98	0.36	1.16
83 - Hobbies	0.69	3.88	0.06	0.43	0.35	2.67
84 - Domestic crafts	0.30	1.59	2.00	4.72	1.21	3.93
85 - Art/literature 0.05	0.45	0.13	1.03	0.09	0.81	
86 - Music/drama/dance	0.06	0.49	0.07	0.47	0.07	0.48
87 - Games	0.60	2.00	0.99	3.16	0.81	2.69
88 - Classes/other	0.41	1.75	0.28	1.50	0.34	1.62
89 - Travel: active leisure	0.76	1.91	0.43	1.43	0.58	1.68
90 - Radio	0.39	1.40	0.39	1.55	0.39	1.49
91 - TV	14.75	12.14	13.95	10.67	14.32	11.38
92 - Records/tapes	0.46	2.35	0.33	2.13	0.39	2.23
93 - Reading books	0.37	1.52	0.56	1.83	0.47	1.70
94 - Reading magazines/N.A.	1.32	2.81	1.97	3.67	1.67	3.32
95 - Reading newspapers	1.86	2.72	1.47	2.27	1.65	2.49
96 - Conversations	1.61	2.19	2.18	2.74	1.91	2.52
97 - Letters	0.20	1.06	0.31	1.12	0.26	1.10
98 - Other passive leisure	1.68	3.53	1.41	3.32	1.53	3.42
99 - Travel: passive leisure	0.18	0.49	0.13	0.49	0.15	0.49

Source: Hill, 1985.

Table 14A-7. Ranking of Occupations by Median Years of Occupational Tenure

Occupation	Median years of occupational tenure
Barbers	24.8
Farmers, except horticultural	21.1
Railroad conductors and yardmasters	18.4
Clergy	15.8
Dentists	15.7
Telephone line installers and repairers	15.0
Millwrights	14.8
Locomotive operating occupations	14.8
Managers; farmers, except horticultural	14.4
Telephone installers and repairers	14.3
Airplane pilots and navigators	14.0
Supervisors: police and detectives	13.8
Grader, dozer, and scraper operators	13.3
Tailors	13.3
Civil engineers	13.0
Crane and tower operators	12.9
Supervisors, n.e.c.	12.9
Teachers, secondary school	12.5
Teachers, elementary school	12.4
Dental laboratory and medical applicance technicians	12.3
Separating, filtering, and clarifying machine oeprators	12.1
Tool and die makers	12.0
Lathe and turning machine operators	11.9
Machinists	11.9
Pharmacists	11.8
Stationary engineers	11.7
Mechanical engineers	11.4
Chemists, except biochemists	11.1
Inspectors, testers, and graders	11.0
Electricians	11.0
Operating engineers	11.0
Radiologic technicians	10.9
Electrical power installers and repairers	10.8
Supervisors; mechanics and repairers	10.7
Heavy equipment mechanics	10.7
Bus, truck, and stationary engine mechanics	10.7
Physicians	10.7
Construction inspectors	10.7
Cabinet makers and bench carpenters	10.6
Industrial machinery repairers	10.6
Automobile body and related repairers	10.4

(Continued on the following page)

Table 14A-7. Ranking of Occupations by Median Years of Occupational Tenure (continued)

Occupation	Median years of occupational tenure
Electrical and electronic engineers	10.4
Plumbers, pipefitters, and steamfitters	10.4
Licensed practical nurses	10.3
Brickmasons and stonemasons	10.2
Truck drivers, heavy	10.1
Tile setters, hard and soft	10.1
Lawyers	10.1
Supervisors: production occupations	10.1
Administrators, education and related fields	10.1
Engineers, n.e.c.	10.0
Excavating and loading machine operators	10.0
Firefighting occupations	10.0
Aircraft engine mechanics	10.0
Police and detectives, public service	9.7
Counselors, educational and vocational	9.7
Architects	9.6
Stuctural metal workers	9.6
Aerospace engineers	9.6
Miscellaneous aterial moving equipment operators	9.4
Dental hygienists	9.4
Automobile mechanics	9.3
Registered nurses	9.3
Speech therapists	9.3
Binding and twisting machine operators	9.3
Managers and administrators, n.e.c.	9.1
Personnel and labor relations managers	9.0
Office machine repairer	9.0
Electronic repairers, commercial and industrial equipment	9.0
Welders and cutters	9.0
Punching and stamping press machine operators	9.0
Sheet metal workers	8.9
Administrators and officials, public administraion	8.9
Hairdressers and cosmetologists	8.9
Industrial engineers	8.9
Librarians	8.8
Inspectors and compliance officers, except construction	8.8
Upholsterers	8.6
Payroll and timekeeping clerks	8.6
Furnace, kiln, and oven operators, except food	8.6
Surveying and mapping technicians	8.6
Chemical engineers	8.6

(continued on the following page)

Table 14A-7. Ranking of Occupations by Median Years of Occupational Tenure (continued)

Occupation	Median years of occupational tenure
Sheriffs, bailiffs, and other law enforcement officers	8.6
Concrete and terrazzo finishers	8.6
Sales representatives, mining, manufacturing, and wholesale	8.6
Supervisors: general office	8.6
Specified mechanics and repairers, n.e.c.	8.5
Stenographers	8.5
Typesetters and compositors	8.5
Financial managers	8.4
Psychologists	8.4
Teachers: special education	8.4
Statistical clerks	8.3
Designers	8.3
Water and Sewage Treatment plant operators	8.3
Printing machine operators	8.2
Heating, air conditioning, and refrigeration mechanics	8.1
Supervisors; distribution, scheduling, and adjusting clerks	8.1
Insurance sales occupations	8.1
Carpenters	8.0
Public transportation attendants	8.0
Drafting occupations	8.0
Butchers and meatcutters	8.0
Miscellaneous electrical and electronic equipment repairers	7.9
Dressmakers	7.9
Musicians and composers	7.9
Supervisors and proprietors; sales occupations	7.9
Painters, Sculptors, craft-artists, and artist printmakers	7.9
Mechanics and repairers, not specified	7.7
Engineering technicians, n.e.c.	7.7
Clinical laboratory technologists and technicians	7.7
Purchasing managers	7.7
Purchasing agents and buyers, n.e.c.	7.7
Photographers	7.6
Chemical technicians	7.6
Managers; properties and real estate	7.6
Accountants and auditors	7.6
Religious workers, n.e.c.	7.6
Secretaries	7.5
Social workers	7.5
Operations and systems researchers and analysts	7.4
Postal clerks, except mail carriers	7.4
Managers; marketing, advertising, and public relations	7.3

(continued on the following page)

Table 14A-7. Ranking of Occupations by Median Years of Occupational Tenure (continued)

Occupation	Median years of occupational tenure
Farm workers	7.3
Managers; medicine and health	7.2
Data processing equipment repairers	7.2
Bookkeepers, accounting and auditing clerks	7.1
Grinding, abrading, buffing, and polishing machine operators	7.0
Management related occupations, n.e.c.	7.0
Supervisiors; cleaning and building service workers	7.0
Management analysts	7.0
Science technicians, n.e.c.	7.0
Mail carriers, postal service	7.0
Knitting, looping, taping, and weaving machine operators	6.9
Electrical and electronic technicians	6.9
Painting and paint spraying machine operators	6.9
Postsecondary teachers, subject not specified	6.8
Crossing guards	6.8
Inhalation therapists	6.7
Carpet installers	6.7
Computer systems analysts and scientists	6.6
Other financial officers	6.6
Industrial truck and tractor equipment operators	6.6
Textile sewing machine operators	6.6
Correctional institution officers	6.5
Teachers, prekindergarten and kindergarten	6.4
Supervisors; financial records processing	6.4
Miscellaneous Textile machine operators	6.4
Production inspectors, checkers, and examiners	6.3
Actors and directors	6.3
Health technologists and technicians, n.e.c.	6.3
Miscellaneous machine operators, n.e.c.	6.2
Private household cleaners, and servants	6.2
Buyers, wholesale and retail trade, excluding farm products	6.0
Real estate sales occupations	6.0
Electrical and electronic equipment assemblers	6.0
Bus drivers	6.0
Editors and reporters	6.0
Laundering and dry cleaning machine operators	6.0
Meter readers	5.9
Painters, construction and maintenance	5.9
Driver-sales workers	5.9
Teachers, n.e.c.	5.9
Order clerks	5.8
Physicians' assistants	5.8

(continued on the following page)

Table 14A-7. Ranking of Occupations by Median Years of Occupational Tenure (continued)

Occupation	Median years of occupational tenure
Billing clerks	5.8
Drywall installers	5.7
Construction trades, n.e.c.	5.7
Telephone operators	5.7
Authors	5.6
Nursing aides, orderlies, and attendants	5.6
Dental assistants	5.6
Timber cutting and logging occupations	5.5
Molding and casting machine operators	5.5
Miscellaneous hand-working occupations	5.5
Production coordinators	5.5
Public relations specialists	5.5
Personnel clerks, except payroll and bookkeeping	5.4
Assemblers	5.4
Securities and financial services sales occupations	5.4
Salesworkers, furniture and home furnishings	5.4
Insurance adjusters, examiners, and investigators	5.3
Pressing machine operators	5.3
Roofers	5.3
Graders and sorters, except agricultural	5.3
Supervisors; related agricultural occupations	5.2
Typists	5.2
Supervisors; motor vehicle operators	5.2
Personnel, training, and labor relations specialists	5.2
Legal assistants	5.2
Physical therapists	5.2
Advertising and related sales occupations	5.1
Records clerks	5.1
Economists	5.1
Technicians, n.e.c.	5.0
Expediters	5.0
Sales occupations, other business services	4.9
Computer operators	4.8
Computer programmers	4.8
Investigators and adjusters, except insurance	4.8
Underwriters	4.8
Salesworkers, parts	4.8
Artists, performers, and related workers, n.e.c.	4.8
Teachers' aides	4.6
Maids and housemen	4.6
Sawing machine operators	4.6
Machine operators, not specified	4.5
Weighers, measurers, and checkers	4.5

(continued on the following page)

Table 14A-7. Ranking of Occupations by Median Years of Occupational Tenure (continued)

Occupation	Median years of occupational tenure
Traffic, shipping, and receiving clerks	4.5
Salesworkers, hardware and building supplies	4.5
Biological technicians	4.4
Athletes	4.4
Bill and account collectors	4.4
Taxicab drivers and chauffeurs	4.4
Slicing and cutting machine operators	4.3
Administrative support occupations, n.e.c.	4.3
Mixing and blending machine operators	4.3
Waiters and waitresses	4.2
Janitors and cleaners	4.2
Production helpers	4.1
General office clerks	4.0
Machine feeders and offbearers	3.9
Interviewers	3.9
Bartenders	3.9
Eligibility clerks, social welfare	3.9
Bank tellers	3.8
Cooks, except short-order	3.8
Health aides, except nursing	3.7
Laborers, except construction	3.7
Welfare service aides	3.7
Salesworkers, motor vehicles and boats	3.7
Cost and rate clerks	3.6
Construction laborers	3.6
Hand packers and packagers	3.5
Transportation ticket and reservation agents	3.5
Animal caretakers, except farm	3.5
Photographic process machine operators	3.5
Freight, stock, and material movers, hand, n.e.c.	3.4
Data-entry keyers	3.4
Bakers	3.4
Dispatchers	3.3
Guards and police, except public service	3.3
Packaging and filling machine operators	3.3
Receptionists	3.3
Library clerks	3.3
Truckdrivers, light	3.2
Salesworkers, radio, television, hi-fi, and appliances	3.2
Salesworkers, apparel	3.1
Sales counter clerks	3.1
Salesworkers, other commodities	3.1

(continued on the following page)

Table 14A-7. Ranking of Occupations by Median Years of Occupational Tenure (continued)

Occupation	Median years of occupational tenure
Small engine repairers	3.1
Supervisors, food preparation and service occupations	3.0
Health record technologists and technicians	2.9
Helpers, construction trades	2.9
Attendants, amusement and recreation facilities	2.8
Street and door-to-door salesworkers	2.7
Child-care workers, private household	2.7
Child-care workers, except private household	2.7
Information clerks, n.e.c.	2.7
Hotel clerks	2.7
Personal service occupations, n.e.c.	2.7
Salesworkers, shoes	2.6
Garage and service station related occupations	2.6
Short-order cooks	2.5
File clerks	2.5
Cashiers	2.4
Mail clerks, except postal service	2.3
Miscellaneous food preparation occupations	2.3
News vendors	2.3
Vehicle washers and equipment cleaners	2.3
Messengers	2.3
Kitchen workers, food preparation	2.1
Stock handlers and baggers	1.9
Waiters and waitresses assistants	1.7
Food counter, fountain, and related occupations	1.5

[a] n.e.c. - not elsewhere classified

Source: Carey, 1988.

Table 14B-1. Annual Geographical Mobility Rates, by Type of Movement for Selected 1-Year Periods: 1960-1992 (Numbers in Thousands)

		Residing in the United States at beginning of period						Residing outside the United States at the beginning of period
			Different house, same county	Different County				
Mobility period	Total movers	Total		Total	Same State	Different State	Different Region	
NUMBER								
1991-92	42,800	41,545	26,587	14,957	7,853	7,105	3,285	1,255
1990-91	41,539	40,154	25,151	15,003	7,881	7,122	3,384	1,385
1989-90	43,381	41,821	25,726	16,094	8,061	8,033	3,761	1,560
1988-89	42,620	41,153	26,123	15,030	7,949	7,081	3,258	1,467
1987-88	42,174	40,974	26,201	14,772	7,727	7,046	3,098	1,200
1986-87	43,693	42,551	27,196	15,355	8,762	6,593	3,546	1,142
1985-86	43,237	42,037	26,401	15,636	8,665	6,791	3,778	1,200
1984-85	46,470	45,043	30,126	14,917	7,995	6,921	3,647	1,427
1983-84	39,379	38,300	23,659	14,641	8,198	6,444	3,540	1,079
1982-83	37,408	36,430	22,858	13,572	7,403	6,169	3,192	978
1981-82	38,127	37,039	23,081	13,959	7,330	6,628	3,679	1,088
1980-81	38,200	36,887	23,097	13,789	7,614	6,175	3,363	1,313
1970-71	37,705	36,161	23,018	13,143	6,197	6,946	3,936	1,544
1960-61	36,533	35,535	24,289	11,246	5,493	5,753	3,097	988
PERCENT								
1991-92	17.3	16.8	10.7	6.0	3.2	2.9	1.3	0.5
1990-91	17.0	16.4	10.3	6.1	3.2	2.9	1.4	0.6
1989-90	17.9	17.3	10.6	6.6	3.3	3.3	1.6	0.6
1988-89	17.8	17.2	10.9	6.3	3.3	3.0	1.4	0.6
1987-88	17.8	17.3	11.0	6.2	3.3	3.0	1.3	0.5
1986-87	18.6	18.1	11.6	6.5	3.7	2.8	1.5	0.5
1985-86	18.6	18.0	11.3	6.7	3.7	3.0	1.6	0.5
1984-85	20.2	19.6	13.1	6.5	3.5	3.0	1.6	0.6
1983-84	17.3	16.8	10.4	6.4	3.6	2.8	1.6	0.5
1982-83	16.6	16.1	10.1	6.0	3.3	2.7	1.4	0.4
1981-82	17.0	16.6	10.3	6.2	3.3	3.0	1.6	0.5
1980-81	17.2	16.6	10.4	6.2	3.4	2.8	1.5	0.6
1970-71	18.7	17.9	11.4	6.5	3.1	3.4	2.0	0.8
1960-61	20.6	20.0	13.7	6.3	3.1	3.2	1.7	0.6

Source: U.S. Bureau of Census, 1993.

Table 14B-2. Mobility of the Resident Population by State: 1980

Region, division, and state	Persons 5 years old, and over[b] 1980 (1,000)	Percent distribution - residence in 1975[a]: Same house in 1980 as 1975	Different house, same county	Different county, same state	Different county, different state
United States	210,323	53.6	25.1	9.8	9.7
Northeast	46,052	61.7	22.3	8.0	6.1
New England	11,594	59.1	23.4	6.7	9.2
Maine	1,047	56.9	24.0	7.5	10.8
New Hampshire	857	51.6	22.8	6.2	18.5
Vermont	476	54.4	23.9	6.5	14.3
Massachusetts	5,398	61.0	22.7	7.6	7.0
Rhode Island	891	60.5	23.9	5.0	8.7
Connecticut	2,925	59.0	24.4	5.5	9.3
Middle Atlantic	34,458	62.6	21.9	8.4	5.0
New York	16,432	61.5	22.6	9.3	3.8
New Jersey	6,904	61.5	20.0	8.6	7.8
Pennsylvania	11,122	65.0	22.0	7.1	5.2
Midwest	54,513	55.4	26.4	10.2	7.0
East North Central	38,623	56.0	27.4	9.6	6.0
Ohio	10,015	56.7	27.9	9.0	5.7
Indiana	5,074	54.8	27.5	9.6	7.6
Illinois	10,593	55.5	28.5	8.1	6.1
Michigan	8,582	56.4	26.2	11.3	5.1
Wisconsin	4,360	56.2	25.5	11.0	6.7
West North Central	15,890	53.9	24.0	11.8	9.4
Minnesota	3,770	55.6	22.8	13.3	7.3
Iowa	2,693	55.6	25.0	10.9	7.9
Missouri	4,564	54.0	24.1	11.8	9.4
North Dakota	598	51.7	23.1	11.4	12.7
South Dakota	633	52.9	23.2	12.1	11.1
Nebraska	1,448	53.1	24.4	11.0	10.5
Kansas	2,184	50.2	25.1	10.7	12.6

(Continued on the following page)

Table 14B-2. Mobility of the Resident Population by State: 1980 (continued)

Region, division, and state	Persons 5 years old, and over[b] 1980 (1,000)	Percent distribution - residence in 1975[a] Same house in 1980 as 1975	Different house, same county	Different county, same state	Different county, different state
South	69,880	52.4	24.1	10.0	12.0
South Atlantic	34,498	52.7	22.4	9.7	13.6
Delaware	555	57.0	26.3	2.0	13.3
Maryland	3,947	55.5	21.9	10.3	10.4
District of Columbia	603	58.2	22.7	NA	16.3
Virginia	4,99i	51.0	17.9	15.0	13.9
West Virginia	1,806	60.9	23.4	6.6	8.6
North Carolina	5,476	56.9	23.5	8.9	9.8
South Carolina	2,884	57.5	22.3	7.7	11.5
Georgia	5,052	52.5	22.8	12.2	11.5
Florida	9,183	46.2	23.7	7.8	19.6
East South Central	13,556	56.0	25.9	7.9	9.5
Kentucky	3,379	54.4	27.2	8.6	9.0
Tennessee	4,269	54.2	27.2	7.4	10.6
Alabama	3,601	57.6	25.3	7.4	8.9
Mississippi	2,307	59.0	22.5	8.6	9.2
West South Central	21,826	49.6	25.6	11.8	11.0
Arkansas	2,113	53.1	24.8	9.1	12.4
Louisiana	3,847	57.0	24.3	9.2	8.4
Oklahoma	2,793	47.6	24.9	12.3	13.7
Texas	13,074	47.3	26.2	12.9	11.0
West	39,879	43.8	28.3	11.0	13.4
Mountain	10,386	42.7	25.1	9.1	21.1
Montana	722	47.3	24.5	12.3	15.0
Idaho	852	44.4	24.7	9.5	20.0
Wyoming	425	38.4	23.6	8.6	28.3
Colorado	2,676	39.8	22.7	14.8	20.6
New Mexico	1,188	50.3	23.2	7.2	17.4
Arizona	2,506	41.9	27.1	5.0	23.9
Utah	1,272	45.8	27.8	8.4	16.0
Nevada	745	34.8	27.4	3.6	31.5

(continued on the following page)

Table 14B-2. Mobility of the Resident Population by State: 1980 (continued)

Region, division, and state	Persons 5 years old, and over[b] 1980 (1,000)	Percent distribution - residence in 1975[a]			
		Same house in 1980 as 1975	Different house, same county	Different county, same state	Different county, different state
Pacific	29,493	44.2	29.4	11.6	10.7
Washington	3,825	43.7	27.7	10.1	16.2
Oregon	2,437	41.4	26.6	13.4	16.9
California	21,980	44.6	30.2	12.1	8.5
Alaska	363	32.2	27.6	8.7	29.1
Hawaii	888	49.3	25.2	2.8	16.9

[a] Survey assessed changes in residence between 1975 and 1980.
[b] Includes persons residing abroad in 1975.
NA = not applicable.

Source: U.S. Bureau of the Census, Statistical Abstract, 1984.

TOC

Previous Home Table of Contents Glossary Next

TABLE OF CONTENTS

15. CONSUMER PRODUCTS

15.1. BACKGROUND

Consumer products may contain toxic or potentially toxic chemical constituents to which humans may be exposed as a result of their use. For example, methylene chloride and other solvents and carriers are common in consumer products and may have human health concerns. Potential pathways of exposure to consumer products or chemicals released from consumer products during use occur via ingestion, inhalation, and dermal contact. Exposure assessments that address consumer products involve characterization of these potential exposure pathways and calculating exposure or dose (based on exposure pathway) of chemical substances released during use of consumer products. In order to estimate specific-pathway exposure for consumer products or their components, the following information is needed: amount of product used; concentration of product in each type of activity; percent weight of chemical present in product; duration and frequency of use or activity; and for dermal exposure, the amount of solution on skin after exposure (Hakkinen et al., 1991; U.S. EPA, 1987).

This chapter presents information on the amount of product used, frequency of use, and duration of use for various consumer products typically found in consumer households. All tables that present information for these consumer products are located at the end of this chapter. U.S. EPA (1987) has complied a comprehensive list of consumer products found in typical American households. This list of consumer products is presented in Table 15-1. It should be noted that this chapter does not provide an exhaustive treatment of all consumer products, but rather provides some background and data that can be utilized in an exposure assessment. The studies presented in the following sections represent readily available surveys for which data were collected on the frequency and duration of use and amount of use of cleaning products, painting products, household solvent products, cosmetic and other personal care products, household equipment, pesticides, and tobacco. The studies have been classified as either key or relevant based on their applicability to exposure assessment needs.

The reader is also referred to a document developed by the U.S. EPA, Office of Toxic Substances:

- "Standard Scenarios for Estimating Exposure to Chemical Substances During Use of Consumer Products - Volumes I and II" (1986).

This document presents data and supporting information required to assess consumer exposure to constituents in household cleaners and components of adhesives. Information presented includes a description of standard scenarios selected to represent upper bound exposures for each product. Values are also presented for parameters that are needed to estimate exposure for defined exposure routes and pathways assumed for each scenario.

An additional reference is the Simmons Market Research Bureau (SMRB), "Simmons Study of Media and Markets." This document provides an example of marketing data that are available that may be useful in assessing exposure to selected products. The reports are published annually. Data are collected on the buying habits of the U.S. populations over the past 12 months. This information is collected for over 1,000 consumer products. Data are presented on frequency of use, total number of buyers in each use category, and selected demographics. The consumer product data are presented according to the "buyer" and not necessarily according to the "user" (actively exposed person). It may be necessary to adjust the data to reflect potential uses in a household. The reports are available for purchase from the Simmons Market Research Bureau, (212) 916-8970. Appendix Table 15A-1 presents a list of product categories for which information is available.

15.2. KEY CONSUMER PRODUCTS USE STUDIES

Westat (1987a) - Household Solvent Products: A National Usage Survey - Westat (1987a) conducted a nationwide survey to determine consumer exposure to common household products believed to contain methylene chloride or its substitutes (trichloroethane, trichloro-ethylene, carbon tetrachloride, perchloroethylene, and 1,1,1,2,2,2- trichlorotrifluoroethane). The survey method-ology was comprised of three phases. In the first phase, the sample population was generated by using a random digit dialing (RDD) procedure. Using this procedure, telephone numbers of households were randomly selected by utilizing an unbiased, equal probability of selection method, known as the "Waksberg Method" (Westat, 1987a). After the respondents in the selected households (18 years and older) agreed to participate in the survey, the second phase was initiated. It involved a mailout of questionnaires and product pictures to each respondent. In the third phase, a telephone follow-up call was made to those respondents who did not respond to the mailed questionnaire within a 4-week period. The same questionnaire was administered over the telephone to participants who did not respond to the mailed questionnaire. Of the 6,700 individuals contacted for the survey, 4,920 individuals either responded to the mailed questionnaire or to a telephone interview (a response rate of 73 percent). Survey questions included how often the products were used in the last 12 months; when they were last used; how much time was spent using a product (per occasion or year), and the time the respondent remained in the room after use; how much of a product was used per occasion or year; and what protective measures were used (Westat, 1987a).

Thirty-two categories of common household products were included in the survey and are presented in Table 15-2. Tables 15-2, 15-3, 15-4, and 15-5 provide means, medians, and percentile rankings for the following variables: frequency of use, exposure time, amount of use, and time exposed after use.

An advantage of this study is that the random digit dialing procedure (Waksberg Method) used in identifying participants for this survey enabled a diverse selection of a representative, unbiased, sample of the U.S. population (Westat 1987a). Also, empirical data generated from this study will provide more accurate calculations of human exposure to consumer household products than estimates previously used. However, a limitation associated with this study is that the data generated were based on recall behavior. Another limitation is that extrapolation of these data to long-term use patterns may be difficult.

CPSC (1992) - Methylene Chloride Consumer Use Study Survey Findings - As part of a plan to assess the effectiveness of labeling of consumer products containing methylene chloride, CPSC conducted a telephone survey of nearly five thousand households (CPSC, 1992). The survey was conducted in April and May of 1991. Three classes of products were of concern: paint strippers, non-automotive spray paint, and adhesive removers. The survey paralleled a 1986 consumer use survey sponsored jointly by CPSC and the U.S. EPA. Results of the survey were the following (CPSC, 1992):

- Compared to the 1986 findings, a significantly smaller proportion of current survey respondents used a paint stripper, spray paint, or adhesive remover.

- The proportion of the population who used the three products recently (within the past year) decreased substantially.

- Those who used the products reported a significantly longer time since their last use.

- For all three products, the reported amount used per year was significantly higher in the current survey.

The survey was conducted to estimate the percent of the U.S. adult population using paint remover, adhesive remover, and non-automotive spray paint. In addition, an estimate of the population using these products containing methylene chloride was determined. A survey questionnaire was developed to collect product usage data and demographic data. The survey sample was generated using a RDD technique.

A total of 4,997 product screener interviews were conducted for the product interview sections; the number of respondents were: 381 for paint strippers, 58 for adhesive removers, and 791 for non-automotive spray paint. Survey responses were weighted to allow estimation at the level of the total U.S. population (CPSC, 1992). A follow-up mail survey was also conducted using a short questionnaire. Respondents who had used the product in the past year or had purchased the product in the past 2 years and still had the container were asked to respond to the questionnaire (CPSC, 1992). Of the mail questionnaires (527) sent out, 259 were returned. The questionnaire responses included 67 on paint strippers, 6 on adhesive removers, and 186 on non-automotive spray paint. Results of the survey are presented in Tables 15-6 through 15-11 (N's are unweighted). Data are presented for recent users. Recent users were defined as persons who have used the product within the last year of the survey or who have purchased the product in the past 2 years.

An advantage of this survey is that the survey population was large and the survey responses were weighted to represent the U.S. population. In addition, the survey was designed to collect data for frequency of product use and amount of product used by gender. A limitation of the survey is that the data were generated based on recall behavior. Extrapolation of these data to accurately reflect long-term use patterns may be difficult.

Westat (1987b) - National Usage Survey of Household Cleaning Products - Westat (1987b) collected usage data from a nationwide survey to assess the magnitude of exposure of consumers to various products used when performing certain household cleaning tasks. The survey was conducted between the middle of November, 1985 to the middle of January, 1986. Telephone interviews were conducted with 193 households. According to Westat (1987b), the resulting response rate for this survey was 78 percent. The

Waksberg method discussed previously in the Westat (1987a) study was also used in randomly selecting telephone numbers employed in the Westat (1987b) survey. The survey was designed to obtain information on cleaning activities performed in the interior of the home during the previous year. The person who did the majority of the cleaning in the kitchen and bathroom areas of each household was interviewed. Of those respondents, the primary cleaner was female in 160 households (83 percent) and male in 30 households (16 percent); the sex of the respondents in three remaining households was not ascertained (Westat, 1987b). Data obtained from the survey included the frequency of performing 14 different cleaning tasks; the amount of time (duration) spent at each task; the cleaning product most frequently used; the type of product (liquid, powder, aerosol or spray pump) used; and the protective measures taken during cleaning such as wearing rubber gloves or having a window open or an exhaust fan on (Westat, 1987b).

The survey data are presented in Tables 15-12 through 15-16. Table 15-12 presents the mean and median total exposure time of use for each cleaning task and the product type preferred for each task. The percentile rankings for the total time exposed to the products used for 14 cleaning tasks are presented in Table 15-13. The mean and percentile rankings of the frequency in performing each task are presented in Table 15-14. Table 15-15 shows the mean and percentile rankings for exposure time per event of performing household tasks. The mean and percentile rankings for total number of hours spent per year using the top 10 product groups are presented in Table 15-16.

Westat (1987b) randomly selected a subset of 30 respondents from the original survey and reinterviewed them during the first two weeks of March, 1986 as a reliability check on the recall data obtained from the original phone survey. Frequency and duration data for 3 of the original 14 cleaning tasks were obtained from the reinterviews. In a second effort to validate the phone survey, 50 respondents of the original phone survey participated in a four-week diary study (between February and March, 1986) of 8 of the 14 cleaning tasks originally studied. The diary approach assessed the validity of using a one-time telephone survey to determine usual cleaning behavior (Westat, 1987b). The data (i.e., frequency and duration) obtained from the reinterviews and the diary approach were lower than the data from the original telephone survey. The data from the reinterviews and the diary approach were more consistent with each other. Westat (1987b) attributed the significant differences in the data obtained from these surveys to seasonal changes rather than methodological problems.

A limitation of this survey is evident from the reliability and validity check of the data conducted by Westat (1987b). The data obtained from the telephone survey may reflect heavier seasonal cleaning because the survey was conducted during the holidays (November through January). Therefore, usage data obtained in this study may be biased and may represent upper bound estimates. Another limitation of this study is the small size of the sample population. An advantage of this survey is that the RDD procedure (Waksberg Method) used provides unbiased results of sample selection and reduces the number of unproductive calls. Another advantage of this study is that it provides empirical data on frequency and duration of consumer use, thereby eliminating best judgment or guesswork.

Westat (1987c) - National Household Survey of Interior Painters - Westat (1987c) conducted a study between November, 1985 and January, 1986 to obtain usage information to estimate the magnitude of exposure of consumers to different types of painting and painting related products used while painting the interior of the home. Seven-hundred and seventy-seven households were sampled to determine whether any household member had painted the interior of the home during the last 12 months prior to the survey date. Of the sampled households, 208 households (27 percent) had a household member who had painted during the last 12 months. Based on the households with primary painters, the response rate was 90 percent (Westat, 1987c). The person in each household who did most of the interior painting during the last 12 months was interviewed over the telephone. The RDD procedure (Waksberg Method) previously described in Westat (1987a) was used to generate sample blocks of telephone numbers in this survey. Questions were asked on frequency and time spent for interior painting activities; the amount of paint used; and protective measures used (i.e., wearing gloves, hats, and masks or keeping a window open) (Westat, 1987c). Fifty-three percent of the primary painters in the households interviewed were male, 46 percent were female, and the sex of the remaining 1 percent was not ascertained. Three types of painting products were used in this study; latex paint, oil-based paint, and wood stains and varnishes. Of the respondents, 94.7 percent used latex paint, 16.8 percent used oil-based paint, and 20.2 percent used wood stains and varnishes.

Data generated from this survey are summarized in Tables 15-17, 15-18, and 15-19. Table 15-17 presents the mean, standard duration, and percentile rankings for the total exposure time for painting activity by paint type. Table 15-18 presents the mean and standard exposure time for the painting activity per occasion for each paint type. A "painting occasion" is defined as a time period from start to cleanup (Westat 1987c). Table 15-18 also presents the frequency and percentile rankings of painting occasions per year. Table 15-19 presents the total amount of paint used by interior painters.

In addition, 30 respondents from the original survey were reinterviewed in April 1986, as a reliability check on the recall data obtained from the original painting survey. There were no significant differences between the data obtained from the reinterviews and the original painting survey (Westat, 1987c).

An advantage of this survey, based on the reliability check conducted by Westat (1987c), is the stability in the painting data obtained. Another advantage of this survey is that the response rate was high (90 percent), therefore, minimizing non-response bias. Also, the Waksberg Method employed provides an unbiased equal probability method of RDD. A limitation of the survey is the data are based on 12-month recall and may not accurately reflect long-term use patterns.

Tsang and Klepeis (1996) - National Human Activity Pattern Survey (NHAPS) - The U.S. EPA collected information for the general population on the duration and frequency of selected activities and the time spent in selected microenvironments via 24-hour diaries. Over 9000 individuals from 48 contiguous states participated in NHAPS. The survey was conducted between October 1992 and September 1994. Individuals were interviewed to categorize their 24-hour routines (diaries) and/or answer follow-up exposure questions that were related to exposure events. Data were collected based on selected socioeconomic (gender, age, race, education, etc.) and geographic (census region, state, etc.) factors and time/season (day of week, month) (Tsang and Klepeis, 1996).

Data were collected for a maximum of 82 possible microenvironments and 91 different activities (Tsang and Klepeis, 1996). Respondents were also asked exposure-related follow up questions, mostly on air and water exposure pathways, on specific pollutant sources (paint, glue, etc.), or prolonged background activities (tobacco smoke, gas heaters, etc.) (Tsang and Klepeis, 1996).

As part of the survey, data were also collected on duration and frequency of use of selected consumer products. These data are presented in Tables 15-20 through 15-41. Distribution data are presented for selected percentiles (where possible). Other data are presented in ranges of time spent in an activity (e.g., working with or near a product being used) or ranges for the number of times an activity involving a consumer product was performed. Tables 15-20 through 15-41 provide duration and/or frequency data for the following categories: selected cosmetics and personal care items; household cleaners and other household products; household equipment; pesticides; and tobacco products.

The advantages of NHAPS is that the data were collected for a large number of individuals and are representative of the U.S. general population. In addition, frequency distributions of time spent and frequency of occurrence data for activities and locations are provided, when possible. Also, data on 9,386 different respondents are grouped by various socioeconomic, geographic, time/seasonal factors.

15.3. RELEVANT CONSUMER PRODUCTS USE STUDY

CRFA (1983) - Cosmetic, Toiletry, and Fragrance Association, Inc. - Summary of Results of Surveys of the Amount and Frequency of Use of Cosmetic Products by Women - The Cosmetic, Toiletry, and Fragrance Association Inc. (CTFA, 1983), a major manufacturer and a market research bureau, conducted surveys to obtain information on frequency of use of various cosmetic products. Three surveys were conducted to collect data on the frequency of use of various cosmetic products and selected baby products. In the first of these three surveys CTFA (1983) conducted a one-week prospective survey of 47 female employees and relatives of employees between the ages of 13 and 61 years. In the second survey, a cosmetic manufacturer conducted a retrospective survey of 1,129 of its customers. The third survey was conducted by a market research bureau which sampled 19,035 female consumers nationwide over a 9-1/2 month period. Of the 19,035 females interviewed, responses from only 9,684 females were tabulated (CFTA, 1983). The third survey was designed to reflect the sociodemographic (i.e., age, income, etc) characteristics of the entire U.S. population. The respondents in all three surveys were asked to record the number of times they used the various products in a given time period, i.e., a week, a day, a month, or a year (CTFA, 1983).

To obtain the average frequency of use for each cosmetic product, responses were averaged for each product in each survey. Thus, the averages were calculated by adding the reported number of uses per given time period for each product, dividing by the total number of respondents in the survey, and then dividing again by the number of days in the given time period (CFTA, 1983). The average frequency of use of cosmetic products was determined for both "users" and "non-users." The frequency of use of baby products was determined among "users" only. The upper 90th percentile frequency of use values were determined by eliminating the top ten percent most extreme frequencies of use. Therefore, the highest remaining frequency of use was recorded as the upper 90th percentile value (CFTA, 1983). Table 15-42 presents the amount of product used per application (grams) and the average and 90th percentile frequency of use per day for baby products and various cosmetic products for all the surveys.

An advantage of the frequency data obtained from the third survey (market research bureau) is that the sample population was more likely to be representative of the U.S. population. Another advantage of the third dataset is that the survey was conducted over a longer period of time when compared with the other two frequency datasets. Also, the study provided empirical data which will be useful in generating more accurate estimates of consumer exposure to cosmetic products. In contrast to the large market research bureau survey, the CTFA employee survey is very small and both that survey and the cosmetic company survey are likely to be biased toward high end users. Therefore, data from these two surveys should be used with caution.

15.4. RECOMMENDATIONS

Due to the large range and variation among consumer products and their exposure pathways, it is not feasible to specify recommended exposure values as has been done in other chapters of this handbook. The user is referred to the contents and references in the chapter to derive appropriate exposure factors. Table 15-43 summarizes the key and relevant studies in this chapter. In order to estimate consumer exposure to household products, several types of information are needed for the exposure equation. The information needed includes frequency and duration of use, amount of product used, percent weight of the chemical of concern found in the product, and for dermal exposure, the amount of the solution on the skin after exposure. The studies of Westat (1987a, b, and c), (CPSC, 1992), and Tsang and Klepeis (1996) provide information on amount, duration, and frequency of use of household products. The frequency and duration of use and amount of product used for some household and other consumer products can be obtained from Tables 15-2 through 15-42. Exposure to chemicals present in common household products can be estimated by utilizing data presented in these tables and the appropriate exposure equation. It should be noted that if these data are used to model indoor air concentrations, the values for time of use, time exposed after use, and frequency in the indoor air, should be the same values used in the dose equation for frequency and contact time for a given individual.

15.5. REFERENCES FOR CHAPTER 15

CPSC. (1992) Methylene chloride consumer products use survey findings. Prepared by ABT Associates for the U.S. Consumer Product Safety Commission, Bethesda, MD.

Cosmetic, Toiletry and Fragrance Association (CFTA). (1983). Summary of the results of surveys of the amount and frequency of use of cosmetic products by women. Prepared by Environ Corporation, Washington, DC for CFFA Inc., Washington, DC.

Hakkinen, P.J.; Kelling, C.K.; Callender, J.C. (1991) Exposure assessment of consumer products: Human body weights and total body surface areas to use; and sources of data for specific products. Veterinary and Human Toxicology 1(33):61-65.

Tsang, A.M.; Klepeis, N.E. (1996) Results tables from a detailed analysis of the National Human Activity Pattern Survey (NHAPS) response. Draft Report prepared for the U.S. Environmental Protection Agency by Lockheed Martin, Contract No. 68-W6-001, Delivery Order No. 13.

U.S. EPA. (1986) Standard scenarios for estimating exposure to chemical substances during use of consumer products. Prepared by Versar, Inc. For the Office of Toxic Substances, Contract No. 68-02-3968.

U.S. EPA. (1987) Methods for assessing exposure to chemical substances - Volume 7 - Methods for assessing consumer exposure to chemical substances. Washington, DC: Office of Toxic Substances. EPA Report No. 560/5-85-007.

Westat. (1987a) Household solvent products - a national usage survey. Under Subcontract to Battelle Columbus Div., Washington DC. Prepared for U.S. Environmental Protection Agency, Washington, DC. Available from NTIS, Springfield, VA. PB88-132881.

Westat. (1987b) National usage survey of household cleaning products. Prepared for U.S. Environmental Protection Agency, Office of Toxic Substances and Office of Pesticides and Toxic Substances, Washington, DC.

Westat. (1987c) National household survey of interior painters. Prepared for U.S. Environmental Protection Agency, Office of Toxic Substances and Office of Pesticides and Toxic Substances, Washington DC.

Table 15-1. Consumer Products Found in the Typical U.S. Household[a]

Consumer Product Category	Consumer Product
Cosmetics Hygiene Products	Adhesive bandages
	Bath additives (liquid)
	Bath additives (powder)
	Cologne/perfume/aftershave
	Contact lens solutions
	Deodorant/antiperspirant (aerosol)
	Deodorant/antiperspirant (wax and liquid)
	Depilatories
	Facial makeup
	Fingernail cosmetics
	Hair coloring/tinting products
	Hair conditioning products
	Hairsprays (aerosol)
	Lip products
	Mouthwash/breath freshener
	Sanitary napkins and pads
	Shampoo
	Shaving creams (aerosols)
	Skin creams (non-drug)
	Skin oils (non-drug)
	Soap (toilet bar)
	Sunscreen/suntan products
	Talc/body powder (non-drug)
	Toothpaste
	Waterless skin cleaners
Household Furnishings	Carpeting
	Draperies/curtains
	Rugs (area)
	Shower curtains
	Vinyl upholstery, furniture
Garment Conditioning Products	Anti-static spray (aerosol)
	Leather treatment (liquid and wax)
	Shoe polish
	Spray starch (aerosol)
	Suede cleaner/polish (liquid and aerosol)
	Textile water-proofing (aerosol)
Household Maintenance Products	Adhesive (general) (liquid)
	Bleach (household) (liquid)
	Bleach (see laundry)
	Candles
	Cat box litter
	Charcoal briquets
	Charcoal lighter fluid
	Drain cleaner (liquid and powder)
	Dishwasher detergent (powder)
	Dishwashing liquid
	Fabric dye (DIY)[b]
	Fabric rinse/softener (liquid)

Table 15-1. Consumer Products Found in the Typical U.S. Household[a] (continued)

Consumer Product Category	Consumer Product
Household Maintenance Products (continued)	Fabric rinse/softener (powder)
	Fertilizer (garden) (liquid)
	Fertilizer (garden) (powder)
	Fire extinguishers (aerosol)
	Floor polish/wax (liquid)
	Food packaging and packaged food
	Furniture polish (liquid)
	Furniture polish (aerosol)
	General cleaner/disinfectant (liquid)
	General cleaner (powder)
	General cleaner/disinfectant (aerosol and pump)
	General spot/stain remover (liquid)
	General spot/stain remover (aerosol and pump)
	Herbicide (garden-patio) (Liquid and aerosol)
	Insecticide (home and garden) (powder)
	Insecticide (home and garden) (aerosol and pump)
	Insect repellent (liquid and aerosol)
	Laundry detergent/bleach (liquid)
	Laundry detergent (powder)
	Laundry pre-wash/soak (powder)
	Laundry pre-wash/soak (liquid)
	Laundry pre-wash/soak (aerosol and pump)
	Lubricant oil (liquid)
	Lubricant (aerosol)
	Matches
	Metal polish
	Oven cleaner (aerosol)
	Pesticide (home) (solid)
	Pesticide (pet dip) (liquid)
	Pesticide (pet) (powder)
	Pesticide (pet) (aerosol)
	Pesticide (pet) (collar)
	Petroleum fuels (home((liquid and aerosol)
	Rug cleaner/shampoo (liquid and aerosol)
	Rug deodorizer/freshener (powder)
	Room deodorizer (solid)
	Room deodorizer (aerosol)
	Scouring pad
	Toilet bowl cleaner
	Toiler bowl deodorant (solid)
	Water-treating chemicals (swimming pools)
Home Building/Improvement Products (DIY)[b]	Adhesives, specialty (liquid)
	Ceiling tile
	Caulks/sealers/fillers
	Dry wall/wall board
	Flooring (vinyl)
	House Paint (interior) (liquid)
	House Paint and Stain (exterior) (liquid)
	Insulation (solid)
	Insulation (foam)

Table 15-1. Consumer Products Found in the Typical U.S. Household[a] (continued)

Consumer Product Category	Consumer Product
Home Building/Improvement Products (DIY)[b] (Continued)	Paint/varnish removers
	Paint thinner/brush cleaners
	Patching/ceiling plaster
	Roofing
	Refinishing products (polyurethane, varnishes, etc.)
	Spray paints (home) (aerosol)
	Wall paneling
	Wall paper
	Wall paper glue
Automobile-related Products	Antifreeze
	Car polish/wax
	Fuel/lubricant additives
	Gasoline/diesel fuel
	Interior upholstery/components, synthetic
	Motor oil
	Radiator flush/cleaner
	Automotive touch-up paint (aerosol)
	Windshield washer solvents
Personal Materials	Clothes/shoes
	Diapers/vinyl pants
	Jewelry
	Printed material (colorprint, newsprint, photographs)
	Sheets/towels
	Toys (intended to be placed in mouths)

[a] A subjective listing based on consumer use profiles.
[b] DIY = Do It Yourself.
Source: U.S. EPA, 1987.

Table 15-2. Frequency of Use For Household Solvent Products

Products	Mean	Std. dev.	Min.	Percentile Rankings for Frequency of Use/Year: 1	5	10	25	50	75	90	95	99	Max.
Spray Shoe Polish	10.28	20.10	1.00	1.00	1.00	1.00	2.00	4.00	8.00	24.30	52.00	111.26	156.00
Water Repellents/Protectors	3.50	11.70	1.00	1.00	1.00	1.00	1.00	2.00	3.00	6.00	10.00	35.70	300.00
Spot Removers	15.59	43.34	1.00	1.00	1.00	1.00	2.00	3.00	10.00	40.00	52.00	300.00	365.00
Solvent-Type Cleaning Fluids or Degreasers	16.46	44.12	1.00	1.00	1.00	1.00	2.00	4.00	12.00	46.00	52.00	300.00	365.00
Wood Floor and Paneling Cleaners	8.48	20.89	1.00	1.00	1.00	1.00	NA	2.00	6.00	24.00	50.00	56.00	350.00
TypeWriter Correction Fluid	40.00	74.78	1.00	1.00	1.00	2.00	4.00	12.00	40.00	100.00	200.00	365.00	520.00
Adhesives	8.89	26.20	1.00	1.00	1.00	1.00	2.00	3.00	6.00	15.00	28.00	100.00	500.00
Adhesive Removers	4.22	12.30	1.00	1.00	1.00	1.00	1.00	1.00	3.00	6.00	16.80	100.00	100.00
Silicone Lubricants	10.32	25.44	1.00	1.00	1.00	1.00	2.00	3.00	10.00	20.00	46.35	150.00	300.00
Other Lubricants (excluding Automotive)	10.66	25.46	1.00	1.00	1.00	1.00	2.00	4.00	10.00	20.00	50.00	100.00	420.00
Specialized Electronic Cleaners (for TVs, Etc.)	13.41	38.16	1.00	1.00	1.00	1.00	2.00	3.00	10.00	24.00	52.00	224.50	400.00
Latex Paint	3.93	20.81	1.00	1.00	1.00	1.00	1.00	2.00	4.00	6.00	10.00	30.00	800.00
Oil Paint	5.66	23.10	1.00	1.00	1.00	1.00	1.00	1.00	3.00	6.00	12.00	139.20	300.00
Wood Stains, Varnishes, and Finishes	4.21	12.19	1.00	1.00	1.00	1.00	1.00	2.00	4.00	7.00	12.00	50.80	250.00
Paint Removers/Strippers	3.68	9.10	1.00	1.00	1.00	1.00	4.00	2.00	3.00	6.00	11.80	44.56	100.00
Paint Thinners	6.78	22.10	0.03	0.03	0.10	0.23	1.00	2.00	4.00	12.00	23.00	100.00	352.00
Aerosol Spray Paint	4.22	15.59	1.00	1.00	1.00	1.00	1.00	2.00	4.00	6.10	12.00	31.05	365.00
Primers and Special Primers	3.43	8.76	1.00	1.00	1.00	1.00	1.00	1.00	3.00	6.00	10.00	50.06	104.00
Aerosol Rust Removers	6.17	9.82	1.00	1.00	1.00	1.00	1.00	2.00	6.00	15.00	24.45	50.90	80.00
Outdoor Water Repellents (for Wood or Cement)	2.07	3.71	1.00	1.00	1.00	1.00	1.00	2.00	2.00	3.00	5.90	12.00	52.00
Glass Frostings, Window Tints, and Artificial Snow	2.78	21.96	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	27.20	365.00
Engine Degreasers	4.18	13.72	1.00	1.00	1.00	1.00	1.00	2.00	3.25	6.70	12.00	41.70	300.00
Carburetor Cleaners	3.77	7.10	1.00	1.00	1.00	1.00	1.00	2.00	3.00	6.00	12.00	47.28	100.00
Aerosol Spray Paints for Cars	4.50	9.71	1.00	1.00	1.00	1.00	1.00	2.00	4.00	10.00	15.00	60.00	100.00
Auto Spray Primers	6.42	33.89	1.00	1.00	1.00	1.00	1.00	2.00	3.75	10.00	15.00	139.00	500.00
Spray Lubricant for Cars	10.31	30.71	1.00	1.00	1.00	1.00	2.00	3.00	6.00	20.00	40.00	105.60	365.00
Transmission Cleaners	2.28	3.55	1.00	NA	1.00	1.00	1.00	1.00	2.00	3.00	9.00	NA	26.00
Battery Terminal Protectors	3.95	24.33	1.00	1.00	1.00	1.00	1.00	2.00	2.00	4.00	6.55	41.30	365.00
Brake Quieters Cleaners	3.00	6.06	1.00	NA	1.00	1.00	1.00	2.00	2.00	6.00	10.40	NA	52.00
Gasket Remover	2.50	4.39	1.00	NA	1.00	1.00	1.00	1.00	2.00	5.00	6.50	NA	30.00
Tire/Hubcap Cleaners	11.18	18.67	1.00	1.00	1.00	1.00	2.00	4.00	12.00	30.00	50.00	77.00	200.00
Ignition and Wire Dryers	3.01	5.71	1.00	1.00	1.00	1.00	1.00	2.00	3.00	5.00	9.70	44.52	60.00

NA = Not Available
Source: Westat, 1987a

Table 15-3. Exposure Time of Use For Household Solvent Products

Products	Mean (mins)	Std. dev.	Min.	1	5	10	25	50	75	90	95	99	Max.
			Percentile Rankings for Duration of Use (mins)										
Spray Shoe Polish	7.49	9.60	0.02	0.03	0.25	0.50	2.00	5.00	10.00	18.00	30.00	60.00	60.00
Water Repellents/Protectors	14.46	24.10	0.02	0.08	0.50	1.40	3.00	10.00	15.00	30.00	60.00	120.00	480.00
Spot Removers	10.68	22.36	0.02	0.03	0.08	0.25	2.00	5.00	10.00	30.00	30.00	120.00	360.00
Solvent-Type Cleaning Fluids or Degreasers	29.48	97.49	0.02	0.03	1.00	2.00	5.00	15.00	30.00	60.00	120.00	300.00	1800.00
Wood Floor and Paneling Cleaners	74.04	128.43	0.02	1.00	5.00	10.00	20.00	30.00	90.00	147.00	240.00	480.00	2700.00
TypeWriter Correction Fluid	7.62	29.66	0.02	0.02	0.03	0.03	0.17	1.00	2.00	10.00	32.00	120.00	480.00
Adhesives	15.58	81.80	0.02	0.03	0.08	0.33	1.00	4.25	10.00	30.00	60.00	180.00	2880.00
Adhesive Removers	121.20	171.63	0.03	0.03	1.45	3.00	15.00	60.00	120.00	246.00	480.00	960.00	960.00
Silicone Lubricants	10.42	29.47	0.02	0.03	0.08	0.17	0.50	2.00	10.00	20.00	45.00	180.00	360.00
Other Lubricants (excluding Automotive)	8.12	32.20	0.02	0.03	0.05	0.08	0.50	2.00	5.00	15.00	30.00	90.00	900.00
Specialized Electronic Cleaners (for TVs, Etc.)	9.47	45.35	0.02	0.03	0.08	0.17	0.50	2.00	5.00	20.00	30.00	93.60	900.00
Latex Paint	295.08	476.11	0.02	1.00	22.50	30.00	90.00	180.00	360.00	480.00	810.00	2880.00	5760.00
Oil Paint	194.12	345.68	0.02	0.51	15.00	30.00	60.00	12.00	240.00	480.00	579.00	1702.80	5760.00
Wood Stains, Varnishes, and Finishes	117.17	193.05	0.02	0.74	5.00	10.00	30.00	60.00	120.00	140.00	360.00	720.00	280.00
Paint Removers/Strippers	125.27	286.59	0.02	0.38	5.00	5.00	20.00	60.00	120.00	240.00	420.00	1200.00	4320.00
Paint Thinners	39.43	114.85	0.02	0.08	1.00	2.00	5.00	10.00	30.00	60.00	180.00	480.00	2400.00
Aerosol Spray Paint	39.54	87.79	0.02	0.17	2.00	5.00	10.00	20.00	45.00	60.00	120.00	300.00	1800.00
Primers and Special Primers	91.29	175.05	0.05	0.24	3.00	5.00	15.00	30.00	120.00	240.00	360.00	981.60	1920.00
Aerosol Rust Removers	18.57	48.54	0.02	0.05	0.17	0.25	2.00	5.00	20.00	60.00	60.00	130.20	720.00
Outdoor Water Repellents	104.94	115.36	0.02	0.05	5.00	15.00	30.00	60.00	120.00	240.00	300.00	480.00	960.00
(for Wood or Cement)	29.45	48.16	0.03	0.14	2.00	3.00	5.00	15.00	30.00	60.00	96.00	268.80	360.00
Glass Frostings, Window Tints, and Artificial Snow	29.29	48.14	0.02	0.95	2.00	5.00	10.00	15.00	30.00	60.00	120.00	180.00	900.00
Engine Degreasers, Carburetor Cleaners	13.57	23.00	0.02	0.08	0.33	1.00	3.00	7.00	15.00	30.00	45.00	120.00	300.00
Aerosol Spray Paints for Cars	42.77	71.39	0.03	0.19	1.00	3.00	10.00	20.00	60.00	120.00	145.00	360.00	900.00
Auto Spray Primers	51.45	86.11	0.05	0.22	2.00	5.00	10.00	27.50	60.00	120.00	180.00	529.20	600.00
Spray Lubricant for Cars	9.90	35.62	0.02	0.03	0.08	0.17	1.00	5.00	10.00	15.00	30.00	120.00	720.00
Transmission Cleaners	27.90	61.44	0.17	NA	0.35	1.80	5.00	15.00	30.00	60.00	60.00	NA	450.00
Battery Terminal Protectors	9.61	18.15	0.03	0.04	0.08	0.23	1.00	5.00	10.00	20.00	30.00	120.00	180.00
Brake Quieters/Cleaners	23.38	36.32	0.07	NA	0.50	1.00	5.00	15.00	30.00	49.50	120.00	NA	240.00
Gasket Remover	23.57	27.18	0.33	NA	0.50	2.00	6.25	15.00	30.00	60.00	60.00	NA	180.00
Tire/Hubcap Cleaners	22.66	23.94	0.08	0.71	3.00	5.00	10.00	15.00	30.00	60.00	60.00	120.00	240.00
Ignition and Wire Dryers	7.24	8.48	0.02	0.02	0.08	0.47	1.50	5.00	10.00	15.00	25.50	48.60	60.00

NA = Not Available
Source: Westat, 1987a

Table 15-4. Amount of Products Used For Household Solvent Products

Products	Mean (ounces/yr)	Std. dev	Min.	1	5	10	25	50	75	90	95	99	Max.
			Percentile Rankings for Amount of Products Used (ounces/yr)										
Spray Shoe Polish	9.90	17.90	0.04	0.20	0.63	1.00	2.00	4.50	10.00	24.00	36.00	99.36	180.00
Water Repellents/Protectors	11.38	22.00	0.04	0.47	0.98	1.43	2.75	6.00	12.00	24.00	33.00	121.84	450.00
Spot Removers	26.32	90.10	0.01	0.24	0.60	1.00	2.00	5.50	16.00	48.00	119.20	384.00	1600.00
Solvent-Type Cleaning Fluids or Degreasers	58.30	226.97	0.04	0.50	2.00	3.00	6.50	16.00	32.00	96.00	192.00	845.00	5120.00
Wood Floor and Paneling Cleaners	28.41	57.23	0.03	0.80	2.45	3.50	7.00	14.00	30.00	64.00	96.00	204.40	1144.00
TypeWriter Correction Fluid	4.14	13.72	0.01	0.02	0.06	0.12	0.30	0.94	2.40	8.00	18.00	67.44	181.80
Adhesives	7.49	55.90	0.01	0.02	0.05	0.12	0.35	1.00	3.00	8.00	20.00	128.00	1280.00
Adhesive Removers	34.46	96.60	0.25	0.29	1.22	2.80	6.00	10.88	32.00	64.00	138.70	665.60	1024.00
Silicone Lubricants	12.50	27.85	0.02	0.20	0.69	1.00	2.25	4.50	12.00	24.00	41.20	192.00	312.00
Other Lubricants (excluding Automotive)	9.93	44.18	0.01	0.18	0.30	0.52	1.00	2.25	8.00	18.00	32.00	128.00	1280.00
Specialized Electronic Cleaners (for TVs, Etc.)	9.48	55.26	0.01	0.05	0.13	0.25	0.52	2.00	6.00	12.65	24.00	109.84	1024.00
Latex Paint	371.27	543.86	0.03	4.00	12.92	32.00	64.00	256.00	384.00	857.60	1280.00	2560.00	6400.00
Oil Paint	168.92	367.82	0.02	0.33	4.00	8.00	25.20	64.00	148.48	384.00	640.00	1532.16	5120.00
Wood Stains, Varnishes, and Finishes	65.06	174.01	0.12	1.09	4.00	4.00	8.00	16.00	64.00	128.00	256.00	768.00	3840.00
Paint Removers/Strippers	63.73	144.33	0.64	1.50	4.00	8.00	16.00	32.00	64.00	128.00	256.00	512.00	2560.00
Paint Thinners	69.45	190.55	0.03	0.45	3.10	4.00	8.00	20.48	64.00	128.00	256.00	640.00	3200.00
Aerosol Spray Paint	30.75	52.84	0.02	0.75	2.01	3.25	7.00	13.00	32.00	65.00	104.00	240.00	1053.00
Primers and Special Primers	68.39	171.21	0.01	0.09	1.30	3.23	8.00	16.00	60.00	128.00	256.00	867.75	1920.00
Aerosol Rust Removers	18.21	81.37	0.09	0.25	1.00	1.43	2.75	8.00	13.00	32.00	42.60	199.80	1280.00
Outdoor Water Repellents (for Wood or Cement)	148.71	280.65	0.01	0.37	3.63	8.00	16.00	64.00	128.00	448.00	640.00	979.20	3200.00
Glass Frostings, Window Tints, and Artificial Snow	13.82	14.91	1.00	1.40	2.38	3.25	6.00	12.00	14.00	28.00	33.00	98.40	120.00
Engine Degreasers	46.95	135.17	0.04	1.56	4.00	6.00	12.00	16.00	36.00	80.00	160.00	480.00	2560.00
Carburetor Cleaners	22.00	50.60	0.10	0.50	1.50	3.00	5.22	12.00	16.00	39.00	75.00	212.00	672.00
Aerosol Spray Paints for Cars	44.95	89.78	0.04	0.14	1.50	3.00	6.12	16.00	48.00	100.80	156.00	557.76	900.00
Auto Spray Primers	70.37	274.56	0.12	0.77	3.00	4.00	9.00	16.00	48.00	128.00	222.00	1167.36	3840.00
Spray Lubricant for Cars	18.63	54.74	0.08	0.40	0.96	1.00	2.75	6.00	15.50	36.00	64.00	240.00	864.00
Transmission Cleaners	35.71	62.93	2.00	NA	3.75	4.00	8.00	15.00	32.00	77.00	140.00	NA	360.00
Battery Terminal Protectors	16.49	87.84	0.12	0.13	0.58	1.00	2.00	4.00	8.00	15.00	24.60	627.00	1050.00
Brake Quieters/Cleaners	11.72	13.25	0.50	NA	1.00	2.00	3.02	8.00	14.25	32.00	38.60	NA	78.00
Gasket Remover	13.25	22.35	0.50	NA	1.00	1.00	3.75	7.75	16.00	24.00	58.40	NA	160.00
Tire/Hubcap Cleaners	31.58	80.39	0.12	0.50	1.82	3.00	6.00	12.00	28.00	64.00	96.00	443.52	960.00
Ignition and Wire Dryers	9.02	14.59	0.13	0.32	1.09	1.50	3.00	6.00	10.75	16.00	20.55	113.04	120.00

NA = Not Available
Source: Westat, 1987a

Table 15-5. Time Exposed After Duration of Use For Household Solvent Products

Products	Mean (mins)	Std. dev.	Min.	1	5	10	25	50	75	90	95	99	Max.
			Percentile Rankings for Time Exposed After Duration of Use (mins)										
Spray Shoe Polish	31.40	80.50	0.00	0.00	0.00	0.00	0.00	5.00	20.00	120.00	120.00	480.00	720.00
Water Repellents/Protectors	37.95	111.40	0.00	0.00	0.00	0.00	0.00	3.00	20.00	120.00	240.00	480.00	1800.00
Spot Removers	43.65	106.97	0.00	0.00	0.00	0.00	1.00	5,.00	30.00	120.00	240.00	480.00	1440.00
Solvent-Type Cleaning Fluids or Degreasers	33.29	90.39	0.00	0.00	0.00	0.00	0.00	3.00	28.75	60.00	180.00	480.00	1440.00
Wood Floor and Paneling Cleaners	96.75	192.88	0.00	0.00	0.00	0.00	5.00	30.00	120.00	240.00	480.00	1062.00	1440.00
TypeWriter Correction Fluid	124.70	153.46	0.00	0.00	1.00	5.00	30.00	60.00	180.00	360.00	480.00	600.00	1800.00
Adhesives	68.88	163.72	0.00	0.00	0.00	0.00	1.00	10.00	60.00	180.00	360.00	720.00	2100.00
Adhesive Removers	94.12	157.69	0.00	0.00	0.00	0.00	1.75	20.00	120.00	360.00	480.00	720.00	720.00
Silicone Lubricants	30.77	107.39	0.00	0.00	0.00	0.00	0.00	0.00	10.00	60.00	180.00	480.00	1440.00
Other Lubricants (excluding Automotive)	47.45	127.11	0.00	0.00	0.00	0.00	0.00	2.00	30.00	120.00	240.00	485.40	1440.00
Specialized Electronic Cleaners (for TVs, Etc.)	117.24	154.38	0.00	0.00	0.00	1.00	10.00	60.00	180.00	300.00	480.00	720.00	1440.00
Latex Paint	91.38	254.61	0.00	0.00	0.00	0.00	0.00	5.00	60.00	240.00	480.00	1440.00	2880.00
Oil Paint	44.56	155.19	0.00	0.00	0.00	0.00	0.00	0.00	30.00	120.00	240.00	480.00	2880.00
Wood Stains, Varnishes, and Finishes	48.33	156.44	0.00	0.00	0.00	0.00	0.00	1.00	30.00	120.00	240.00	694.00	2880.00
Paint Removers/Strippers	31.38	103.07	0.00	0.00	0.00	0.00	0.00	0.00	20.00	60.00	180.00	541.20	1440.00
Paint Thinners	32.86	105.62	0.00	0.00	0.00	0.00	0.00	0.00	15.00	60.00	180.00	480.00	1440.00
Aerosol Spray Paint	12.70	62.80	0.00	0.00	0.00	0.00	0.00	0.00	1.00	30.00	60.00	260.50	1440.00
Primers and Special Primers	22.28	65.57	0.00	0.00	0.00	0.00	0.00	0.00	10.00	60.00	120.00	319.20	720.00
Aerosol Rust Removers	15.06	47.58	0.00	0.00	0.00	0.00	0.00	0.00	5.00	60.00	60.00	190.20	600.00
Outdoor Water Repellents (for Wood or Cement)	8.33	43.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	58.50	309.60	420.00
Glass Frostings, Window Tints, and Artificial Snow	137.87	243.21	0.00	0.00	0.00	0.00	3.00	60.00	180.00	360.00	480.00	1440.00	1800.00
Engine Degreasers	4.52	24.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.50	120.00	360.00
Carburetor Cleaners	7.51	68.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	30.00	120.60	1800.00
Aerosol Spray Paints for Cars	10.71	45.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.50	60.00	282.00	480.00
Auto Spray Primers	11.37	45.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	77.25	360.00	360.00
Spray Lubricant for Cars	4.54	30.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	15.00	70.20	420.00
Transmission Cleaners	5.29	29.50	0.00	NA	0.00	0.00	0.00	0.00	0.00	5.00	22.50	NA	240.00
Battery Terminal Protectors	3.25	17.27	0.00	NA	0.00	0.00	0.00	0.00	0.00	2.90	15.00	120.00	180.00
Brake Quieters/Cleaners	10.27	30.02	0.00	NA	0.00	0.00	0.00	0.00	0.00	30.00	120.00	NA	120.00
Gasket Remover	27.56	58.54	0.00	NA	0.00	0.00	0.00	0.00	12.50	120.00	180.00	NA	240.00
Tire/Hubcap Cleaners	1.51	20.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00	480.00
Ignition and Wire Dryers	6.39	31.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	30.00	216.60	240.00

NA = Not Available

Source: Westat, 1987a

Table 15-6. Frequency of Use and Amount of Product Used for Adhesive Removers

	No. of Times Used Within the Last 12 Months N=58	Minutes Using N=52	Minutes in Room After Using[a] N=51	Minutes in Room After Using[b] N=5	Amount Used in Past Year (Fluid oz.) N=51	Amount per Use (Fluid oz.) N=51
Mean	1.66	172.87	13.79	143.37	96.95	81.84
Standard deviation	1.67	304.50	67.40	169.31	213.20	210.44
Minimum Value	1.00	5.00	0.00	5.00	13.00	5.20
1st Percentile	1.00	5.00	0.00	5.00	13.00	5.20
5th Percentile	1.00	10.00	0.00	5.00	13.00	6.50
10th Percentile	1.00	15.00	0.00	5.00	16.00	10.67
25th Percentile	1.00	29.50	0.00	20.00	16.00	16.00
Median Value	1.00	120.00	0.00	120.00	32.00	26.00
75th Percentile	2.00	240.00	0.00	420.00	96.00	64.00
90th Percentile	3.00	480.00	0.00	420.00	128.00	128.00
95th Percentile	5.00	1440.00	120.00	420.00	384.00	192.00
99th Percentile	12.00	1440.00	420.00	420.00	1280.00	1280.00
Maximum Value	12.00	1440.00	420.00	1440.00	1280.00	1280.00

[a] Includes those who did not spend anytime in the room after use.
[b] Includes only those who spent time in the room.
Source: CPSC, 1992.

Table 15-7. Adhesive Remover Usage by Gender

	Gender	
	Male N=25	Female N=33
Mean number of months since last time adhesive remover was used - includes <u>all</u> respondents. (Unweighted N=240)	35.33	43.89
Mean number of uses of product in the past year.	1.94	1.30
Mean number of minutes spent with the product during last use.	127.95	233.43
Mean number of minutes spent in the room after last use of product. (Includes all recent users)	19.76	0
Mean number of minutes spent in the room after last use of product. (Includes only those who did not leave immediately)	143.37	0
Mean ounces of product used in the past year.	70.48	139.71
Mean ounces of product used per use in the past year.	48.70	130.36

Source: CPSC, 1992.

Table 15-8. Frequency of Use and Amount of Product Used for Spray Paint

	No. of Times Used Within the Last 12 Months N=775	Minutes Using N=786	Minutes in Room After Using[a] N=791	Minutes in Room After Using[b] N=35	Amount Used in Past Year (Fluid oz.) N=778	Amount per Use (Fluid oz.) N=778
Mean	8.23	40.87	3.55	65.06	83.92	19.04
Standard deviation	31.98	71.71	22.03	70.02	175.32	25.34
Minimum Value	1.00	1.00	0.00	1.00	13.00	0.36
1st Percentile	1.00	1.00	0.00	1.00	13.00	0.36
5th Percentile	1.00	3.00	0.00	1.00	13.00	3.47
10th Percentile	1.00	5.00	0.00	10.00	13.00	6.50
25th Percentile	1.00	10.00	0.00	15.00	13.00	9.75
Median Value	2.00	20.00	0.00	30.00	26.00	13.00
75th Percentile	4.00	45.00	0.00	60.00	65.00	21.67
90th Percentile	11.00	90.00	0.00	120.00	156.00	36.11
95th Percentile	20.00	120.00	0.00	120.00	260.00	52.00
99th Percentile	104.00	360.00	120.00	300.00	1170.00	104.00
Maximum Value	365.00	960.00	300.00	300.00	1664.00	312.00

[a] Includes those who did not spend anytime in the room after use.
[b] Includes only those who spent time in the room.
Source: CPSC, 1992.

Table 15-9. Spray Paint Usage by Gender

	Gender	
	Male N=405	Female N=386
Mean number of months since last time spray paint was used - includes <u>all</u> respondents. (Unweighted N=1724)	17.39	26.46
Mean number of uses of product in the past year.	10.45	4.63
Mean number of minutes spent with the product during last use.	40.87	40.88
Mean number of minutes spent in the room after last use of product. (Includes all recent users)	5.49	0.40
Mean number of minutes spent in the room after last use of product. (Includes only those who did not leave immediately)	67.76	34.69
Mean ounces of product used in the past year.	103.07	59.99
Mean ounces of product used per use in the past year.	18.50	19.92

Source: CPSC, 1992.

Table 15-10. Frequency of Use and Amount of Product Used for Paint Removers/Strippers

	No. of Times Used Within the Last 12 Months N=316	Minutes Using N=390	Minutes in Room After Using[a] N=390	Minutes in Room After Using[b] N=39	Amount Used in Past Year (Fluid oz.) N=307	Amount per Use (Fluid oz.) N=307
Mean	3.54	144.59	12.96	93.88	142.05	64.84
Standard deviation	7.32	175.54	85.07	211.71	321.73	157.50
Minimum Value	1.00	2.00	0.00	1.00	15.00	0.35
1st Percentile	1.00	5.00	0.00	1.00	15.00	2.67
5th Percentile	1.00	15.00	0.00	1.00	16.00	8.00
10th Percentile	1.00	20.00	0.00	3.00	16.00	10.67
25th Percentile	1.00	45.00	0.00	10.00	32.00	16.00
Median Value	2.00	120.00	0.00	60.00	64.00	32.00
75th Percentile	3.00	180.00	0.00	120.00	128.00	64.00
90th Percentile	6.00	360.00	10.00	180.00	256.00	128.00
95th Percentile	12.00	480.00	60.00	420.00	384.00	192.00
99th Percentile	50.00	720.00	180.00	1440.00	1920.00	320.00
Maximum Value	70.00	1440.00	1440.00	1440.00	3200.00	2560.00

[a] Includes those who did not spend anytime in the room after use.
[b] Includes only those who spent time in the room.
Source: CPSC, 1992.

Table 15-11. Paint Stripper Usage by Gender

	Gender	
	Male N=156	Female N=162
Mean number of months since last time paint stripper was used - includes all respondents. (Unweighted N=1724)	32.07	47.63
Mean number of uses of product in the past year.	3.88	3.01
Mean number of minutes spent with the product during last use.	136.70	156.85
Mean number of minutes spent in the room after last use of product. (Includes all recent users)	15.07	9.80
Mean number of minutes spent in the room after last use of product. (Includes only those who did not leave immediately)	101.42	80.15
Mean ounces of product used in the past year.	160.27	114.05
Mean ounces of product used per use in the past year.	74.32	50.29

Source: CPSC, 1992.

Table 15-12. Total Exposure Time of Performing Task and Product Type Used by Task For Household Cleaning Products

Tasks	Mean (hrs/year)	Median (hrs/year)	Product Type Used	Percent of Preference
Clean Bathroom Sinks and Tubs	44	26	Liquid	29%
			Powder	44%
			Aerosol	16%
			Spray pump	10%
			Other	1%
Clean Kitchen Sinks	41	18	Liquid	31%
			Powder	61%
			Aerosol	2%
			Spray pump	4%
			Other	2%
Clean Inside of Cabinets (such as kitchen)	12	5	Liquid	68%
			Powder	12%
			Aerosol	2%
			Spray pump	16%
			Other	2%
Clean Outside of Cabinets	21	6	Liquid	61%
			Powder	8%
			Aerosol	16%
			Spray pump	13%
			Other	2%
Wipe Off Kitchen Counters	92	55	Liquid	67%
			Powder	13%
			Aerosol	2%
			Spray pump	15%
			Other	3%
Thoroughly Clean Counters	24	13	Liquid	56%
			Powder	21%
			Aerosol	5%
			Spray pump	17%
			Other	1%
Clean Bathroom Floors	20	9	Liquid	70%
			Powder	21%
			Aerosol	2%
			Spray pump	4%
			Other	3%
Clean Kitchen Floors	31	14	Liquid	70%
			Powder	27%
			Aerosol	2%
			Spray pump	1%
			Other	--
Clean Bathroom or Other Tilted or Ceramic Walls	16	9	Liquid	37%
			Powder	18%
			Aerosol	17%
			Spray pump	25%
			Other	3%

Table 15-12. Total Exposure Time of Performing Task and Product Type Used by Task For Household Cleaning Products (continued)

Tasks	Mean (hrs/year)	Median (hrs/year)	Product Type Used	Percent of Preference
Clean Outside of Windows	13	6	Liquid	27%
			Powder	2%
			Aerosol	6%
			Spray pump	65%
			Other	--
Clean Inside of Windows	18	6	Liquid	24%
			Powder	1%
			Aerosol	8%
			Spray pump	66%
			Other	2%
Clean Glass Surfaces Such as Mirrors & Tables	34	13	Liquid	13%
			Powder	1%
			Aerosol	8%
			Spray pump	76%
			Other	2%
Clean Outside of Refrigerator and Other Appliances	27	13	Liquid	48%
			Powder	3%
			Aerosol	7%
			Spray pump	38%
			Other	4%
Clean Spots or Dirt on Walls or Doors Finishes	19	8	Liquid	46%
			Powder	15%
			Aerosol	4%
			Spray pump	30%
			Other	4%

Source: Westat, 1987b.

Table 15-13. Percentile Rankings for Total Exposure Time in Performing Household Tasks

Tasks	Percentile Rankings for Total Exposure Exposure Time Performing Task (hrs/yr)							
	100th	95th	90th	75th	50th	25th	10th	0th
Clean Bathroom Sinks and Tubs	365	121.67	91.25	52	26	13	5.2	0.4
Clean Kitchen Sinks	547.5	121.67	97.6	60.83	18.25	8.67	3.47	0.33
Clean Inside of Kitchen Cabinets	208	48	32.48	12	4.75	2	1	0.17
Clean Outside of Cabinets	780	78.66	36	17.33	6	2	0.967	0.07
Wipe Off Kitchen Counters	912.5	456.25	231.16	91.25	54.75	24.33	12.17	1.2
Thoroughly Clean Counters	547.5	94.43	52	26	13	6	1.75	0.17
Clean Bathroom Floors	365	71.49	36.83	26	8.67	4.33	2	0.1
Clean Kitchen Floors	730	96.98	52	26	14	8.67	4.33	0.5
Clean Bathroom or Other Tilted or Ceramic Walls	208	52	36	26	8.67	3	1	0.17
Clean Outside of Windows	468	32.6	24	11.5	6	2	1.5	0.07
Clean Inside of Windows	273	72	36	19.5	6	3	1.15	0.07
Clean Glass Surfaces Such as Mirrors & Tables	1460	104	60.83	26	13	6	1.73	0.17
Clean Outside Refrigerator and Other Appliances	365	95.29	91.25	30.42	13	4.33	1.81	0.1
Clean Spots or Dirt on Walls or Doors	312	78	52	24	8	2	0.568	0.07

Source: Westat, 1987b.

Table 15-14. Mean Percentile Rankings for Frequency of Performing Household Tasks

Tasks	Mean	Percentile Rankings							
		0th	10th	25th	50th	75th	90th	95th	100th
Clean bathroom sinks and tubs	3 x/week	0.2 x/week	1 x/week	1 x/week	2 x/week	3.5 x/week	7 x/week	7 x/week	42 x/week
Clean kitchen sinks	7 x/week	0 x/week	1 x/week	2 x/week	7 x/week	7 x/week	15 x/week	21 x/week	28 x/week
Clean inside of cabinets such as those in the kitchen	9 x/year	1 x/year	1 x/year	1 x/year	2 x/year	12 x/year	12 x/year	52 x/year	156 x/year
Clean outside of cabinets	3 x/month	0.1 x/month	0.1 x/month	0.3 x/month	1 x/month	4 x/month	4 x/month	22 x/month	30 x/month
Wipe off counters such as those in the kitchen	2 x/day	0 x/day	0.4 x/day	1 x/day	1 x/day	3 x/day	4 x/day	6 x/day	16 x/day
Thoroughly clean counters	8 x/month	0.1 x/month	0.8 x/month	1 x/month	4 x/month	4 x/month	30 x/month	30 x/month	183 x/month
Clean bathroom floors	6 x/month	0.2 x/month	1 x/month	2 x/month	4 x/month	4 x/month	13 x/month	30 x/month	30 x/month
Clean kitchen floors	6 x/month	0.1 x/month	1 x/month	2 x/month	4 x/month	4 x/month	13 x/month	30 x/month	30 x/month
Clean bathroom or other tiled or ceramic walls	4 x/month	0.1 x/month	0.2 x/month	1 x/month	2 x/month	4 x/month	9 x/month	13 x/month	30 x/month
Clean outside of windows	5 x/year	1 x/year	1 x/year	1 x/year	2 x/year	4 x/year	12 x/year	12 x/year	156 x/year
Clean inside of windows	10 x/year	1 x/year	1 x/year	2 x/year	4 x/year	12 x/year	24 x/year	52 x/year	156 x/year
Clean other glass surfaces such as mirrors and tables	7 x/month	0.1 x/month	1 x/month	2 x/month	4 x/month	4 x/month	17 x/month	30 x/month	61 x/month
Clean outside of refrigerator and other appliances	10 x/month	0.2 x/month	1 x/month	2 x/month	4 x/month	13 x/month	30 x/month	30 x/month	61 x/month
Clean spots or dirt on walls or doors	6 x/month	0.1 x/month	0.2 x/month	0.3 x/month	1 x/month	4 x/month	13 x/month	30 x/month	152 x/month

Source: Westat, 1987b.

Table 15-15. Mean and Percentile Rankings for Exposure Time Per Event of Performing Household Tasks

Tasks	Mean (minutes/event)	Percentile Rankings (minutes/event)							
		0th	10th	25th	50th	75th	90th	95th	100th
Clean bathroom sinks and tubs	20	1	5	10	15	30	45	60	90
Clean kitchen sinks	10	1	2	3	5	10	15	20	480
Clean inside of cabinets such as those in the kitchen	137	5	24	44	120	180	240	360	2,880
Clean outside of cabinets	52	1	5	15	30	60	120	180	330
Wipe off counters such as those in the kitchen	9	1	2	3	5	10	15	30	120
Thoroughly clean counters	25	1	5	10	15	30	60	90	180
Clean bathroom floors	16	1	5	10	15	20	30	38	60
Clean kitchen floors	30	2	10	15	20	30	60	60	180
Clean bathroom or other tiled or ceramic walls	34	1	5	15	30	45	60	120	240
Clean outside of windows	180	4	30	60	120	240	420	480	1,200
Clean inside of windows	127	4	20	45	90	158	300	381	1,200
Clean other glass surfaces such as mirrors and tables	24	1	5	10	15	30	60	60	180
Clean outside of refrigerator and other appliances	19	1	4	5	10	20	30	45	240
Clean spots or dirt on walls or doors	50	1	5	10	20	60	120	216	960

Source: Westat, 1987b.

Table 15-16. Total Exposure Time for Ten Product Groups Most Frequently Used For Household Cleaning[a]

Products	Mean (hrs/yr)	Percentile Rankings of Total Exposure Time (hrs/yr)							
		0th	10th	25th	50th	75th	90th	95th	100th
Dish Detergents	107	0.2	6	24	56	134	274	486	941
Glass Cleaners	67	0.4	3	12	29	62	139	260	1,508
Floor Cleaners	52	0.7	4	7	22	52	102	414	449
Furniture Polish	32	0.1	0.3	1	12	36	101	215	243
Bathroom Tile Cleaners	47	0.5	2	8	17	48	115	287	369
Liquid Cleansers	68	0.2	2	9	22	52	122	215	2,381
Scouring Powders	78	0.3	9	17	35	92	165	281	747
Laundry Detergents	66	0.6	8	14	48	103	174	202	202
Rug Cleaners/Shampoos	12	0.3	0.3	0.3	9	26	26	26	26
All Purpose Cleaners	64	0.3	4	9	26	77	174	262	677

[a] The data in Table 15-15 above reflect for only the 14 tasks included in the survey. Therefore, many of the durations reported in the table underestimate the hours of the use of the product group. For example, use of dish detergents to wash dishes is not included.

Source: Westat, 1987b.

Table 15-17. Total Exposure Time of Painting Activity of Interior Painters (hrs)

Types of Paint	Mean (hrs)	Std. dev.	Percentile Rankings for Duration of Painting Activity (hrs) Min.	10	25	50	75	90	95	Max.
Latex	12.2	11.28	1	3	4	9	15	24	40	248
Oil-based	10.68	15.56	1	1.6	3	6	10	21.6	65.6	72
Wood Stains and Varnishes	8.57	10.85	1	1	2	4	9.3	24	40	42

Source: Westat, 1987c.

Table 15-18. Exposure Time of Interior Painting Activity/Occasion (hrs) and Frequency of Occasions Spent Painting Per Year

Types of Paint	Duration of Painting/Occasion (hrs)		Frequency of Occasions Spent Painting/Year		Percentile Rankings for Frequency of Occasions Spent Painting							
	Mean	Median	Mean	Std. dev.	Min	10	25	50	75	90	95	Max.
Latex	2.97	3	4.16	5.54	1	1	2	3	4	9	10	62
Oil-based	2.14	3	5.06	11.98	1	1	1	2	4	8	26	72
Wood Stains and Varnishes	2.15	2	4.02	4.89	1	1	1	2	4	9	20	20

Source: Westat, 1987c.

Table 15-19. Amount of Paint Used by Interior Painters

Types of Paint	Median (gallons)	Mean (gallons)	Std. dev.	Percentile Rankings for Amount of Paint Used (gallons) Min	10	25	50	75	90	95	Max.
Latex	3.0	3.89	4.56	0.13	1	2	3	5	8	10	50
Oil-based	2.0	2.55	3.03	0.13	0.25	0.5	2	3	7	12	12
Wood Stains and Varnishes	0.75	0.88	0.81	0.13	0.14	0.25	0.75	1	2	2	4.25

Source: Westat, 1987c.

Chapter 15 Consumer Products

Table 15-1. Consumer Products Found in the Typical U.S. Household[a]	
Consumer Product Category	Consumer Product
Cosmetics Hygiene Products	Adhesive bandages
	Bath additives (liquid)
	Bath additives (powder)
	Cologne/perfume/aftershave
	Contact lens solutions
	Deodorant/antiperspirant (aerosol)
	Deodorant/antiperspirant (wax and liquid)
	Depilatories
	Facial makeup
	Fingernail cosmetics
	Hair coloring/tinting products
	Hair conditioning products
	Hairsprays (aerosol)
	Lip products
	Mouthwash/breath freshener
	Sanitary napkins and pads
	Shampoo
	Shaving creams (aerosols)
	Skin creams (non-drug)
	Skin oils (non-drug)
	Soap (toilet bar)
	Sunscreen/suntan products
	Talc/body powder (non-drug)
	Toothpaste
	Waterless skin cleaners
Household Furnishings	Carpeting
	Draperies/curtains
	Rugs (area)
	Shower curtains
	Vinyl upholstery, furniture
Garment Conditioning Products	Anti-static spray (aerosol)
	Leather treatment (liquid and wax)
	Shoe polish
	Spray starch (aerosol)
	Suede cleaner/polish (liquid and aerosol)
	Textile water-proofing (aerosol)
Household Maintenance Products	Adhesive (general) (liquid)
	Bleach (household) (liquid)
	Bleach (see laundry)
	Candles
	Cat box litter
	Charcoal briquets
	Charcoal lighter fluid
	Drain cleaner (liquid and powder)
	Dishwasher detergent (powder)
	Dishwashing liquid
	Fabric dye (DIY)[b]
	Fabric rinse/softener (liquid)

Table 15-1. Consumer Products Found in the Typical U.S. Household[a] (continued)	
Consumer Product Category	Consumer Product
Household Maintenance Products (continued)	Fabric rinse/softener (powder)
	Fertilizer (garden) (liquid)
	Fertilizer (garden) (powder)
	Fire extinguishers (aerosol)
	Floor polish/wax (liquid)
	Food packaging and packaged food
	Furniture polish (liquid)
	Furniture polish (aerosol)
	General cleaner/disinfectant (liquid)
	General cleaner (powder)
	General cleaner/disinfectant (aerosol and pump)
	General spot/stain remover (liquid)
	General spot/stain remover (aerosol and pump)
	Herbicide (garden-patio) (Liquid and aerosol)
	Insecticide (home and garden) (powder)
	Insecticide (home and garden) (aerosol and pump)
	Insect repellent (liquid and aerosol)
	Laundry detergent/bleach (liquid)
	Laundry detergent (powder)
	Laundry pre-wash/soak (powder)
	Laundry pre-wash/soak (liquid)
	Laundry pre-wash/soak (aerosol and pump)
	Lubricant oil (liquid)
	Lubricant (aerosol)
	Matches
	Metal polish
	Oven cleaner (aerosol)
	Pesticide (home) (solid)
	Pesticide (pet dip) (liquid)
	Pesticide (pet) (powder)
	Pesticide (pet) (aerosol)
	Pesticide (pet) (collar)
	Petroleum fuels (home((liquid and aerosol)
	Rug cleaner/shampoo (liquid and aerosol)
	Rug deodorizer/freshener (powder)
	Room deodorizer (solid)
	Room deodorizer (aerosol)
	Scouring pad
	Toilet bowl cleaner
	Toiler bowl deodorant (solid)
	Water-treating chemicals (swimming pools)
Home Building/Improvement Products (DIY)[b]	Adhesives, specialty (liquid)
	Ceiling tile
	Caulks/sealers/fillers
	Dry wall/wall board
	Flooring (vinyl)
	House Paint (interior) (liquid)
	House Paint and Stain (exterior) (liquid)
	Insulation (solid)
	Insulation (foam)

Table 15-1. Consumer Products Found in the Typical U.S. Household[a] (continued)

Consumer Product Category	Consumer Product
Home Building/Improvement Products (DIY)[b] (Continued)	Paint/varnish removers
	Paint thinner/brush cleaners
	Patching/ceiling plaster
	Roofing
	Refinishing products (polyurethane, varnishes, etc.)
	Spray paints (home) (aerosol)
	Wall paneling
	Wall paper
	Wall paper glue
Automobile-related Products	Antifreeze
	Car polish/wax
	Fuel/lubricant additives
	Gasoline/diesel fuel
	Interior upholstery/components, synthetic
	Motor oil
	Radiator flush/cleaner
	Automotive touch-up paint (aerosol)
	Windshield washer solvents
Personal Materials	Clothes/shoes
	Diapers/vinyl pants
	Jewelry
	Printed material (colorprint, newsprint, photographs)
	Sheets/towels
	Toys (intended to be placed in mouths)

[a] A subjective listing based on consumer use profiles.
[b] DIY = Do It Yourself.
Source: U.S. EPA, 1987.

Table 15-2. Frequency of Use For Household Solvent Products

Products	Mean	Std. dev.	Min.	Percentile Rankings for Frequency of Use/Year									Max.
				1	5	10	25	50	75	90	95	99	
Spray Shoe Polish	10.28	20.10	1.00	1.00	1.00	1.00	2.00	4.00	8.00	24.30	52.00	111.26	156.00
Water Repellents/Protectors	3.50	11.70	1.00	1.00	1.00	1.00	1.00	2.00	3.00	6.00	10.00	35.70	300.00
Spot Removers	15.59	43.34	1.00	1.00	1.00	1.00	2.00	3.00	10.00	40.00	52.00	300.00	365.00
Solvent-Type Cleaning Fluids or Degreasers	16.46	44.12	1.00	1.00	1.00	1.00	2.00	4.00	12.00	46.00	52.00	300.00	365.00
Wood Floor and Paneling Cleaners	8.48	20.89	1.00	1.00	1.00	1.00	NA	2.00	6.00	24.00	50.00	56.00	350.00
TypeWriter Correction Fluid	40.00	74.78	1.00	1.00	1.00	2.00	4.00	12.00	40.00	100.00	200.00	365.00	520.00
Adhesives	8.89	26.20	1.00	1.00	1.00	1.00	2.00	3.00	6.00	15.00	28.00	100.00	500.00
Adhesive Removers	4.22	12.30	1.00	1.00	1.00	1.00	1.00	1.00	3.00	6.00	16.80	100.00	100.00
Silicone Lubricants	10.32	25.44	1.00	1.00	1.00	1.00	2.00	3.00	10.00	20.00	46.35	150.00	300.00
Other Lubricants (excluding Automotive)	10.66	25.46	1.00	1.00	1.00	1.00	2.00	4.00	10.00	20.00	50.00	100.00	420.00
Specialized Electronic Cleaners (for TVs, Etc.)	13.41	38.16	1.00	1.00	1.00	1.00	2.00	3.00	10.00	24.00	52.00	224.50	400.00
Latex Paint	3.93	20.81	1.00	1.00	1.00	1.00	1.00	2.00	4.00	6.00	10.00	30.00	800.00
Oil Paint	5.66	23.10	1.00	1.00	1.00	1.00	1.00	1.00	3.00	6.00	12.00	139.20	300.00
Wood Stains, Varnishes, and Finishes	4.21	12.19	1.00	1.00	1.00	1.00	1.00	2.00	4.00	7.00	12.00	50.80	250.00
Paint Removers/Strippers	3.68	9.10	1.00	1.00	1.00	1.00	4.00	2.00	3.00	6.00	11.80	44.56	100.00
Paint Thinners	6.78	22.10	0.03	0.03	0.10	0.23	1.00	2.00	4.00	12.00	23.00	100.00	352.00
Aerosol Spray Paint	4.22	15.59	1.00	1.00	1.00	1.00	1.00	2.00	4.00	6.10	12.00	31.05	365.00
Primers and Special Primers	3.43	8.76	1.00	1.00	1.00	1.00	1.00	1.00	3.00	6.00	10.00	50.06	104.00
Aerosol Rust Removers	6.17	9.82	1.00	1.00	1.00	1.00	1.00	2.00	6.00	15.00	24.45	50.90	80.00
Outdoor Water Repellents (for Wood or Cement)	2.07	3.71	1.00	1.00	1.00	1.00	1.00	2.00	2.00	3.00	5.90	12.00	52.00
Glass Frostings, Window Tints, and Artificial Snow	2.78	21.96	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	27.20	365.00
Engine Degreasers													
Carburetor Cleaners	4.18	13.72	1.00	1.00	1.00	1.00	1.00	2.00	3.25	6.70	12.00	41.70	300.00
Aerosol Spray Paints for Cars	3.77	7.10	1.00	1.00	1.00	1.00	1.00	2.00	3.00	6.00	12.00	47.28	100.00
Auto Spray Primers	4.50	9.71	1.00	1.00	1.00	1.00	1.00	2.00	4.00	10.00	15.00	60.00	100.00
Spray Lubricant for Cars	6.42	33.89	1.00	1.00	1.00	1.00	1.00	2.00	3.75	10.00	15.00	139.00	500.00
Transmission Cleaners	10.31	30.71	1.00	1.00	1.00	1.00	2.00	3.00	6.00	20.00	40.00	105.60	365.00
Battery Terminal Protectors	2.28	3.55	1.00	NA	1.00	1.00	1.00	1.00	2.00	3.00	9.00	NA	26.00
Brake Quieters Cleaners	3.95	24.33	1.00	1.00	1.00	1.00	1.00	2.00	2.00	4.00	6.55	41.30	365.00
Gasket Remover	3.00	6.06	1.00	NA	1.00	1.00	1.00	2.00	2.00	6.00	10.40	NA	52.00
Tire/Hubcap Cleaners	2.50	4.39	1.00	NA	1.00	1.00	1.00	1.00	2.00	5.00	6.50	NA	30.00
Ignition and Wire Dryers	11.18	18.67	1.00	1.00	1.00	1.00	2.00	4.00	12.00	30.00	50.00	77.00	200.00
	3.01	5.71	1.00	1.00	1.00	1.00	1.00	2.00	3.00	5.00	9.70	44.52	60.00

NA = Not Available

Source: Westat, 1987a

Table 15-3. Exposure Time of Use For Household Solvent Products													
				Percentile Rankings for Duration of Use (mins)									
Products	Mean (mins)	Std. dev.	Min.	1	5	10	25	50	75	90	95	99	Max.
Spray Shoe Polish	7.49	9.60	0.02	0.03	0.25	0.50	2.00	5.00	10.00	18.00	30.00	60.00	60.00
Water Repellents/Protectors	14.46	24.10	0.02	0.08	0.50	1.40	3.00	10.00	15.00	30.00	60.00	120.00	480.00
Spot Removers	10.68	22.36	0.02	0.03	0.08	0.25	2.00	5.00	10.00	30.00	30.00	120.00	360.00
Solvent-Type Cleaning Fluids or Degreasers	29.48	97.49	0.02	0.03	1.00	2.00	5.00	15.00	30.00	60.00	120.00	300.00	1800.00
Wood Floor and Paneling Cleaners	74.04	128.43	0.02	1.00	5.00	10.00	20.00	30.00	90.00	147.00	240.00	480.00	2700.00
TypeWriter Correction Fluid	7.62	29.66	0.02	0.02	0.03	0.03	0.17	1.00	2.00	10.00	32.00	120.00	480.00
Adhesives	15.58	81.80	0.02	0.03	0.08	0.33	1.00	4.25	10.00	30.00	60.00	180.00	2880.00
Adhesive Removers	121.20	171.63	0.03	0.03	1.45	3.00	15.00	60.00	120.00	246.00	480.00	960.00	960.00
Silicone Lubricants	10.42	29.47	0.02	0.03	0.08	0.17	0.50	2.00	10.00	20.00	45.00	180.00	360.00
Other Lubricants (excluding Automotive)	8.12	32.20	0.02	0.03	0.05	0.08	0.50	2.00	5.00	15.00	30.00	90.00	900.00
Specialized Electronic Cleaners (for TVs, Etc.)	9.47	45.35	0.02	0.03	0.08	0.17	0.50	2.00	5.00	20.00	30.00	93.60	900.00
Latex Paint	295.08	476.11	0.02	1.00	22.50	30.00	90.00	180.00	360.00	480.00	810.00	2880.00	5760.00
Oil Paint	194.12	345.68	0.02	0.51	15.00	30.00	60.00	12.00	240.00	480.00	579.00	1702.80	5760.00
Wood Stains, Varnishes, and Finishes	117.17	193.05	0.02	0.74	5.00	10.00	30.00	60.00	120.00	140.00	360.00	720.00	280.00
Paint Removers/Strippers	125.27	286.59	0.02	0.38	5.00	5.00	20.00	60.00	120.00	240.00	420.00	1200.00	4320.00
Paint Thinners	39.43	114.85	0.02	0.08	1.00	2.00	5.00	10.00	30.00	60.00	180.00	480.00	2400.00
Aerosol Spray Paint	39.54	87.79	0.02	0.17	2.00	5.00	10.00	20.00	45.00	60.00	120.00	300.00	1800.00
Primers and Special Primers	91.29	175.05	0.05	0.24	3.00	5.00	15.00	30.00	120.00	240.00	360.00	981.60	1920.00
Aerosol Rust Removers	18.57	48.54	0.02	0.05	0.17	0.25	2.00	5.00	20.00	60.00	60.00	130.20	720.00
Outdoor Water Repellents	104.94	115.36	0.02	0.05	5.00	15.00	30.00	60.00	120.00	240.00	300.00	480.00	960.00
(for Wood or Cement)	29.45	48.16	0.03	0.14	2.00	3.00	5.00	15.00	30.00	60.00	96.00	268.80	360.00
Glass Frostings, Window Tints, and Artificial Snow	29.29	48.14	0.02	0.95	2.00	5.00	10.00	15.00	30.00	60.00	120.00	180.00	900.00
Engine Degreasers, Carburetor Cleaners	13.57	23.00	0.02	0.08	0.33	1.00	3.00	7.00	15.00	30.00	45.00	120.00	300.00
Aerosol Spray Paints for Cars	42.77	71.39	0.03	0.19	1.00	3.00	10.00	20.00	60.00	120.00	145.00	360.00	900.00
Auto Spray Primers	51.45	86.11	0.05	0.22	2.00	5.00	10.00	27.50	60.00	120.00	180.00	529.20	600.00
Spray Lubricant for Cars	9.90	35.62	0.02	0.03	0.08	0.17	1.00	5.00	10.00	15.00	30.00	120.00	720.00
Transmission Cleaners	27.90	61.44	0.17	NA	0.35	1.80	5.00	15.00	30.00	60.00	60.00	NA	450.00
Battery Terminal Protectors	9.61	18.15	0.03	0.04	0.08	0.23	1.00	5.00	10.00	20.00	30.00	120.00	180.00
Brake Quieters/Cleaners	23.38	36.32	0.07	NA	0.50	1.00	5.00	15.00	30.00	49.50	120.00	NA	240.00
Gasket Remover	23.57	27.18	0.33	NA	0.50	2.00	6.25	15.00	30.00	60.00	60.00	NA	180.00
Tire/Hubcap Cleaners	22.66	23.94	0.08	0.71	3.00	5.00	10.00	15.00	30.00	60.00	60.00	120.00	240.00
Ignition and Wire Dryers	7.24	8.48	0.02	0.02	0.08	0.47	1.50	5.00	10.00	15.00	25.50	48.60	60.00

NA = Not Available

Source: Westat, 1987a

Table 15-4. Amount of Products Used For Household Solvent Products

Products	Mean (ounces/yr)	Std. dev	Min.	1	5	10	25	50	75	90	95	99	Max.
			Percentile Rankings for Amount of Products Used (ounces/yr)										
Spray Shoe Polish	9.90	17.90	0.04	0.20	0.63	1.00	2.00	4.50	10.00	24.00	36.00	99.36	180.00
Water Repellents/Protectors	11.38	22.00	0.04	0.47	0.98	1.43	2.75	6.00	12.00	24.00	33.00	121.84	450.00
Spot Removers	26.32	90.10	0.01	0.24	0.60	1.00	2.00	5.50	16.00	48.00	119.20	384.00	1600.00
Solvent-Type Cleaning Fluids or Degreasers	58.30	226.97	0.04	0.50	2.00	3.00	6.50	16.00	32.00	96.00	192.00	845.00	5120.00
Wood Floor and Paneling Cleaners	28.41	57.23	0.03	0.80	2.45	3.50	7.00	14.00	30.00	64.00	96.00	204.40	1144.00
TypeWriter Correction Fluid	4.14	13.72	0.01	0.02	0.06	0.12	0.30	0.94	2.40	8.00	18.00	67.44	181.80
Adhesives	7.49	55.90	0.01	0.02	0.05	0.12	0.35	1.00	3.00	8.00	20.00	128.00	1280.00
Adhesive Removers	34.46	96.60	0.25	0.29	1.22	2.80	6.00	10.88	32.00	64.00	138.70	665.60	1024.00
Silicone Lubricants	12.50	27.85	0.02	0.20	0.69	1.00	2.25	4.50	12.00	24.00	41.20	192.00	312.00
Other Lubricants (excluding Automotive)	9.93	44.18	0.01	0.18	0.30	0.52	1.00	2.25	8.00	18.00	32.00	128.00	1280.00
Specialized Electronic Cleaners (for TVs, Etc.)	9.48	55.26	0.01	0.05	0.13	0.25	0.52	2.00	6.00	12.65	24.00	109.84	1024.00
Latex Paint	371.27	543.86	0.03	4.00	12.92	32.00	64.00	256.00	384.00	857.60	1280.00	2560.00	6400.00
Oil Paint	168.92	367.82	0.02	0.33	4.00	8.00	25.20	64.00	148.48	384.00	640.00	1532.16	5120.00
Wood Stains, Varnishes, and Finishes	65.06	174.01	0.12	1.09	4.00	4.00	8.00	16.00	64.00	128.00	256.00	768.00	3840.00
Paint Removers/Strippers	63.73	144.33	0.64	1.50	4.00	8.00	16.00	32.00	64.00	128.00	256.00	512.00	2560.00
Paint Thinners	69.45	190.55	0.03	0.45	3.10	4.00	8.00	20.48	64.00	128.00	256.00	640.00	3200.00
Aerosol Spray Paint	30.75	52.84	0.02	0.75	2.01	3.25	7.00	13.00	32.00	65.00	104.00	240.00	1053.00
Primers and Special Primers	68.39	171.21	0.01	0.09	1.30	3.23	8.00	16.00	60.00	128.00	256.00	867.75	1920.00
Aerosol Rust Removers	18.21	81.37	0.09	0.25	1.00	1.43	2.75	8.00	13.00	32.00	42.60	199.80	1280.00
Outdoor Water Repellents (for Wood or Cement)	148.71	280.65	0.01	0.37	3.63	8.00	16.00	64.00	128.00	448.00	640.00	979.20	3200.00
Glass Frostings, Window Tints, and Artificial Snow	13.82	14.91	1.00	1.40	2.38	3.25	6.00	12.00	14.00	28.00	33.00	98.40	120.00
Engine Degreasers	46.95	135.17	0.04	1.56	4.00	6.00	12.00	16.00	36.00	80.00	160.00	480.00	2560.00
Carburetor Cleaners	22.00	50.60	0.10	0.50	1.50	3.00	5.22	12.00	16.00	39.00	75.00	212.00	672.00
Aerosol Spray Paints for Cars	44.95	89.78	0.04	0.14	1.50	3.00	6.12	16.00	48.00	100.80	156.00	557.76	900.00
Auto Spray Primers	70.37	274.56	0.12	0.77	3.00	4.00	9.00	16.00	48.00	128.00	222.00	1167.36	3840.00
Spray Lubricant for Cars	18.63	54.74	0.08	0.40	0.96	1.00	2.75	6.00	15.50	36.00	64.00	240.00	864.00
Transmission Cleaners	35.71	62.93	2.00	NA	3.75	4.00	8.00	15.00	32.00	77.00	140.00	NA	360.00
Battery Terminal Protectors	16.49	87.84	0.12	0.13	0.58	1.00	2.00	4.00	8.00	15.00	24.60	627.00	1050.00
Brake Quieters/Cleaners	11.72	13.25	0.50	NA	1.00	2.00	3.02	8.00	14.25	32.00	38.60	NA	78.00
Gasket Remover	13.25	22.35	0.50	NA	1.00	1.00	3.75	7.75	16.00	24.00	58.40	NA	160.00
Tire/Hubcap Cleaners	31.58	80.39	0.12	0.50	1.82	3.00	6.00	12.00	28.00	64.00	96.00	443.52	960.00
Ignition and Wire Dryers	9.02	14.59	0.13	0.32	1.09	1.50	3.00	6.00	10.75	16.00	20.55	113.04	120.00

NA = Not Available
Source: Westat, 1987a

Table 15-5. Time Exposed After Duration of Use For Household Solvent Products

Products	Mean (mins)	Std. dev.	Percentile Rankings for Time Exposed After Duration of Use (mins) Min.	1	5	10	25	50	75	90	95	99	Max.
Spray Shoe Polish	31.40	80.50	0.00	0.00	0.00	0.00	0.00	5.00	20.00	120.00	120.00	480.00	720.00
Water Repellents/Protectors	37.95	111.40	0.00	0.00	0.00	0.00	0.00	3.00	20.00	120.00	240.00	480.00	1800.00
Spot Removers	43.65	106.97	0.00	0.00	0.00	0.00	1.00	5,.00	30.00	120.00	240.00	480.00	1440.00
Solvent-Type Cleaning Fluids or Degreasers	33.29	90.39	0.00	0.00	0.00	0.00	0.00	3.00	28.75	60.00	180.00	480.00	1440.00
Wood Floor and Paneling Cleaners	96.75	192.88	0.00	0.00	0.00	0.00	5.00	30.00	120.00	240.00	480.00	1062.00	1440.00
TypeWriter Correction Fluid	124.70	153.46	0.00	0.00	1.00	5.00	30.00	60.00	180.00	360.00	480.00	600.00	1800.00
Adhesives	68.88	163.72	0.00	0.00	0.00	0.00	1.00	10.00	60.00	180.00	360.00	720.00	2100.00
Adhesive Removers	94.12	157.69	0.00	0.00	0.00	0.00	1.75	20.00	120.00	360.00	480.00	720.00	720.00
Silicone Lubricants	30.77	107.39	0.00	0.00	0.00	0.00	0.00	0.00	10.00	60.00	180.00	480.00	1440.00
Other Lubricants (excluding Automotive)	47.45	127.11	0.00	0.00	0.00	0.00	0.00	2.00	30.00	120.00	240.00	485.40	1440.00
Specialized Electronic Cleaners (for TVs, Etc.)	117.24	154.38	0.00	0.00	0.00	1.00	10.00	60.00	180.00	300.00	480.00	720.00	1440.00
Latex Paint	91.38	254.61	0.00	0.00	0.00	0.00	0.00	5.00	60.00	240.00	480.00	1440.00	2880.00
Oil Paint	44.56	155.19	0.00	0.00	0.00	0.00	0.00	0.00	30.00	120.00	240.00	480.00	2880.00
Wood Stains, Varnishes, and Finishes	48.33	156.44	0.00	0.00	0.00	0.00	0.00	1.00	30.00	120.00	240.00	694.00	2880.00
Paint Removers/Strippers	31.38	103.07	0.00	0.00	0.00	0.00	0.00	0.00	20.00	60.00	180.00	541.20	1440.00
Paint Thinners	32.86	105.62	0.00	0.00	0.00	0.00	0.00	0.00	15.00	60.00	180.00	480.00	1440.00
Aerosol Spray Paint	12.70	62.80	0.00	0.00	0.00	0.00	0.00	0.00	1.00	30.00	60.00	260.50	1440.00
Primers and Special Primers	22.28	65.57	0.00	0.00	0.00	0.00	0.00	0.00	10.00	60.00	120.00	319.20	720.00
Aerosol Rust Removers	15.06	47.58	0.00	0.00	0.00	0.00	0.00	0.00	5.00	60.00	60.00	190.20	600.00
Outdoor Water Repellents (for Wood or Cement)	8.33	43.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	58.50	309.60	420.00
Glass Frostings, Window Tints, and Artificial Snow	137.87	243.21	0.00	0.00	0.00	0.00	3.00	60.00	180.00	360.00	480.00	1440.00	1800.00
Engine Degreasers	4.52	24.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.50	120.00	360.00
Carburetor Cleaners	7.51	68.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	30.00	120.60	1800.00
Aerosol Spray Paints for Cars	10.71	45.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.50	60.00	282.00	480.00
Auto Spray Primers	11.37	45.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	77.25	360.00	360.00
Spray Lubricant for Cars	4.54	30.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	15.00	70.20	420.00
Transmission Cleaners	5.29	29.50	0.00	NA	0.00	0.00	0.00	0.00	0.00	5.00	22.50	NA	240.00
Battery Terminal Protectors	3.25	17.27	0.00	NA	0.00	0.00	0.00	0.00	0.00	2.90	15.00	120.00	180.00
Brake Quieters/Cleaners	10.27	30.02	0.00	NA	0.00	0.00	0.00	0.00	0.00	30.00	120.00	NA	120.00
Gasket Remover	27.56	58.54	0.00	NA	0.00	0.00	0.00	0.00	12.50	120.00	180.00	NA	240.00
Tire/Hubcap Cleaners	1.51	20.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00	480.00
Ignition and Wire Dryers	6.39	31.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	30.00	216.60	240.00

NA = Not Available
Source: Westat, 1987a

Table 15-6. Frequency of Use and Amount of Product Used for Adhesive Removers						
	No. of Times Used Within the Last 12 Months N=58	Minutes Using N=52	Minutes in Room After Using[a] N=51	Minutes in Room After Using[b] N=5	Amount Used in Past Year (Fluid oz.) N=51	Amount per Use (Fluid oz.) N=51
Mean	1.66	172.87	13.79	143.37	96.95	81.84
Standard deviation	1.67	304.50	67.40	169.31	213.20	210.44
Minimum Value	1.00	5.00	0.00	5.00	13.00	5.20
1st Percentile	1.00	5.00	0.00	5.00	13.00	5.20
5th Percentile	1.00	10.00	0.00	5.00	13.00	6.50
10th Percentile	1.00	15.00	0.00	5.00	16.00	10.67
25th Percentile	1.00	29.50	0.00	20.00	16.00	16.00
Median Value	1.00	120.00	0.00	120.00	32.00	26.00
75th Percentile	2.00	240.00	0.00	420.00	96.00	64.00
90th Percentile	3.00	480.00	0.00	420.00	128.00	128.00
95th Percentile	5.00	1440.00	120.00	420.00	384.00	192.00
99th Percentile	12.00	1440.00	420.00	420.00	1280.00	1280.00
Maximum Value	12.00	1440.00	420.00	1440.00	1280.00	1280.00

[a] Includes those who did not spend anytime in the room after use.
[b] Includes only those who spent time in the room.
Source: CPSC, 1992.

Table 15-7. Adhesive Remover Usage by Gender		
	Gender	
	Male N=25	Female N=33
Mean number of months since last time adhesive remover was used - includes all respondents. (Unweighted N=240)	35.33	43.89
Mean number of uses of product in the past year.	1.94	1.30
Mean number of minutes spent with the product during last use.	127.95	233.43
Mean number of minutes spent in the room after last use of product. (Includes all recent users)	19.76	0
Mean number of minutes spent in the room after last use of product. (Includes only those who did not leave immediately)	143.37	0
Mean ounces of product used in the past year.	70.48	139.71
Mean ounces of product used per use in the past year.	48.70	130.36

Source: CPSC, 1992.

Table 15-8. Frequency of Use and Amount of Product Used for Spray Paint						
	No. of Times Used Within the Last 12 Months N=775	Minutes Using N=786	Minutes in Room After Using[a] N=791	Minutes in Room After Using[b] N=35	Amount Used in Past Year (Fluid oz.) N=778	Amount per Use (Fluid oz.) N=778
Mean	8.23	40.87	3.55	65.06	83.92	19.04
Standard deviation	31.98	71.71	22.03	70.02	175.32	25.34
Minimum Value	1.00	1.00	0.00	1.00	13.00	0.36
1st Percentile	1.00	1.00	0.00	1.00	13.00	0.36
5th Percentile	1.00	3.00	0.00	1.00	13.00	3.47
10th Percentile	1.00	5.00	0.00	10.00	13.00	6.50
25th Percentile	1.00	10.00	0.00	15.00	13.00	9.75
Median Value	2.00	20.00	0.00	30.00	26.00	13.00
75th Percentile	4.00	45.00	0.00	60.00	65.00	21.67
90th Percentile	11.00	90.00	0.00	120.00	156.00	36.11
95th Percentile	20.00	120.00	0.00	120.00	260.00	52.00
99th Percentile	104.00	360.00	120.00	300.00	1170.00	104.00
Maximum Value	365.00	960.00	300.00	300.00	1664.00	312.00

[a] Includes those who did not spend anytime in the room after use.
[b] Includes only those who spent time in the room.
Source: CPSC, 1992.

Table 15-9. Spray Paint Usage by Gender		
	Gender	
	Male N=405	Female N=386
Mean number of months since last time spray paint was used - includes all respondents. (Unweighted N=1724)	17.39	26.46
Mean number of uses of product in the past year.	10.45	4.63
Mean number of minutes spent with the product during last use.	40.87	40.88
Mean number of minutes spent in the room after last use of product. (Includes all recent users)	5.49	0.40
Mean number of minutes spent in the room after last use of product. (Includes only those who did not leave immediately)	67.76	34.69
Mean ounces of product used in the past year.	103.07	59.99
Mean ounces of product used per use in the past year.	18.50	19.92

Source: CPSC, 1992.

Table 15-10. Frequency of Use and Amount of Product Used for Paint Removers/Strippers

	No. of Times Used Within the Last 12 Months N=316	Minutes Using N=390	Minutes in Room After Using[a] N=390	Minutes in Room After Using[b] N=39	Amount Used in Past Year (Fluid oz.) N=307	Amount per Use (Fluid oz.) N=307
Mean	3.54	144.59	12.96	93.88	142.05	64.84
Standard deviation	7.32	175.54	85.07	211.71	321.73	157.50
Minimum Value	1.00	2.00	0.00	1.00	15.00	0.35
1st Percentile	1.00	5.00	0.00	1.00	15.00	2.67
5th Percentile	1.00	15.00	0.00	1.00	16.00	8.00
10th Percentile	1.00	20.00	0.00	3.00	16.00	10.67
25th Percentile	1.00	45.00	0.00	10.00	32.00	16.00
Median Value	2.00	120.00	0.00	60.00	64.00	32.00
75th Percentile	3.00	180.00	0.00	120.00	128.00	64.00
90th Percentile	6.00	360.00	10.00	180.00	256.00	128.00
95th Percentile	12.00	480.00	60.00	420.00	384.00	192.00
99th Percentile	50.00	720.00	180.00	1440.00	1920.00	320.00
Maximum Value	70.00	1440.00	1440.00	1440.00	3200.00	2560.00

[a] Includes those who did not spend anytime in the room after use.
[b] Includes only those who spent time in the room.
Source: CPSC, 1992.

Table 15-11. Paint Stripper Usage by Gender

	Gender	
	Male N=156	Female N=162
Mean number of months since last time paint stripper was used - includes all respondents. (Unweighted N=1724)	32.07	47.63
Mean number of uses of product in the past year.	3.88	3.01
Mean number of minutes spent with the product during last use.	136.70	156.85
Mean number of minutes spent in the room after last use of product. (Includes all recent users)	15.07	9.80
Mean number of minutes spent in the room after last use of product. (Includes only those who did not leave immediately)	101.42	80.15
Mean ounces of product used in the past year.	160.27	114.05
Mean ounces of product used per use in the past year.	74.32	50.29

Source: CPSC, 1992.

Table 15-12. Total Exposure Time of Performing Task and Product Type Used by Task For Household Cleaning Products

Tasks	Mean (hrs/year)	Median (hrs/year)	Product Type Used	Percent of Preference
Clean Bathroom Sinks and Tubs	44	26	Liquid	29%
			Powder	44%
			Aerosol	16%
			Spray pump	10%
			Other	1%
Clean Kitchen Sinks	41	18	Liquid	31%
			Powder	61%
			Aerosol	2%
			Spray pump	4%
			Other	2%
Clean Inside of Cabinets (such as kitchen)	12	5	Liquid	68%
			Powder	12%
			Aerosol	2%
			Spray pump	16%
			Other	2%
Clean Outside of Cabinets	21	6	Liquid	61%
			Powder	8%
			Aerosol	16%
			Spray pump	13%
			Other	2%
Wipe Off Kitchen Counters	92	55	Liquid	67%
			Powder	13%
			Aerosol	2%
			Spray pump	15%
			Other	3%
Thoroughly Clean Counters	24	13	Liquid	56%
			Powder	21%
			Aerosol	5%
			Spray pump	17%
			Other	1%
Clean Bathroom Floors	20	9	Liquid	70%
			Powder	21%
			Aerosol	2%
			Spray pump	4%
			Other	3%
Clean Kitchen Floors	31	14	Liquid	70%
			Powder	27%
			Aerosol	2%
			Spray pump	1%
			Other	--
Clean Bathroom or Other Tilted or Ceramic Walls	16	9	Liquid	37%
			Powder	18%
			Aerosol	17%
			Spray pump	25%
			Other	3%

Table 15-12. Total Exposure Time of Performing Task and Product Type Used by Task For Household Cleaning Products (continued)				
Tasks	Mean (hrs/year)	Median (hrs/year)	Product Type Used	Percent of Preference
Clean Outside of Windows	13	6	Liquid	27%
			Powder	2%
			Aerosol	6%
			Spray pump	65%
			Other	--
Clean Inside of Windows	18	6	Liquid	24%
			Powder	1%
			Aerosol	8%
			Spray pump	66%
			Other	2%
Clean Glass Surfaces Such as Mirrors & Tables	34	13	Liquid	13%
			Powder	1%
			Aerosol	8%
			Spray pump	76%
			Other	2%
Clean Outside of Refrigerator and Other Appliances	27	13	Liquid	48%
			Powder	3%
			Aerosol	7%
			Spray pump	38%
			Other	4%
Clean Spots or Dirt on Walls or Doors Finishes	19	8	Liquid	46%
			Powder	15%
			Aerosol	4%
			Spray pump	30%
			Other	4%

Source: Westat, 1987b.

Table 15-13. Percentile Rankings for Total Exposure Time in Performing Household Tasks								
	Percentile Rankings for Total Exposure Exposure Time Performing Task (hrs/yr)							
Tasks	100th	95th	90th	75th	50th	25th	10th	0th
Clean Bathroom Sinks and Tubs	365	121.67	91.25	52	26	13	5.2	0.4
Clean Kitchen Sinks	547.5	121.67	97.6	60.83	18.25	8.67	3.47	0.33
Clean Inside of Kitchen Cabinets	208	48	32.48	12	4.75	2	1	0.17
Clean Outside of Cabinets	780	78.66	36	17.33	6	2	0.967	0.07
Wipe Off Kitchen Counters	912.5	456.25	231.16	91.25	54.75	24.33	12.17	1.2
Thoroughly Clean Counters	547.5	94.43	52	26	13	6	1.75	0.17
Clean Bathroom Floors	365	71.49	36.83	26	8.67	4.33	2	0.1
Clean Kitchen Floors	730	96.98	52	26	14	8.67	4.33	0.5
Clean Bathroom or Other Tilted or Ceramic Walls	208	52	36	26	8.67	3	1	0.17
Clean Outside of Windows	468	32.6	24	11.5	6	2	1.5	0.07
Clean Inside of Windows	273	72	36	19.5	6	3	1.15	0.07
Clean Glass Surfaces Such as Mirrors & Tables	1460	104	60.83	26	13	6	1.73	0.17
Clean Outside Refrigerator and Other Appliances	365	95.29	91.25	30.42	13	4.33	1.81	0.1
Clean Spots or Dirt on Walls or Doors	312	78	52	24	8	2	0.568	0.07

Source: Westat, 1987b.

Table 15-14. Mean Percentile Rankings for Frequency of Performing Household Tasks									
Tasks	Mean	Percentile Rankings							
		0th	10th	25th	50th	75th	90th	95th	100th
Clean bathroom sinks and tubs	3 x/week	0.2 x/week	1 x/week	1 x/week	2 x/week	3.5 x/week	7 x/week	7 x/week	42 x/week
Clean kitchen sinks	7 x/week	0 x/week	1 x/week	2 x/week	7 x/week	7 x/week	15 x/week	21 x/week	28 x/week
Clean inside of cabinets such as those in the kitchen	9 x/year	1 x/year	1 x/year	1 x/year	2 x/year	12 x/year	12 x/year	52 x/year	156 x/year
Clean outside of cabinets	3 x/month	0.1 x/month	0.1 x/month	0.3 x/month	1 x/month	4 x/month	4 x/month	22 x/month	30 x/month
Wipe off counters such as those in the kitchen	2 x/day	0 x/day	0.4 x/day	1 x/day	1 x/day	3 x/day	4 x/day	6 x/day	16 x/day
Thoroughly clean counters	8 x/month	0.1 x/month	0.8 x/month	1 x/month	4 x/month	4 x/month	30 x/month	30 x/month	183 x/month
Clean bathroom floors	6 x/month	0.2 x/month	1 x/month	2 x/month	4 x/month	4 x/month	13 x/month	30 x/month	30 x/month
Clean kitchen floors	6 x/month	0.1 x/month	1 x/month	2 x/month	4 x/month	4 x/month	13 x/month	30 x/month	30 x/month
Clean bathroom or other tiled or ceramic walls	4 x/month	0.1 x/month	0.2 x/month	1 x/month	2 x/month	4 x/month	9 x/month	13 x/month	30 x/month
Clean outside of windows	5 x/year	1 x/year	1 x/year	1 x/year	2 x/year	4 x/year	12 x/year	12 x/year	156 x/year
Clean inside of windows	10 x/year	1 x/year	1 x/year	2 x/year	4 x/year	12 x/year	24 x/year	52 x/year	156 x/year
Clean other glass surfaces such as mirrors and tables	7 x/month	0.1 x/month	1 x/month	2 x/month	4 x/month	4 x/month	17 x/month	30 x/month	61 x/month
Clean outside of refrigerator and other appliances	10 x/month	0.2 x/month	1 x/month	2 x/month	4 x/month	13 x/month	30 x/month	30 x/month	61 x/month
Clean spots or dirt on walls or doors	6 x/month	0.1 x/month	0.2 x/month	0.3 x/month	1 x/month	4 x/month	13 x/month	30 x/month	152 x/month

Source: Westat, 1987b.

Table 15-15. Mean and Percentile Rankings for Exposure Time Per Event of Performing Household Tasks									
		Percentile Rankings (minutes/event)							
Tasks	Mean (minutes/event)	0th	10th	25th	50th	75th	90th	95th	100th
Clean bathroom sinks and tubs	20	1	5	10	15	30	45	60	90
Clean kitchen sinks	10	1	2	3	5	10	15	20	480
Clean inside of cabinets such as those in the kitchen	137	5	24	44	120	180	240	360	2,880
Clean outside of cabinets	52	1	5	15	30	60	120	180	330
Wipe off counters such as those in the kitchen	9	1	2	3	5	10	15	30	120
Thoroughly clean counters	25	1	5	10	15	30	60	90	180
Clean bathroom floors	16	1	5	10	15	20	30	38	60
Clean kitchen floors	30	2	10	15	20	30	60	60	180
Clean bathroom or other tiled or ceramic walls	34	1	5	15	30	45	60	120	240
Clean outside of windows	180	4	30	60	120	240	420	480	1,200
Clean inside of windows	127	4	20	45	90	158	300	381	1,200
Clean other glass surfaces such as mirrors and tables	24	1	5	10	15	30	60	60	180
Clean outside of refrigerator and other appliances	19	1	4	5	10	20	30	45	240
Clean spots or dirt on walls or doors	50	1	5	10	20	60	120	216	960

Source: Westat, 1987b.

Table 15-16. Total Exposure Time for Ten Product Groups Most Frequently Used For Household Cleaning[a]

Products	Mean (hrs/yr)	Percentile Rankings of Total Exposure Time (hrs/yr)							
		0th	10th	25th	50th	75th	90th	95th	100th
Dish Detergents	107	0.2	6	24	56	134	274	486	941
Glass Cleaners	67	0.4	3	12	29	62	139	260	1,508
Floor Cleaners	52	0.7	4	7	22	52	102	414	449
Furniture Polish	32	0.1	0.3	1	12	36	101	215	243
Bathroom Tile Cleaners	47	0.5	2	8	17	48	115	287	369
Liquid Cleansers	68	0.2	2	9	22	52	122	215	2,381
Scouring Powders	78	0.3	9	17	35	92	165	281	747
Laundry Detergents	66	0.6	8	14	48	103	174	202	202
Rug Cleaners/Shampoos	12	0.3	0.3	0.3	9	26	26	26	26
All Purpose Cleaners	64	0.3	4	9	26	77	174	262	677

[a] The data in Table 15-15 above reflect for only the 14 tasks included in the survey. Therefore, many of the durations reported in the table underestimate the hours of the use of the product group. For example, use of dish detergents to wash dishes is not included.

Source: Westat, 1987b.

Table 15-17. Total Exposure Time of Painting Activity of Interior Painters (hrs)										
Types of Paint	Mean (hrs)	Std. dev.	Percentile Rankings for Duration of Painting Activity (hrs)							
			Min.	10	25	50	75	90	95	Max.
Latex	12.2	11.28	1	3	4	9	15	24	40	248
Oil-based	10.68	15.56	1	1.6	3	6	10	21.6	65.6	72
Wood Stains and Varnishes	8.57	10.85	1	1	2	4	9.3	24	40	42

Source: Westat, 1987c.

Table 15-18. Exposure Time of Interior Painting Activity/Occasion (hrs) and Frequency of Occasions Spent Painting Per Year												
Types of Paint	Duration of Painting/Occasion (hrs)		Frequency of Occasions Spent Painting/Year		Percentile Rankings for Frequency of Occasions Spent Painting							
	Mean	Median	Mean	Std. dev.	Min	10	25	50	75	90	95	Max.
Latex	2.97	3	4.16	5.54	1	1	2	3	4	9	10	62
Oil-based	2.14	3	5.06	11.98	1	1	1	2	4	8	26	72
Wood Stains and Varnishes	2.15	2	4.02	4.89	1	1	1	2	4	9	20	20

Source: Westat, 1987c.

Table 15-19. Amount of Paint Used by Interior Painters												
Types of Paint	Median (gallons)	Mean (gallons)	Std. dev.	Percentile Rankings for Amount of Paint Used (gallons)								
				Min	10	25	50	75	90	95	Max.
Latex	3.0	3.89	4.56	0.13	1	2	3	5	8	10	50
Oil-based	2.0	2.55	3.03	0.13	0.25	0.5	2	3	7	12	12
Wood Stains and Varnishes	0.75	0.88	0.81	0.13	0.14	0.25	0.75	1	2	2	4.25

Source: Westat, 1987c.

Table 15-20. Number of Cans or Bottles of Carbonate Soft Drink Consumed by the Respondent

		CAN-BOTTLE CARBONATED DRINKS RES DRANK							
		.	0:NONE	1:1-2	2:3-5	3:6-9	4:10-19	5:20+	8:DK
	ALL	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.
	N	N	N	N	N	N	N	N	N
OVERALL	4663	35	2181	1720	568	100	28	4	27
----- GENDER ------									
1:MALE	2163	16	950	804	308	56	16	1	12
2:FEMALE	2498	19	1230	915	260	44	12	3	15
9:REF	2	.	1	1	.	.	.	.	.
------ AGE -------									
.	84	6	48	19	6	2	.	.	3
1:1-4	263	.	194	59	7	1	.	.	2
2:5-11	348	1	169	152	20	.	1	.	5
3:12-17	326	3	88	160	61	7	3	1	3
4:18-64	2972	17	1218	1159	457	87	23	3	8
5:> 64	670	8	464	171	17	3	1	.	6
------ RACE -------									
1:WHITE	3774	20	1760	1398	475	80	20	2	19
2:BLACK	463	6	212	177	50	10	5	2	1
3:ASIAN	77	1	48	25	3	.	.	.	.
4:SOME OTHERS	96	.	58	27	8	1	1	.	1
5:HISPANIC	193	1	81	75	27	7	1	.	1
9:REF	60	7	22	18	5	2	1	.	5
----- HISPANIC ----									
0:NO	4244	26	2004	1561	517	88	25	4	19
1:YES	347	2	148	140	42	11	2	.	2
8:DK	26	.	13	8	4	.	.	.	1
9:REF	46	7	16	11	5	1	1	.	5
--- EMPLOYMENT ----									
.	926	4	448	369	84	6	4	1	10
1:FULL TIME	2017	11	788	814	317	64	18	2	3
2:PART TIME	379	.	160	156	52	9	1	.	1
3:NOT EMPLOYED	1309	16	768	375	114	21	5	1	9
9:REF	32	4	17	6	1	.	.	.	4
--- EDUCATION ----									
.	1021	11	484	397	98	9	4	1	17
1:< HIGH SCHOOL	399	2	221	120	39	12	3	.	2
2:HIGH SCHOOL GRAD	1253	11	548	459	190	29	9	1	6
3:< COLLEGE	895	2	438	308	104	32	9	1	1
4:COLLEGE GRAD.	650	6	294	256	83	8	2	1	.
5:POST GRAD.	445	3	196	180	54	10	1	.	1
-- CENSUS REGION --									
1:NORTHEAST	1048	8	559	345	106	21	5	1	3
2:MIDWEST	1036	5	446	405	133	30	10	1	6
3:SOUTH	1601	13	691	621	220	35	10	.	11
4:WEST	978	9	485	349	109	14	3	2	7
--- DAY 0F WEEK ---									
1:WEEKDAY	3156	31	1475	1183	367	64	18	2	16
2:WEEKEND	1507	4	706	537	201	36	10	2	11
------ SEASON -----									
1:WINTER	1264	5	593	477	144	31	9	2	3
2:SPRING	1181	13	548	432	149	27	7	1	4
3:SUMMER	1275	13	574	475	158	30	8	.	17
4:FALL	943	4	466	336	117	12	4	1	3
------ ASTHMA -----									
0:NO	4287	27	2008	1585	529	90	25	3	20
1:YES	341	1	159	129	37	9	3	1	2
8:DK	35	7	14	6	2	1	.	.	5
------ ANGINA -----									
0:NO	4500	27	2086	1681	556	97	28	4	21
1:YES	125	2	80	33	8	1	.	.	1
8:DK	38	6	15	6	4	2	.	.	5
-- BRONCH/EMPHYS --									
0:NO	4424	26	2063	1644	546	95	26	4	20
1:YES	203	3	106	66	19	5	2	.	2
8:DK	36	6	12	10	3	.	.	.	5

NOTE: . = MISSING DATA; DK = DON'T KNOW; N = SAMPLE SIZE
Source: Tsang and Klepeis, 1996.

Table 15-21. Frequency of Cologne, Perfume, Aftershave or Other Fragrances Used in One Day

		[USE COLOGNE-PERFUME-AFTERSHAVE-FRAGRANCE] HOW MANY TIMES				
		1:1-2	2:3-5	3:6-9	4:10+	8:DK
	ALL	RESP.	RESP.	RESP.	RESP.	RESP.
	N	N	N	N	N	N
OVERALL	2223	2100	113	4	2	4
----- GENDER ------						
1:MALE	912	868	44	.	.	.
2:FEMALE	1311	1232	69	4	2	4
------ AGE -------						
.	33	31	1	1	.	.
2:5-11	26	24	2	.	.	.
3:12-17	144	133	9	.	1	1
4:18-64	1735	1635	93	3	1	3
5:> 64	285	277	8	.	.	.
------ RACE -------						
1:WHITE	1781	1684	91	4	.	2
2:BLACK	242	233	7	.	1	1
3:ASIAN	30	30	.	.	.	.
4:SOME OTHERS	38	35	3	.	.	.
5:HISPANIC	111	98	11	.	1	1
9:REF	21	20	1	.	.	.
----- HISPANIC ----						
0:NO	2012	1909	95	4	1	3
1:YES	182	165	15	.	1	1
8:DK	11	9	2	.	.	.
9:REF	18	17	1	.	.	.
--- EMPLOYMENT ----						
.	157	145	10	.	1	1
1:FULL TIME	1195	1125	67	2	.	1
2:PART TIME	240	228	11	.	1	.
3:NOT EMPLOYED	618	591	23	2	.	2
9:REF	13	11	2	.	.	.
--- EDUCATION ----						
.	208	194	12	.	1	1
1:< HIGH SCHOOL	190	177	13	.	.	.
2:HIGH SCHOOL GRAD	739	704	32	2	.	1
3:< COLLEGE	504	480	21	.	1	2
4:COLLEGE GRAD.	331	308	21	2	.	.
5:POST GRAD.	251	237	14	.	.	.
-- CENSUS REGION --						
1:NORTHEAST	459	434	21	3	.	1
2:MIDWEST	530	502	25	1	.	2
3:SOUTH	813	766	46	.	1	.
4:WEST	421	398	21	.	1	1
--- DAY 0F WEEK ---						
1:WEEKDAY	1480	1402	71	3	.	4
2:WEEKEND	743	698	42	1	2	.
------ SEASON -----						
1:WINTER	604	574	26	1	1	2
2:SPRING	588	549	36	1	1	1
3:SUMMER	568	535	31	2	.	.
4:FALL	463	442	20	.	.	1
------ ASTHMA -----						
0:NO	2075	1959	106	4	2	4
1:YES	143	136	7	.	.	.
8:DK	5	5	.	.	.	.
------ ANGINA -----						
0:NO	2161	2043	108	4	2	4
1:YES	52	47	5	.	.	.
8:DK	10	10	.	.	.	.
-- BRONCH/EMPHYS --						
0:NO	2112	1994	108	4	2	4
1:YES	103	98	5	.	.	.
8:DK	8	8	.	.	.	.

NOTE: . = MISSING DATA; “DK” = DON’T KNOW; % = ROW PERCENTAGE; N = SAMPLE SIZE

Source: Tsang and Klepeis, 1996.

Table 15-22. Frequency of Use of Any Aerosol Spray Product for Personal Care Such as Deodorant or Hair Spray

		[DID SM USE AEROSOL SPRAY PRODUCTS] ABOUT HOW MANY TIMES									
		1	2	3	4	5	6	7	10	11:MORE THAN 10	88:DK
	ALL	RESP.	RESP.	RESP.	RESP.	RESP.	RESP.	RESP.	RESP.	RESP.	RESP.
	N	N	N	N	N	N	N	N	N	N	N
OVERALL	1491	1019	352	57	22	17	2	1	3	10	8
----- GENDER ------											
1:MALE	528	375	125	14	4	3	2	.	.	2	3
2:FEMALE	962	644	226	43	18	14	.	1	3	8	5
9:REF	1	.	1	.	.	.	.	.	.	.	.
------ AGE -------											
.	27	14	8	1	2	1	.	.	.	.	1
1:1-4	40	30	9	.	.	1	.	.	.	.	.
2:5-11	75	57	14	1	1	1	1	.	.	.	.
3:12-17	103	53	31	12	4	1	.	.	1	1	.
4:18-64	1071	724	263	39	15	13	1	1	2	8	5
5:> 64	175	141	27	4	.	.	.	.	.	1	2
------ RACE -------											
1:WHITE	1232	855	285	47	17	8	2	.	3	10	5
2:BLACK	131	84	32	5	3	5	.	.	.	.	2
3:ASIAN	24	18	5	.	.	.	.	.	.	.	1
4:SOME OTHERS	22	12	8	1	.	.	.	1	.	.	.
5:HISPANIC	73	45	19	4	1	4	.	.	.	.	.
9:REF	9	5	3	.	1	.	.	.	.	.	.
----- HISPANIC ----											
0:NO	1359	937	316	49	20	13	2	1	3	10	8
1:YES	119	74	32	7	2	4	.	.	.	.	.
8:DK	6	3	2	1	.	.	.	.	.	.	.
9:REF	7	5	2	.	.	.	.	.	.	.	.
--- EMPLOYMENT ----											
.	210	137	52	11	4	3	1	.	1	1	.
1:FULL TIME	714	492	171	24	11	5	1	1	1	4	4
2:PART TIME	152	99	35	7	.	5	.	.	.	4	2
3:NOT EMPLOYED	404	284	92	14	6	4	.	.	1	1	2
9:REF	11	7	2	1	1	.	.	.	.	.	.
--- EDUCATION ----											
.	240	151	61	14	6	4	1	.	1	2	.
1:< HIGH SCHOOL	128	83	37	2	1	1	.	.	.	2	2
2:HIGH SCHOOL GRAD	528	365	121	23	7	5	1	.	2	1	3
3:< COLLEGE	311	212	77	7	3	6	.	1	.	4	1
4:COLLEGE GRAD.	161	115	34	8	1	1	.	.	.	1	1
5:POST GRAD.	123	93	22	3	4	.	.	.	.	.	1
-- CENSUS REGION --											
1:NORTHEAST	292	201	70	8	8	1	.	.	.	1	3
2:MIDWEST	340	227	85	14	4	3	1	.	1	3	2
3:SOUTH	585	388	148	23	8	8	.	1	2	4	3
4:WEST	274	203	49	12	2	5	1	.	.	2	.
--- DAY OF WEEK ---											
1:WEEKDAY	994	695	220	35	17	12	1	.	1	7	6
2:WEEKEND	497	324	132	22	5	5	1	1	2	3	2
------ SEASON -----											
1:WINTER	381	264	86	15	5	4	.	.	.	4	3
2:SPRING	408	269	104	12	9	9	.	1	1	1	2
3:SUMMER	400	282	86	21	5	2	1	.	.	1	2
4:FALL	302	204	76	9	3	2	1	.	2	4	1
------ ASTHMA -----											
0:NO	1387	950	327	53	20	15	2	1	1	10	8
1:YES	100	66	24	4	2	2	.	.	2	.	.
8:DK	4	3	1	.	.	.	.	.	.	.	.
------ ANGINA -----											
0:NO	1451	990	344	55	22	17	2	1	3	9	8
1:YES	35	26	7	1	.	.	.	.	.	1	.
8:DK	5	3	1	1	.	.	.	.	.	.	.
-- BRONCH/EMPHYS --											
0:NO	1411	972	322	55	22	17	2	1	3	9	8
1:YES	74	44	29	1	.	.	.	.	.	.	.
8:DK	6	3	1	1	.	.	.	.	.	1	.

NOTE: . = MISSING DATA; "DK" = DON'T KNOW; % = ROW PERCENTAGE; N = SAMPLE SIZE

Source: Tsang and Klepeis, 1996.

Table 15-23. Number of Minutes Spent in Activities Working With or Being Near Freshly Applied Paints

			PERCENTILES											
GROUP NAME	**GROUP CODE**	**N**	**1**	**2**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**	**100**
OVERALL		276	0	0	1.0	2.0	15.0	60.0	121.0	121	121	121	121	121
GENDER	1:MALE	145	0	0	1.0	2.0	10.0	48.0	121.0	121	121	121	121	121
GENDER	2:FEMALE	131	0	0	1.0	3.0	15.0	120.0	121.0	121	121	121	121	121
AGE	1:1-4	7	3	3	3.0	3.0	5.0	15.0	121.0	121	121	121	121	121
AGE	2:5-11	12	5	5	5.0	15.0	20.0	45.0	120.0	120	121	121	121	121
AGE	3:12-17	20	0	0	0.5	3.0	8.0	45.0	75.0	121	121	121	121	121
AGE	4:18-64	212	0	0	1.0	2.0	11.0	60.0	121.0	121	121	121	121	121
AGE	5:> 64	20	0	0	0.0	2.5	17.5	90.0	121.0	121	121	121	121	121
RACE	1:WHITE	241	0	0	2.0	4.0	15.0	60.0	121.0	121	121	121	121	121
RACE	2:BLACK	16	0	0	0.0	1.0	2.5	10.0	90.0	121	121	121	121	121
RACE	3:ASIAN	3	20	20	20.0	20.0	20.0	30.0	60.0	60	60	60	60	60
RACE	4:SOME OTHERS	2	10	10	10.0	10.0	10.0	20.0	30.0	30	30	30	30	30
RACE	5:HISPANIC	12	0	0	0.0	1.0	3.5	27.5	120.5	121	121	121	121	121
HISPANIC	0:NO	257	0	0	1.0	3.0	15.0	60.0	121.0	121	121	121	121	121
HISPANIC	1:YES	17	0	0	0.0	1.0	6.0	45.0	121.0	121	121	121	121	121
EMPLOYMENT	1:FULL TIME	145	0	1	2.0	3.0	10.0	60.0	121.0	121	121	121	121	121
EMPLOYMENT	2:PART TIME	31	0	0	0.0	1.0	30.0	60.0	121.0	121	121	121	121	121
EMPLOYMENT	3:NOT EMPLOYED	61	0	0	0.0	2.0	30.0	120.0	121.0	121	121	121	121	121
EDUCATION	1:< HIGH SCHOOL	13	0	0	0.0	1.0	5.0	45.0	121.0	121	121	121	121	121
EDUCATION	2:HIGH SCHOOL GRAD	74	0	1	1.0	5.0	20.0	120.0	121.0	121	121	121	121	121
EDUCATION	3:< COLLEGE	72	0	0	2.0	2.0	12.5	105.0	121.0	121	121	121	121	121
EDUCATION	4:COLLEGE GRAD.	42	0	0	0.0	1.0	6.0	60.0	121.0	121	121	121	121	121
EDUCATION	5:POST GRAD.	30	2	2	3.0	4.5	15.0	30.0	121.0	121	121	121	121	121
CENSUS REGION	1:NORTHEAST	60	0	0	2.0	5.0	25.0	120.0	121.0	121	121	121	121	121
CENSUS REGION	2:MIDWEST	70	0	0	0.0	2.0	10.0	55.0	121.0	121	121	121	121	121
CENSUS REGION	3:SOUTH	90	0	0	1.0	2.0	10.0	47.5	121.0	121	121	121	121	121
CENSUS REGION	4:WEST	56	1	1	1.0	3.0	12.5	75.0	121.0	121	121	121	121	121
DAY OF WEEK	1:WEEKDAY	222	0	0	1.0	2.0	15.0	60.0	121.0	121	121	121	121	121
DAY OF WEEK	2:WEEKEND	54	0	0	0.0	5.0	15.0	45.0	121.0	121	121	121	121	121
SEASON	1:WINTER	67	0	1	2.0	3.0	15.0	60.0	121.0	121	121	121	121	121
SEASON	2:SPRING	74	0	0	1.0	2.0	10.0	30.0	121.0	121	121	121	121	121
SEASON	3:SUMMER	76	0	0	0.0	2.0	13.5	90.0	121.0	121	121	121	121	121
SEASON	4:FALL	59	0	1	2.0	5.0	20.0	120.0	121.0	121	121	121	121	121
ASTHMA	0:NO	257	0	0	1.0	2.0	15.0	60.0	121.0	121	121	121	121	121
ASTHMA	1:YES	19	1	1	1.0	2.0	10.0	45.0	121.0	121	121	121	121	121
ANGINA	0:NO	270	0	0	1.0	2.0	12.0	60.0	121.0	121	121	121	121	121
ANGINA	1:YES	6	45	45	45.0	45.0	60.0	121.0	121.0	121	121	121	121	121
BRONCH/EMPHYS	0:NO	265	0	0	1.0	3.0	15.0	60.0	121.0	121	121	121	121	121
BRONCH/EMPHYS	1:YES	11	0	0	0.0	2.0	5.0	45.0	121.0	121	121	121	121	121

NOTE: . SIGNIFIES MISSING DATA. A VALUE OF "121" FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 120 MINUTES WERE SPENT. DK = RESPONDENTS ANSWERED "DON'T KNOW". REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-25. Number of Minutes Spent in Activities (At Home or Elsewhere) Working With or Near Floorwax, Furniture Wax or Shoe Polish

			PERCENTILES										
GROUP NAME	**GROUP CODE**	**N**	**1**	**2**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**	**100**
OVERALL		325	0	0.0	2	2	5	10.0	30.0	60	121	121	121	121
GENDER	1:MALE	96	0	0.0	1	2	5	11.0	30.0	121	121	121	121	121
GENDER	2:FEMALE	229	0	0.0	2	3	5	10.0	30.0	60	121	121	121	121
AGE	1:1-4	13	0	0.0	0	5	10	15.0	20.0	60	121	121	121	121
AGE	2:5-11	21	0	0.0	2	2	3	5.0	10.0	35	60	120	120	120
AGE	3:12-17	15	0	0.0	0	1	2	10.0	25.0	45	121	121	121	121
AGE	4:18-64	238	0	0.0	2	3	5	15.0	30.0	120	121	121	121	121
AGE	5:> 64	34	0	0.0	0	2	5	10.0	20.0	35	121	121	121	121
RACE	1:WHITE	267	0	0.0	2	2	5	10.0	30.0	60	121	121	121	121
RACE	2:BLACK	32	2	2.0	2	5	5	15.0	30.0	60	121	121	121	121
RACE	3:ASIAN	1	4	4.0	4	4	4	4.0	4.0	4	4	4	4	4
RACE	4:SOME OTHERS	6	0	0.0	0	0	2	22.5	60.0	121	121	121	121	121
RACE	5:HISPANIC	18	1	1.0	1	4	5	12.5	30.0	120	121	121	121	121
HISPANIC	0:NO	291	0	0.0	2	2	5	10.0	30.0	60	121	121	121	121
HISPANIC	1:YES	31	1	1.0	4	5	5	10.0	30.0	90	120	121	121	121
EMPLOYMENT	1:FULL TIME	150	0	0.5	2	3	5	15.0	30.0	121	121	121	121	121
EMPLOYMENT	2:PART TIME	32	3	3.0	5	5	10	15.0	30.0	60	121	121	121	121
EMPLOYMENT	3:NOT EMPLOYED	92	0	0.0	1	2	5	10.0	20.0	60	120	121	121	121
EDUCATION	1:< HIGH SCHOOL	26	2	2.0	3	5	5	10.0	15.0	60	60	60	60	60
EDUCATION	2:HIGH SCHOOL GRAD	115	0	0.0	2	3	5	12.0	30.0	120	121	121	121	121
EDUCATION	3:< COLLEGE	70	0	1.0	2	3	10	15.0	30.0	75	121	121	121	121
EDUCATION	4:COLLEGE GRAD.	29	2	2.0	3	5	7	30.0	60.0	121	121	121	121	121
EDUCATION	5:POST GRAD.	31	0	0.0	0	2	4	10.0	30.0	60	121	121	121	121
CENSUS REGION	1:NORTHEAST	77	0	0.0	2	3	5	10.0	30.0	60	121	121	121	121
CENSUS REGION	2:MIDWEST	70	0	0.0	1	2	5	10.0	25.0	90	121	121	121	121
CENSUS REGION	3:SOUTH	125	0	0.0	2	2	5	10.0	30.0	120	121	121	121	121
CENSUS REGION	4:WEST	53	0	0.0	1	3	5	15.0	30.0	120	121	121	121	121
DAY OF WEEK	1:WEEKDAY	210	0	0.0	2	2	5	10.0	30.0	120	121	121	121	121
DAY OF WEEK	2:WEEKEND	115	0	0.0	2	3	5	10.0	30.0	60	120	121	121	121
SEASON	1:WINTER	92	0	1.0	2	4	7	13.5	30.0	121	121	121	121	121
SEASON	2:SPRING	78	0	0.0	1	2	5	15.0	30.0	60	121	121	121	121
SEASON	3:SUMMER	81	0	0.0	2	2	5	15.0	30.0	120	121	121	121	121
SEASON	4:FALL	74	0	0.0	0	2	5	10.0	15.0	60	121	121	121	121
ASTHMA	0:NO	296	0	0.0	2	2	5	10.0	30.0	60	121	121	121	121
ASTHMA	1:YES	29	0	0.0	0	2	5	15.0	30.0	121	121	121	121	121
ANGINA	0:NO	312	0	0.0	2	2	5	10.0	30.0	60	121	121	121	121
ANGINA	1:YES	12	0	0.0	0	2	4	10.0	12.5	30	121	121	121	121
BRONCH/EMPHYS	0:NO	302	0	0.0	2	2	5	10.0	30.0	90	121	121	121	121
BRONCH/EMPHYS	1:YES	22	0	0.0	2	2	5	10.0	15.0	20	20	121	121	121

NOTE: . SIGNIFIES MISSING DATA. A VALUE OF “121” FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 120 MINUTES WERE SPENT. DK = RESPONDENTS ANSWERED “DON’T KNOW”. REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-26. Number of Minutes Spent in Activities Working With or Being Near Glue

			PERCENTILES											
GROUP NAME	**GROUP CODE**	**N**	**1**	**2**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**	**100**
OVERALL		294	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
GENDER	1:MALE	151	0	0	0	2	5.0	15.0	70	121.0	121	121	121	121
GENDER	2:FEMALE	143	0	0	0	1	5.0	15.0	30	121.0	121	121	121	121
AGE	1:1-4	6	0	0	0	0	30.0	30.0	30	50.0	50	50	50	50
AGE	2:5-11	36	2	2	3	5	5.0	12.5	25	30.0	60	120	120	120
AGE	3:12-17	34	0	0	1	2	5.0	10.0	30	30.0	60	120	120	120
AGE	4:18-64	207	0	0	0	1	5.0	20.0	90	121.0	121	121	121	121
AGE	5:> 64	10	0	0	0	0	0.0	3.5	60	120.5	121	121	121	121
RACE	1:WHITE	241	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
RACE	2:BLACK	28	0	0	0	2	5.0	12.5	45	121.0	121	121	121	121
RACE	3:ASIAN	4	10	10	10	10	12.5	17.5	40	60.0	60	60	60	60
RACE	4:SOME OTHERS	7	1	1	1	1	3.0	30.0	90	120.0	120	120	120	120
RACE	5:HISPANIC	12	5	5	5	5	5.0	27.5	90	121.0	121	121	121	121
HISPANIC	0:NO	260	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
HISPANIC	1:YES	27	3	3	5	5	5.0	30.0	120	121.0	121	121	121	121
EMPLOYMENT	1:FULL TIME	150	0	0	0	1	5.0	20.0	120	121.0	121	121	121	121
EMPLOYMENT	2:PART TIME	24	1	1	2	3	10.0	27.5	90	121.0	121	121	121	121
EMPLOYMENT	3:NOT EMPLOYED	46	0	0	0	0	2.0	10.0	30	121.0	121	121	121	121
EDUCATION	1:< HIGH SCHOOL	11	0	0	0	0	1.0	5.0	10	60.0	121	121	121	121
EDUCATION	2:HIGH SCHOOL GRAD	69	0	0	0	1	5.0	20.0	90	121.0	121	121	121	121
EDUCATION	3:< COLLEGE	66	0	0	0	1	5.0	27.5	121	121.0	121	121	121	121
EDUCATION	4:COLLEGE GRAD.	37	0	0	0	1	5.0	15.0	30	121.0	121	121	121	121
EDUCATION	5:POST GRAD.	32	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
CENSUS REGION	1:NORTHEAST	55	0	0	0	1	5.0	20.0	60	121.0	121	121	121	121
CENSUS REGION	2:MIDWEST	71	0	0	1	2	5.0	15.0	60	121.0	121	121	121	121
CENSUS REGION	3:SOUTH	98	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
CENSUS REGION	4:WEST	70	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
DAY OF WEEK	1:WEEKDAY	228	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
DAY OF WEEK	2:WEEKEND	66	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
SEASON	1:WINTER	85	0	0	0	2	5.0	15.0	45	121.0	121	121	121	121
SEASON	2:SPRING	74	0	0	0	2	5.0	10.0	30	121.0	121	121	121	121
SEASON	3:SUMMER	66	0	0	0	1	10.0	20.0	121	121.0	121	121	121	121
SEASON	4:FALL	69	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
ASTHMA	0:NO	266	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
ASTHMA	1:YES	28	0	0	0	1	5.0	17.5	40	121.0	121	121	121	121
ANGINA	0:NO	290	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
ANGINA	1:YES	3	1	1	1	1	1.0	121.0	121	121.0	121	121	121	121
BRONCH/EMPHYS	0:NO	283	0	0	0	1	5.0	15.0	60	121.0	121	121	121	121
BRONCH/EMPHYS	1:YES	11	1	1	1	1	2.0	30.0	121	121.0	121	121	121	121

NOTE: . SIGNIFIES MISSING DATA. A VALUE OF “121” FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 120 MINUTES WERE SPENT. DK = RESPONDENTS ANSWERED “DON’T KNOW”. REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-27. Number of Minutes Spent in Activities Working with or Near Solvents, Fumes or Strong Smelling chemicals

GROUP NAME	GROUP CODE	N	1	2	5	10	25	50	75	90	95	98	99	100
			PERCENTILES											
OVERALL		495	0	0	0	2.0	5.0	20.0	121.0	121	121	121	121	121
GENDER	1:MALE	258	0	0	1	2.0	5.0	30.0	121.0	121	121	121	121	121
GENDER	2:FEMALE	237	0	0	0	1.0	5.0	15.0	90.0	121	121	121	121	121
AGE	1:1-4	7	0	0	0	0.0	1.0	5.0	60.0	121	121	121	121	121
AGE	2:5-11	16	0	0	0	2.0	5.0	5.0	17.5	45	70	70	70	70
AGE	3:12-17	38	0	0	0	0.0	5.0	10.0	60.0	121	121	121	121	121
AGE	4:18-64	407	0	0	1	2.0	5.0	30.0	121.0	121	121	121	121	121
AGE	5:> 64	21	0	0	0	0.0	2.0	5.0	15.0	121	121	121	121	121
RACE	1:WHITE	413	0	0	0	2.0	5.0	20.0	121.0	121	121	121	121	121
RACE	2:BLACK	40	0	0	1	3.5	9.0	60.0	121.0	121	121	121	121	121
RACE	3:ASIAN	8	5	5	5	5.0	10.0	37.5	120.5	121	121	121	121	121
RACE	4:SOME OTHERS	8	2	2	2	2.0	2.5	5.0	60.0	121	121	121	121	121
RACE	5:HISPANIC	23	0	0	0	0.0	5.0	30.0	121.0	121	121	121	121	121
HISPANIC	0:NO	449	0	0	0	2.0	5.0	20.0	121.0	121	121	121	121	121
HISPANIC	1:YES	41	0	0	0	0.0	5.0	20.0	121.0	121	121	121	121	121
EMPLOYMENT	1:FULL TIME	299	0	0	1	2.0	10.0	30.0	121.0	121	121	121	121	121
EMPLOYMENT	2:PART TIME	44	0	0	2	2.0	5.0	22.5	121.0	121	121	121	121	121
EMPLOYMENT	3:NOT EMPLOYED	91	0	0	0	0.0	2.0	10.0	60.0	121	121	121	121	121
EDUCATION	1:< HIGH SCHOOL	35	0	0	1	2.0	5.0	15.0	121.0	121	121	121	121	121
EDUCATION	2:HIGH SCHOOL GRAD	138	0	0	1	2.0	5.0	30.0	121.0	121	121	121	121	121
EDUCATION	3:< COLLEGE	128	0	0	1	2.0	5.0	30.0	121.0	121	121	121	121	121
EDUCATION	4:COLLEGE GRAD.	69	0	0	0	1.0	5.0	30.0	121.0	121	121	121	121	121
EDUCATION	5:POST GRAD.	60	0	0	0	1.5	5.0	27.5	121.0	121	121	121	121	121
CENSUS REGION	1:NORTHEAST	101	0	0	2	2.0	5.0	20.0	121.0	121	121	121	121	121
CENSUS REGION	2:MIDWEST	122	0	0	0	2.0	5.0	30.0	121.0	121	121	121	121	121
CENSUS REGION	3:SOUTH	165	0	0	0	2.0	5.0	20.0	121.0	121	121	121	121	121
CENSUS REGION	4:WEST	107	0	0	0	2.0	5.0	20.0	121.0	121	121	121	121	121
DAY OF WEEK	1:WEEKDAY	362	0	0	0	2.0	5.0	30.0	121.0	121	121	121	121	121
DAY OF WEEK	2:WEEKEND	133	0	0	0	2.0	5.0	15.0	90.0	121	121	121	121	121
SEASON	1:WINTER	128	0	0	0	2.0	5.0	20.0	95.0	121	121	121	121	121
SEASON	2:SPRING	127	0	0	0	1.0	5.0	20.0	121.0	121	121	121	121	121
SEASON	3:SUMMER	149	0	0	1	2.0	5.0	21.0	121.0	121	121	121	121	121
SEASON	4:FALL	91	0	0	1	2.0	5.0	30.0	121.0	121	121	121	121	121
ASTHMA	0:NO	445	0	0	0	2.0	5.0	20.0	121.0	121	121	121	121	121
ASTHMA	1:YES	50	0	0	1	1.0	5.0	15.0	121.0	121	121	121	121	121
ANGINA	0:NO	489	0	0	0	2.0	5.0	20.0	121.0	121	121	121	121	121
ANGINA	1:YES	6	0	0	0	0.0	2.0	15.0	121.0	121	121	121	121	121
BRONCH/EMPHYS	0:NO	469	0	0	0	2.0	5.0	20.0	121.0	121	121	121	121	121
BRONCH/EMPHYS	1:YES	26	2	2	2	2.0	5.0	17.5	60.0	121	121	121	121	121

NOTE: . SIGNIFIES MISSING DATA. A VALUE OF "121" FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 120 MINUTES WERE SPENT. DK = RESPONDENTS ANSWERED "DON'T KNOW". REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-28. Number of Minutes Spent in Activities Working With or Near Stain or Spot Removers

GROUP NAME	GROUP CODE	N	PERCENTILES 1	2	5	10	25	50	75	90	95	98	99	100
OVERALL		109	0	0	0	0.0	2.0	5.0	15.0	60.0	121.0	121	121	121
GENDER	1:MALE	42	0	0	0	0.0	3.0	5.0	60.0	121.0	121.0	121	121	121
GENDER	2:FEMALE	67	0	0	0	0.0	2.0	5.0	10.0	20.0	30.0	60	120	120
AGE	1:1-4	3	0	0	0	0.0	0.0	0.0	3.0	3.0	3.0	3	3	3
AGE	2:5-11	3	3	3	3	3.0	3.0	5.0	5.0	5.0	5.0	5	5	5
AGE	3:12-17	7	0	0	0	0.0	5.0	15.0	35.0	60.0	60.0	60	60	60
AGE	4:18-64	87	0	0	0	0.0	2.0	5.0	15.0	60.0	121.0	121	121	121
AGE	5:> 64	9	0	0	0	0.0	2.0	3.0	15.0	121.0	121.0	121	121	121
RACE	1:WHITE	88	0	0	0	0.0	2.0	5.0	15.0	60.0	121.0	121	121	121
RACE	2:BLACK	9	0	0	0	0.0	5.0	5.0	6.0	121.0	121.0	121	121	121
RACE	3:ASIAN	2	5	5	5	5.0	5.0	7.5	10.0	10.0	10.0	10	10	10
RACE	4:SOME OTHERS	3	0	0	0	0.0	0.0	2.0	3.0	3.0	3.0	3	3	3
RACE	5:HISPANIC	7	1	1	1	1.0	2.0	5.0	30.0	35.0	35.0	35	35	35
HISPANIC	0:NO	97	0	0	0	0.0	2.0	5.0	15.0	60.0	121.0	121	121	121
HISPANIC	1:YES	12	0	0	0	1.0	2.0	3.0	22.5	35.0	121.0	121	121	121
EMPLOYMENT	1:FULL TIME	62	0	0	0	0.0	2.0	5.0	15.0	120.0	121.0	121	121	121
EMPLOYMENT	2:PART TIME	8	0	0	0	0.0	3.0	5.0	12.5	20.0	20.0	20	20	20
EMPLOYMENT	3:NOT EMPLOYED	25	0	0	0	0.0	2.0	4.0	15.0	60.0	121.0	121	121	121
EDUCATION	1:< HIGH SCHOOL	6	3	3	3	3.0	3.0	20.0	30.0	60.0	60.0	60	60	60
EDUCATION	2:HIGH SCHOOL GRAD	34	0	0	0	0.0	1.0	4.0	10.0	120.0	121.0	121	121	121
EDUCATION	3:< COLLEGE	22	0	0	0	1.0	3.0	5.0	15.0	20.0	121.0	121	121	121
EDUCATION	4:COLLEGE GRAD.	16	0	0	0	1.0	3.0	5.0	12.5	60.0	121.0	121	121	121
EDUCATION	5:POST GRAD.	16	0	0	0	0.0	1.0	5.0	15.0	20.0	121.0	121	121	121
CENSUS REGION	1:NORTHEAST	21	0	0	1	1.0	3.0	5.0	10.0	121.0	121.0	121	121	121
CENSUS REGION	2:MIDWEST	25	0	0	0	0.0	2.0	5.0	15.0	60.0	60.0	121	121	121
CENSUS REGION	3:SOUTH	38	0	0	0	0.0	2.0	5.0	15.0	60.0	120.0	121	121	121
CENSUS REGION	4:WEST	25	0	0	0	0.0	2.0	5.0	25.0	60.0	60.0	121	121	121
DAY OF WEEK	1:WEEKDAY	75	0	0	0	0.0	2.0	5.0	15.0	120.0	121.0	121	121	121
DAY OF WEEK	2:WEEKEND	34	0	0	0	0.0	2.0	5.0	15.0	60.0	60.0	120	120	120
SEASON	1:WINTER	26	0	0	0	0.0	2.0	5.0	15.0	60.0	120.0	120	120	120
SEASON	2:SPRING	30	0	0	0	0.5	2.0	5.0	15.0	32.5	121.0	121	121	121
SEASON	3:SUMMER	37	0	0	0	0.0	2.0	5.0	20.0	121.0	121.0	121	121	121
SEASON	4:FALL	16	0	0	0	1.0	5.0	5.0	15.0	60.0	121.0	121	121	121
ASTHMA	0:NO	100	0	0	0	0.0	2.0	5.0	15.0	60.0	120.5	121	121	121
ASTHMA	1:YES	9	0	0	0	0.0	2.0	5.0	6.0	121.0	121.0	121	121	121
ANGINA	0:NO	109	0	0	0	0.0	2.0	5.0	15.0	60.0	121.0	121	121	121
BRONCH/EMPHYS	0:NO	105	0	0	0	0.0	2.0	5.0	15.0	60.0	121.0	121	121	121
BRONCH/EMPHYS	1:YES	4	0	0	0	0.0	0.5	1.5	8.5	15.0	15.0	15	15	15

NOTE: . SIGNIFIES MISSING DATA. A VALUE OF "121" FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 120 MINUTES WERE SPENT. DK = RESPONDENTS ANSWERED "DON'T KNOW". REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-29. Number of Minutes Spent in Activities Working With or Near Gasoline or Diesel-Powered Equipment, Besides Automobiles

			PERCENTILES											
GROUP NAME	**GROUP CODE**	**N**	**1**	**2**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**	**100**
OVERALL		390	0	0	1	3.0	10.0	60.0	121.0	121	121	121	121	121
GENDER	1:MALE	271	0	0	1	3.0	15.0	60.0	121.0	121	121	121	121	121
GENDER	2:FEMALE	119	1	1	1	2.0	8.0	30.0	120.0	121	121	121	121	121
AGE	1:1-4	14	0	0	0	1.0	5.0	22.5	120.0	121	121	121	121	121
AGE	2:5-11	12	1	1	1	3.0	7.5	25.0	50.0	60	60	60	60	60
AGE	3:12-17	25	2	2	5	5.0	13.0	35.0	120.0	121	121	121	121	121
AGE	4:18-64	312	0	0	1	3.0	15.0	60.0	121.0	121	121	121	121	121
AGE	5:> 64	26	2	2	2	3.0	10.0	25.0	90.0	121	121	121	121	121
RACE	1:WHITE	355	0	1	1	3.0	15.0	60.0	121.0	121	121	121	121	121
RACE	2:BLACK	15	1	1	1	1.0	2.0	15.0	121.0	121	121	121	121	121
RACE	3:ASIAN	8	0	0	0	0.0	5.0	11.5	17.5	90	90	90	90	90
RACE	4:SOME OTHERS	2	1	1	1	1.0	1.0	23.0	45.0	45	45	45	45	45
RACE	5:HISPANIC	8	3	3	3	3.0	10.0	105.5	121.0	121	121	121	121	121
HISPANIC	0:NO	367	0	0	1	3.0	10.0	60.0	121.0	121	121	121	121	121
HISPANIC	1:YES	19	1	1	1	2.0	5.0	30.0	121.0	121	121	121	121	121
EMPLOYMENT	1:FULL TIME	237	0	0	1	2.0	20.0	90.0	121.0	121	121	121	121	121
EMPLOYMENT	2:PART TIME	33	1	1	2	2.0	10.0	45.0	121.0	121	121	121	121	121
EMPLOYMENT	3:NOT EMPLOYED	66	0	0	2	4.0	10.0	30.0	121.0	121	121	121	121	121
EDUCATION	1:< HIGH SCHOOL	33	0	0	1	2.0	6.0	60.0	121.0	121	121	121	121	121
EDUCATION	2:HIGH SCHOOL GRAD	135	1	1	2	5.0	20.0	90.0	121.0	121	121	121	121	121
EDUCATION	3:< COLLEGE	89	0	1	2	3.0	15.0	60.0	121.0	121	121	121	121	121
EDUCATION	4:COLLEGE GRAD.	48	0	0	0	1.0	10.0	60.0	120.0	121	121	121	121	121
EDUCATION	5:POST GRAD.	30	0	0	1	1.5	10.0	30.0	120.0	121	121	121	121	121
CENSUS REGION	1:NORTHEAST	57	0	1	1	1.0	10.0	60.0	121.0	121	121	121	121	121
CENSUS REGION	2:MIDWEST	117	0	0	1	5.0	15.0	90.0	121.0	121	121	121	121	121
CENSUS REGION	3:SOUTH	151	0	1	2	3.0	10.0	60.0	121.0	121	121	121	121	121
CENSUS REGION	4:WEST	65	0	0	1	3.0	10.0	45.0	121.0	121	121	121	121	121
DAY OF WEEK	1:WEEKDAY	278	0	0	1	2.0	10.0	60.0	121.0	121	121	121	121	121
DAY OF WEEK	2:WEEKEND	112	1	1	2	5.0	15.0	45.0	120.0	121	121	121	121	121
SEASON	1:WINTER	97	0	0	1	2.0	10.0	60.0	121.0	121	121	121	121	121
SEASON	2:SPRING	110	0	1	1	3.0	10.0	60.0	121.0	121	121	121	121	121
SEASON	3:SUMMER	119	0	1	2	5.0	15.0	60.0	121.0	121	121	121	121	121
SEASON	4:FALL	64	0	1	1	2.0	5.0	30.0	121.0	121	121	121	121	121
ASTHMA	0:NO	361	0	0	1	3.0	10.0	60.0	121.0	121	121	121	121	121
ASTHMA	1:YES	28	2	2	3	3.0	30.0	120.5	121.0	121	121	121	121	121
ANGINA	0:NO	381	0	0	1	3.0	10.0	60.0	121.0	121	121	121	121	121
ANGINA	1:YES	7	15	15	15	15.0	20.0	45.0	121.0	121	121	121	121	121
BRONCH/EMPHYS	0:NO	368	0	0	1	3.0	15.0	60.0	121.0	121	121	121	121	121
BRONCH/EMPHYS	1:YES	21	2	2	3	3.0	5.0	45.0	121.0	121	121	121	121	121

NOTE: . SIGNIFIES MISSING DATA. A VALUE OF “121” FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 120 MINUTES WERE SPENT. DK = RESPONDENTS ANSWERED “DON’T KNOW”. REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-30. Number of Minutes Spent Using Any Microwave Oven

			PERCENTILES											
GROUP NAME	**GROUP CODE**	**N**	**1**	**2**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**	**100**
OVERALL		2298	0	0	1	1.0	3	5	10	15	30	40.0	60	121
GENDER	1:MALE	948	0	0	1	1.0	2	5	10	15	30	40.0	67	121
GENDER	2:FEMALE	1350	0	0	1	1.5	3	5	10	20	30	42.5	60	121
AGE	2:5-11	62	0	0	0	1.0	1	2	5	10	15	20.0	30	30
AGE	3:12-17	141	0	0	0	1.0	2	3	5	10	15	30.0	30	60
AGE	4:18-64	1686	0	0	1	2.0	3	5	10	15	25	45.0	60	121
AGE	5:> 64	375	0	0	1	2.0	3	5	10	20	30	60.0	60	70
RACE	1:WHITE	1953	0	0	1	2.0	3	5	10	16	30	40.0	60	121
RACE	2:BLACK	182	0	0	1	1.0	2	3	6	15	20	30.0	30	121
RACE	3:ASIAN	38	0	0	1	1.0	3	5	10	20	30	60.0	60	60
RACE	4:SOME OTHERS	29	0	0	2	2.0	3	5	10	30	30	50.0	50	50
RACE	5:HISPANIC	74	0	0	0	1.0	2	3	10	15	45	120.0	121	121
HISPANIC	0:NO	2128	0	0	1	1.0	3	5	10	15	30	35.0	60	121
HISPANIC	1:YES	139	0	0	0	1.0	2	5	10	20	30	120.0	120	121
EMPLOYMENT	1:FULL TIME	1114	0	0	1	1.0	3	5	10	15	30	34.0	60	121
EMPLOYMENT	2:PART TIME	237	0	0	1	1.0	3	5	10	20	30	60.0	120	121
EMPLOYMENT	3:NOT EMPLOYED	734	0	0	1	2.0	3	5	10	20	30	45.0	60	120
EDUCATION	1:< HIGH SCHOOL	190	0	0	0	1.5	3	5	10	20	33	60.0	121	121
EDUCATION	2:HIGH SCHOOL GRAD	717	0	0	1	2.0	3	5	10	20	30	45.0	60	121
EDUCATION	3:< COLLEGE	518	0	0	1	2.0	3	5	10	18	30	60.0	120	121
EDUCATION	4:COLLEGE GRAD.	347	0	0	1	2.0	3	5	10	15	25	30.0	60	70
EDUCATION	5:POST GRAD.	288	0	0	1	1.0	3	5	10	15	20	30.0	30	90
CENSUS REGION	1:NORTHEAST	420	0	0	1	2.0	2	5	10	20	30	60.0	60	121
CENSUS REGION	2:MIDWEST	545	0	0	1	1.0	3	5	10	15	30	35.0	60	121
CENSUS REGION	3:SOUTH	831	0	0	1	2.0	3	5	10	16	30	45.0	60	121
CENSUS REGION	4:WEST	502	0	0	1	1.0	2	5	10	15	20	30.0	60	121
DAY OF WEEK	1:WEEKDAY	1567	0	0	1	1.0	3	5	10	15	25	30.0	60	121
DAY OF WEEK	2:WEEKEND	731	0	0	1	1.0	2	5	10	20	30	50.0	120	121
SEASON	1:WINTER	657	0	0	1	2.0	2	5	10	15	30	40.0	67	121
SEASON	2:SPRING	577	0	0	1	2.0	3	5	10	20	30	45.0	60	120
SEASON	3:SUMMER	565	0	0	0	1.0	2	5	10	15	20	30.0	60	120
SEASON	4:FALL	499	0	0	1	1.0	2	5	10	20	30	45.0	120	121
ASTHMA	0:NO	2109	0	0	1	1.0	2	5	10	15	30	40.0	60	121
ASTHMA	1:YES	180	0	0	1	2.0	3	5	10	19	30	45.0	60	121
ANGINA	0:NO	2212	0	0	1	1.0	2	5	10	15	30	40.0	60	121
ANGINA	1:YES	72	0	0	1	2.0	3	6	10	15	30	45.0	60	60
BRONCH/EMPHYS	0:NO	2164	0	0	1	1.0	2	5	10	15	30	40.0	60	121
BRONCH/EMPHYS	1:YES	124	0	0	1	1.0	3	5	10	30	30	60.0	120	121

NOTE: . SIGNIFIES MISSING DATA. A VALUE OF “121” FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 120 MINUTES WERE SPENT. DK = RESPONDENTS ANSWERED “DON’T KNOW”. REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-31. Frequency of Use of Humidifier at Home

	ALL	1:ALMOST EVERY DAY RESPOND.	2:3-5 TIMES A WEEK RESPOND.	3:1-2 A WEEK RESPOND.	4:1-2 A MONTH RESPOND.	8:DK RESPOND.
	N	N	N	N	N	N
OVERALL	1047	300	121	107	495	24
----- GENDER ------						
1:MALE	455	135	53	48	208	11
2:FEMALE	591	165	68	59	286	13
9:REF	1	.	.	.	1	.
------ AGE -------						
.	16	3	1	3	7	2
1:1-4	111	33	16	7	53	2
2:5-11	88	18	10	12	46	2
3:12-17	83	21	7	5	49	1
4:18-64	629	183	77	70	287	12
5:> 64	120	42	10	10	53	5
------ RACE -------						
1:WHITE	879	268	98	79	414	20
2:BLACK	93	24	10	15	42	2
3:ASIAN	18	3	2	1	11	1
4:SOME OTHERS	20	1	3	4	12	.
5:HISPANIC	30	2	7	8	13	.
9:REF	7	2	1	.	3	1
----- HISPANIC ----						
0:NO	978	286	109	95	466	22
1:YES	60	11	11	12	25	1
8:DK	5	3	.	.	2	.
9:REF	4	.	1	.	2	1
--- EMPLOYMENT ----						
.	279	70	32	25	147	5
1:FULL TIME	416	124	43	44	194	11
2:PART TIME	88	22	14	9	43	.
3:NOT EMPLOYED	256	82	29	29	109	7
9:REF	8	2	3	.	2	1
--- EDUCATION ----						
.	303	74	36	27	160	6
1:< HIGH SCHOOL	86	27	15	14	29	1
2:HIGH SCHOOL GRAD	251	85	27	28	104	7
3:< COLLEGE	188	53	16	17	97	5
4:COLLEGE GRAD.	119	32	17	13	56	1
5:POST GRAD.	100	29	10	8	49	4
-- CENSUS REGION --						
1:NORTHEAST	273	84	26	28	132	3
2:MIDWEST	326	102	37	32	142	13
3:SOUTH	302	83	42	31	141	5
4:WEST	146	31	16	16	80	3
--- DAY OF WEEK ---						
1:WEEKDAY	698	196	83	70	335	14
2:WEEKEND	349	104	38	37	160	10
------ SEASON -----						
1:WINTER	320	135	46	34	98	7
2:SPRING	257	58	23	29	144	3
3:SUMMER	269	56	27	20	155	11
4:FALL	201	51	25	24	98	3
------ ASTHMA -----						
0:NO	948	272	110	95	448	23
1:YES	92	27	9	10	45	1
8:DK	7	1	2	2	2	.
------ ANGINA -----						
0:NO	1015	290	116	103	482	24
1:YES	24	8	4	3	9	.
8:DK	8	2	1	1	4	.
-- BRONCH/EMPHYS --						
0:NO	994	278	117	102	473	24
1:YES	48	21	3	4	20	.
8:DK	5	1	1	1	2	.

NOTE: . = MISSING DATA; DK = DON'T KNOW; % = ROW PERCENTAGE; N = SAMPLE SIZE

Source: Tsang and Klepeis, 1996.

Table 15-32. Number of Times Pesticides Were Applied by the Professional at Home to Eradicate Insects, Rodents, or Other Pests

		# TIMES P-CIDES APPLIED BY PROFESSIONAL					
		0:NONE	1:1-2	2:3-5	3:6-9	4:10+	8:DK
	ALL	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.
	N	N	N	N	N	N	N
OVERALL	1946	1057	562	134	150	20	23
----- GENDER ------							
1:MALE	897	498	248	64	64	11	12
2:FEMALE	1048	558	314	70	86	9	11
9:REF	1	1	.	.	.	.	.
------ AGE -------							
.	33	17	8	4	4	.	.
1:1-4	113	60	35	11	6	1	.
2:5-11	150	84	37	10	18	1	.
3:12-17	143	90	40	5	6	.	2
4:18-64	1264	660	387	89	97	15	16
5:> 64	243	146	55	15	19	3	5
------ RACE -------							
1:WHITE	1532	856	429	98	117	14	18
2:BLACK	231	107	78	20	17	4	5
3:ASIAN	24	13	10	1	.	.	.
4:SOME OTHERS	38	24	8	4	2	.	.
5:HISPANIC	100	45	33	10	11	1	.
9:REF	21	12	4	1	3	1	.
----- HISPANIC ----							
0:NO	1750	960	499	121	130	19	21
1:YES	172	83	56	12	18	1	2
8:DK	8	5	3	.	.	.	.
9:REF	16	9	4	1	2	.	.
--- EMPLOYMENT ----							
.	398	229	111	24	30	2	2
1:FULL TIME	855	463	252	59	60	11	10
2:PART TIME	163	84	50	14	12	2	1
3:NOT EMPLOYED	512	272	145	35	46	5	9
9:REF	18	9	4	2	2	.	1
--- EDUCATION ----							
.	436	246	122	27	35	2	4
1:< HIGH SCHOOL	137	80	31	11	10	1	4
2:HIGH SCHOOL GRAD	483	265	140	26	38	9	5
3:< COLLEGE	416	218	131	28	29	4	6
4:COLLEGE GRAD.	272	137	87	25	20	2	1
5:POST GRAD.	202	111	51	17	18	2	3
-- CENSUS REGION --							
1:NORTHEAST	335	201	85	20	22	3	4
2:MIDWEST	318	202	84	17	13	.	2
3:SOUTH	875	404	298	63	86	11	13
4:WEST	418	250	95	34	29	6	4
--- DAY 0F WEEK ---							
1:WEEKDAY	1303	702	374	91	105	16	15
2:WEEKEND	643	355	188	43	45	4	8
------ SEASON -----							
1:WINTER	466	247	129	29	46	9	6
2:SPRING	449	240	128	30	43	3	5
3:SUMMER	584	324	172	40	34	6	8
4:FALL	447	246	133	35	27	2	4
------ ASTHMA -----							
0:NO	1766	969	509	121	129	16	22
1:YES	167	80	50	13	19	4	1
8:DK	13	8	3	.	2	.	.
------ ANGINA -----							
0:NO	1880	1019	549	131	141	19	21
1:YES	53	30	10	3	7	1	2
8:DK	13	8	3	.	2	.	.
-- BRONCH/EMPHYS --							
0:NO	1833	1004	524	127	140	18	20
1:YES	101	46	36	7	8	1	3
8:DK	12	7	2	.	2	1	.

NOTE: . = MISSING DATA; DK = DON'T KNOW; % = ROW PERCENTAGE; N = SAMPLE SIZE

Source: Tsang and Klepeis, 1996.

Table 15-33. Number of Times Pesticides Were Applied by the Consumer at Home to Eradicate Insects, Rodents, or Other Pests

		# OF TIMES P-CIDES APPLIED PERSONALLY					
		0:NONE	1:1-2	2:3-5	3:6-9	4:10+	8:DK
	ALL	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.
	N	N	N	N	N	N	N
OVERALL	1946	721	754	286	73	83	29
----- GENDER ------							
1:MALE	897	318	367	135	31	35	11
2:FEMALE	1048	403	386	151	42	48	18
9:REF	1	.	1	.	.	.	.
------ AGE -------							
.	33	13	12	3	1	4	.
1:1-4	113	46	46	15	3	3	.
2:5-11	150	50	70	24	1	4	1
3:12-17	143	45	64	21	5	8	.
4:18-64	1264	473	477	192	48	55	19
5:> 64	243	94	85	31	15	9	9
------ RACE -------							
1:WHITE	1532	574	600	227	55	50	26
2:BLACK	231	81	77	36	10	25	2
3:ASIAN	24	4	15	3	1	1	.
4:SOME OTHERS	38	11	12	11	1	2	1
5:HISPANIC	100	41	42	9	5	3	.
9:REF	21	10	8	.	1	2	.
----- HISPANIC ----							
0:NO	1750	647	677	258	63	76	29
1:YES	172	66	67	26	10	3	.
8:DK	8	2	3	1	.	2	.
9:REF	16	6	7	1	.	2	.
--- EMPLOYMENT ----							
.	398	139	176	59	9	14	1
1:FULL TIME	855	298	342	131	37	35	12
2:PART TIME	163	67	66	20	4	5	1
3:NOT EMPLOYED	512	209	163	76	23	27	14
9:REF	18	8	7	.	.	2	1
--- EDUCATION ----							
.	436	157	189	62	10	17	1
1:< HIGH SCHOOL	137	44	50	19	4	14	6
2:HIGH SCHOOL GRAD	483	184	196	53	21	18	11
3:< COLLEGE	416	157	158	63	18	16	4
4:COLLEGE GRAD.	272	97	97	53	9	12	4
5:POST GRAD.	202	82	64	36	11	6	3
-- CENSUS REGION --							
1:NORTHEAST	335	112	131	56	12	19	5
2:MIDWEST	318	108	145	35	12	12	6
3:SOUTH	875	363	316	119	30	37	10
4:WEST	418	138	162	76	19	15	8
--- DAY 0F WEEK ---							
1:WEEKDAY	1303	485	503	186	44	66	19
2:WEEKEND	643	236	251	100	29	17	10
------ SEASON -----							
1:WINTER	466	190	153	75	18	21	9
2:SPRING	449	170	192	51	15	16	5
3:SUMMER	584	204	233	89	21	27	10
4:FALL	447	157	176	71	19	19	5
------ ASTHMA -----							
0:NO	1766	643	695	261	70	70	27
1:YES	167	73	54	25	3	11	1
8:DK	13	5	5	.	.	2	1
------ ANGINA -----							
0:NO	1880	696	731	276	70	80	27
1:YES	53	21	19	8	3	1	1
8:DK	13	4	4	2	.	2	1
-- BRONCH/EMPHYS --							
0:NO	1833	675	715	272	72	71	28
1:YES	101	41	35	14	1	10	.
8:DK	12	5	4	.	.	2	1

NOTE: . = MISSING DATA; DK = DON'T KNOW; % = ROW PERCENTAGE; N = SAMPLE SIZE

Table 15-34. Number of Minutes Spent in Activities Working With or Near Pesticides, Including Bug Sprays or Bug Strips

			PERCENTILES											
GROUP NAME	**GROUP CODE**	**N**	**1**	**2**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**	**100**
OVERALL		257	0	0	0	0	2.0	10.0	60.0	121	121	121	121	121
GENDER	1:MALE	121	0	0	1	1	2.0	10.0	90.0	121	121	121	121	121
GENDER	2:FEMALE	136	0	0	0	0	2.0	10.0	35.0	121	121	121	121	121
AGE	1:1-4	6	1	1	1	1	3.0	10.0	15.0	20	20	20	20	20
AGE	2:5-11	16	0	0	0	0	1.5	7.5	30.0	121	121	121	121	121
AGE	3:12-17	10	0	0	0	0	2.0	2.5	40.0	121	121	121	121	121
AGE	4:18-64	190	0	0	0	1	2.0	10.0	88.0	121	121	121	121	121
AGE	5:> 64	31	0	0	0	0	2.0	5.0	15.0	60	121	121	121	121
RACE	1:WHITE	199	0	0	0	1	2.0	10.0	60.0	121	121	121	121	121
RACE	2:BLACK	36	0	0	0	0	1.0	3.0	20.0	121	121	121	121	121
RACE	3:ASIAN	2	5	5	5	5	5.0	7.5	10.0	10	10	10	10	10
RACE	4:SOME OTHERS	4	0	0	0	0	1.5	6.5	10.0	10	10	10	10	10
RACE	5:HISPANIC	15	0	0	0	0	2.0	20.0	121.0	121	121	121	121	121
HISPANIC	0:NO	231	0	0	0	0	2.0	10.0	60.0	121	121	121	121	121
HISPANIC	1:YES	25	0	0	0	1	5.0	20.0	121.0	121	121	121	121	121
EMPLOYMENT	1:FULL TIME	124	0	0	0	1	2.0	10.0	120.5	121	121	121	121	121
EMPLOYMENT	2:PART TIME	26	0	0	0	1	2.0	5.0	60.0	121	121	121	121	121
EMPLOYMENT	3:NOT EMPLOYED	75	0	0	0	0	2.0	5.0	30.0	121	121	121	121	121
EDUCATION	1:< HIGH SCHOOL	20	1	1	1	1	2.5	22.5	105.5	121	121	121	121	121
EDUCATION	2:HIGH SCHOOL GRAD	87	0	0	0	0	2.0	10.0	45.0	121	121	121	121	121
EDUCATION	3:< COLLEGE	56	0	0	0	1	2.0	10.0	89.0	121	121	121	121	121
EDUCATION	4:COLLEGE GRAD.	29	0	0	0	0	1.0	10.0	90.0	121	121	121	121	121
EDUCATION	5:POST GRAD.	29	0	0	0	0	3.0	10.0	30.0	121	121	121	121	121
CENSUS REGION	1:NORTHEAST	45	0	0	1	2	5.0	10.0	88.0	121	121	121	121	121
CENSUS REGION	2:MIDWEST	51	0	0	0	0	2.0	10.0	121.0	121	121	121	121	121
CENSUS REGION	3:SOUTH	106	0	0	0	0	2.0	5.0	30.0	121	121	121	121	121
CENSUS REGION	4:WEST	55	0	0	0	1	2.0	10.0	45.0	121	121	121	121	121
DAY OF WEEK	1:WEEKDAY	183	0	0	0	0	2.0	10.0	60.0	121	121	121	121	121
DAY OF WEEK	2:WEEKEND	74	0	0	0	1	3.0	10.0	30.0	121	121	121	121	121
SEASON	1:WINTER	39	0	0	0	0	2.0	5.0	90.0	121	121	121	121	121
SEASON	2:SPRING	78	0	0	0	0	2.0	10.0	60.0	121	121	121	121	121
SEASON	3:SUMMER	105	0	0	0	1	2.0	10.0	60.0	121	121	121	121	121
SEASON	4:FALL	35	0	0	0	0	1.0	10.0	60.0	121	121	121	121	121
ASTHMA	0:NO	231	0	0	0	1	2.0	10.0	60.0	121	121	121	121	121
ASTHMA	1:YES	24	0	0	0	0	1.0	5.0	90.5	121	121	121	121	121
ANGINA	0:NO	244	0	0	0	0	2.0	10.0	60.0	121	121	121	121	121
ANGINA	1:YES	8	1	1	1	1	2.0	5.0	75.5	121	121	121	121	121
BRONCH/EMPHYS	0:NO	240	0	0	0	0	2.0	10.0	60.0	121	121	121	121	121
BRONCH/EMPHYS	1:YES	14	1	1	1	2	2.0	5.0	30.0	121	121	121	121	121

NOTE: . SIGNIFIES MISSING DATA. A VALUE OF “121” FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 120 MINUTES WERE SPENT. DK = RESPONDENTS ANSWERED “DON’T KNOW”. REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-35. Range of time Spent Smoking Cigars or Pipe Tobacco by the Number of Respondents

	ALL	. TO .	0 TO 3	3 TO 6	6 TO 9	9 TO 12	12 TO 15	15 TO 18	61 TO 61
		RES.	RES.	RES.	RES.	RES.	RES.	RES.	RES.
	N	N	N	N	N	N	N	N	N
OVERALL	62	5	10	8	6	1	2	9	21
----- GENDER ------									
1:MALE	58	5	8	7	6	1	2	9	20
2:FEMALE	4	.	2	1	.	.	.	.	1
------ AGE -------									
2:5-11	1	.	.	1	.	.	.	.	.
3:12-17	1	1	.	.	.	.	.	.	.
4:18-64	46	3	10	4	6	1	1	5	16
5:> 64	14	1	.	3	.	.	1	4	5
------ RACE -------									
1:WHITE	53	3	8	7	4	1	1	9	20
2:BLACK	5	1	2	1	1	.	.	.	.
4:SOME OTHERS	1	1	.	.	.	.	.	.	.
5:HISPANIC	3	.	.	.	1	.	1	.	1
----- HISPANIC ----									
0:NO	57	5	9	8	5	.	1	9	20
1:YES	5	.	1	.	1	1	1	.	1
--- EMPLOYMENT ----									
.	2	1	.	1	.	.	.	.	.
1:FULL TIME	39	2	7	4	5	1	1	4	15
2:PART TIME	3	.	3	.	.	.	.	.	.
3:NOT EMPLOYED	17	1	.	3	1	.	1	5	6
9:REF	1	1	.	.	.	.	.	.	.
--- EDUCATION ----									
.	2	1	.	1	.	.	.	.	.
1:< HIGH SCHOOL	2	.	.	.	.	.	1	.	1
2:HIGH SCHOOL GRAD	24	2	4	4	3	.	.	3	8
3:< COLLEGE	18	2	4	.	.	1	.	4	7
4:COLLEGE GRAD.	10	.	2	2	2	.	.	1	3
5:POST GRAD.	6	.	.	1	1	.	1	1	2
-- CENSUS REGION --									
1:NORTHEAST	20	3	1	4	.	1	.	1	10
2:MIDWEST	19	.	4	4	2	.	1	4	4
3:SOUTH	12	1	3	.	2	.	1	1	4
4:WEST	11	1	2	.	2	.	.	3	3
--- DAY 0F WEEK ---									
1:WEEKDAY	40	3	7	5	2	1	.	7	15
2:WEEKEND	22	2	3	3	4	.	2	2	6
------ SEASON -----									
1:WINTER	16	.	3	5	1	.	1	3	3
2:SPRING	19	3	4	1	1	.	.	2	8
3:SUMMER	19	1	1	1	4	1	1	2	8
4:FALL	8	1	2	1	.	.	.	2	2
------ ASTHMA -----									
0:NO	59	5	8	8	6	1	2	8	21
1:YES	3	.	2	.	.	.	.	1	.
------ ANGINA -----									
0:NO	60	5	10	8	6	1	2	8	20
1:YES	2	.	.	.	.	.	.	1	1
-- BRONCH/EMPHYS --									
0:NO	60	4	10	8	6	1	2	8	21
1:YES	2	1	.	.	.	.	.	1	.

NOTE: "." SIGNIFIES MISSING DATA. DK = RESPONDENTS ANSWERED "DON'T KNOW". REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE IN SPECIFIED RANGE OF NUMBER OF MINUTES SPENT. A VALUE OF "61" FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 60 MINUTES WERE SPENT.

Source: Tsang and Klepeis, 1996.

Table 15-36. Number of Minutes Spent Smoking Cigars or Pipe Tobacco

			PERCENTILES											
GROUP NAME	**GROUP CODE**	**N**	**1**	**2**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**	**100**
OVERALL		57	2	3.0	3.0	10.0	20.0	60.0	61	61	61	61	61	61
GENDER	1:MALE	53	3	5.0	10.0	10.0	20.0	60.0	61	61	61	61	61	61
GENDER	2:FEMALE	4	2	2.0	2.0	2.0	2.5	9.0	38	61	61	61	61	61
AGE	2:5-11	1	15	15.0	15.0	15.0	15.0	15.0	15	15	15	15	15	15
AGE	3:12-17	0	.	.	.	.	.	.	.	.	.	.	.	.
AGE	4:18-64	43	2	2.0	3.0	10.0	15.0	45.0	61	61	61	61	61	61
AGE	5:> 64	13	15	15.0	15.0	20.0	45.0	60.0	61	61	61	61	61	61
RACE	1:WHITE	50	2	2.5	3.0	10.0	20.0	60.0	61	61	61	61	61	61
RACE	2:BLACK	4	10	10.0	10.0	10.0	10.0	15.0	25	30	30	30	30	30
RACE	4:SOME OTHERS	0	.	.	.	.	.	.	.	.	.	.	.	.
RACE	5:HISPANIC	3	30	30.0	30.0	30.0	30.0	45.0	61	61	61	61	61	61
HISPANIC	0:NO	52	2	3.0	3.0	10.0	20.0	60.0	61	61	61	61	61	61
HISPANIC	1:YES	5	10	10.0	10.0	10.0	30.0	40.0	45	61	61	61	61	61
EMPLOYMENT	1:FULL TIME	37	2	2.0	3.0	10.0	20.0	60.0	61	61	61	61	61	61
EMPLOYMENT	2:PART TIME	3	3	3.0	3.0	3.0	3.0	10.0	10	10	10	10	10	10
EMPLOYMENT	3:NOT EMPLOYED	16	15	15.0	15.0	20.0	37.5	60.0	61	61	61	61	61	61
EDUCATION	1:< HIGH SCHOOL	2	45	45.0	45.0	45.0	45.0	53.0	61	61	61	61	61	61
EDUCATION	2:HIGH SCHOOL GRAD	22	2	2.0	10.0	10.0	15.0	45.0	61	61	61	61	61	61
EDUCATION	3:< COLLEGE	16	3	3.0	3.0	3.0	25.0	60.0	61	61	61	61	61	61
EDUCATION	4:COLLEGE GRAD.	10	5	5.0	5.0	7.5	20.0	30.0	61	61	61	61	61	61
EDUCATION	5:POST GRAD.	6	20	20.0	20.0	20.0	30.0	52.5	61	61	61	61	61	61
CENSUS REGION	1:NORTHEAST	17	10	10.0	10.0	20.0	20.0	61.0	61	61	61	61	61	61
CENSUS REGION	2:MIDWEST	19	2	2.0	2.0	3.0	15.0	30.0	60	61	61	61	61	61
CENSUS REGION	3:SOUTH	11	10	10.0	10.0	10.0	10.0	45.0	61	61	61	61	61	61
CENSUS REGION	4:WEST	10	10	10.0	10.0	10.0	30.0	60.0	61	61	61	61	61	61
DAY OF WEEK	1:WEEKDAY	37	2	2.0	3.0	10.0	20.0	60.0	61	61	61	61	61	61
DAY OF WEEK	2:WEEKEND	20	3	3.0	6.5	10.0	20.0	37.5	61	61	61	61	61	61
SEASON	1:WINTER	16	3	3.0	3.0	10.0	15.0	25.0	60	61	61	61	61	61
SEASON	2:SPRING	16	2	2.0	2.0	5.0	15.0	60.5	61	61	61	61	61	61
SEASON	3:SUMMER	18	10	10.0	10.0	20.0	30.0	60.0	61	61	61	61	61	61
SEASON	4:FALL	7	3	3.0	3.0	3.0	10.0	60.0	61	61	61	61	61	61
ASTHMA	0:NO	54	2	3.0	10.0	10.0	20.0	60.0	61	61	61	61	61	61
ASTHMA	1:YES	3	3	3.0	3.0	3.0	3.0	5.0	60	60	60	60	60	60
ANGINA	0:NO	55	2	3.0	3.0	10.0	20.0	60.0	61	61	61	61	61	61
ANGINA	1:YES	2	60	60.0	60.0	60.0	60.0	60.5	61	61	61	61	61	61
BRONCH/EMPHYS	0:NO	56	2	3.0	3.0	10.0	20.0	60.0	61	61	61	61	61	61
BRONCH/EMPHYS	1:YES	1	60	60.0	60.0	60.0	60.0	60.0	60	60	60	60	60	60

NOTE: "." SIGNIFIES MISSING DATA. A VALUE OF "61" FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 60 MINUTES WERE SPENT. DK = RESPONDENTS ANSWERED "DON'T KNOW". REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-37. Range of Numbers of Cigarettes Smoked Based on the Number of Respondents

		# OF CIGARETTES YOU SMOKED YESTERDAY									
		.	0:NONE	1:1-2	2:3-5	3:6-9	4:10-14	5:15-24	6:25-35	7:36+	8:DK
	ALL	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.
	N	N	N	N	N	N	N	N	N	N	N
OVERALL	4663	530	3288	45	92	88	182	315	56	57	10
----- GENDER ------											
1:MALE	2163	278	1467	24	38	32	81	167	30	43	3
2:FEMALE	2498	251	1820	21	54	56	101	148	26	14	7
9:REF	2	1	1	.	.	.	.	.	.	.	.
------ AGE -------											
.	84	2	72	1	1	.	2	3	1	1	1
1:1-4	263	263	.	.	.	.	.	.	.	.	.
2:5-11	348	258	88	.	1	.	.	1	.	.	.
3:12-17	326	1	315	.	1	3	2	3	.	.	1
4:18-64	2972	5	2232	42	76	75	156	276	54	51	5
5:> 64	670	1	581	2	13	10	22	32	1	5	3
------ RACE -------											
1:WHITE	3774	413	2664	30	63	63	156	272	54	52	7
2:BLACK	463	53	319	7	18	22	17	22	1	1	3
3:ASIAN	77	5	71	.	.	.	.	1	.	.	.
4:SOME OTHERS	96	22	55	1	4	1	5	6	1	1	.
5:HISPANIC	193	37	133	7	5	2	2	7	.	.	.
9:REF	60	.	46	.	2	.	2	7	.	3	.
----- HISPANIC ----											
0:NO	4244	452	3010	33	79	79	173	297	56	55	10
1:YES	347	75	225	11	10	7	7	12	.	.	.
8:DK	26	2	18	.	2	2	1	1	.	.	.
9:REF	46	1	35	1	1	.	1	5	.	2	.
--- EMPLOYMENT ----											
.	926	526	388	.	2	3	2	3	.	.	2
1:FULL TIME	2017	1	1510	34	55	51	100	193	37	34	2
2:PART TIME	379	.	307	5	7	6	23	22	4	3	2
3:NOT EMPLOYED	1309	3	1058	6	28	28	57	92	14	20	3
9:REF	32	.	25	.	.	.	.	5	1	.	1
--- EDUCATION ----											
.	1021	526	473	.	4	3	4	8	.	1	2
1:< HIGH SCHOOL	399	3	279	1	9	12	27	42	8	16	2
2:HIGH SCHOOL GRAD	1253	1	899	16	44	35	73	138	23	23	1
3:< COLLEGE	895	.	696	11	19	20	44	75	18	9	3
4:COLLEGE GRAD.	650	.	547	11	10	13	26	32	5	5	1
5:POST GRAD.	445	.	394	6	6	5	8	20	2	3	1
-- CENSUS REGION --											
1:NORTHEAST	1048	112	747	4	12	19	49	78	10	16	1
2:MIDWEST	1036	110	746	11	25	19	29	73	13	8	2
3:SOUTH	1601	193	1079	17	37	34	76	108	29	24	4
4:WEST	978	115	716	13	18	16	28	56	4	9	3
--- DAY 0F WEEK ---											
1:WEEKDAY	3156	341	2239	28	66	61	116	217	38	43	7
2:WEEKEND	1507	189	1049	17	26	27	66	98	18	14	3
------ SEASON -----											
1:WINTER	1264	163	883	16	23	21	50	71	18	14	5
2:SPRING	1181	148	819	13	22	14	45	94	14	10	2
3:SUMMER	1275	142	906	7	20	32	47	89	12	17	3
4:FALL	943	77	680	9	27	21	40	61	12	16	.
------ ASTHMA -----											
0:NO	4287	480	3023	40	85	80	171	292	51	56	9
1:YES	341	48	239	5	6	8	10	18	5	1	1
8:DK	35	2	26	.	1	.	1	5	.	.	.
------ ANGINA -----											
0:NO	4500	526	3161	45	88	85	175	304	52	54	10
1:YES	125	2	99	.	3	3	5	8	3	2	.
8:DK	38	2	28	.	1	.	2	3	1	1	.
-- BRONCH/EMPHYS --											
0:NO	4424	519	3138	43	80	81	170	284	48	52	9
1:YES	203	11	120	2	11	6	11	28	8	5	1
8:DK	36	.	30	.	1	1	1	3	.	.	.

NOTE: . = MISSING DATA; DK = DON'T KNOW; N = SAMPLE SIZE

Source: Tsang and Klepeis, 1996.

Table 15-38. Range of the Number of Cigarettes Smoked While at Home

		# OF CIGARETTES RES SMOKED AT HOME									
		.	0:NONE	1:1-2	2:3-5	3:6-9	4:10-14	5:15-24	6:25-35	7:36+	8:DK
	ALL	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.
	N	N	N	N	N	N	N	N	N	N	N
OVERALL	4723	516	3358	51	193	126	224	180	23	29	23
----- GENDER ------											
1:MALE	2131	277	1463	24	86	53	91	98	11	17	11
2:FEMALE	2590	237	1895	27	107	73	133	82	12	12	12
9:REF	2	2	.	.	.	.	.	.	.	.	.
------ AGE -------											
.	103	8	83	.	2	4	1	2	1	.	2
1:1-4	236	236	.	.	.	.	.	.	.	.	.
2:5-11	355	268	86	.	.	.	1	.	.	.	.
3:12-17	263	2	248	.	6	2	3	1	1	.	.
4:18-64	3087	1	2352	47	170	110	193	150	21	26	17
5:> 64	679	1	589	4	15	10	26	27	.	3	4
------ RACE -------											
1:WHITE	3817	391	2700	30	152	103	208	164	22	28	19
2:BLACK	482	61	345	10	27	20	9	6	1	.	3
3:ASIAN	80	13	65	.	2	.	.	.	.	.	.
4:SOME OTHERS	86	17	58	1	3	1	2	3	.	1	.
5:HISPANIC	192	32	140	8	3	2	3	4	.	.	.
9:REF	66	2	50	2	6	.	2	3	.	.	1
----- HISPANIC ----											
0:NO	4290	451	3045	41	182	121	210	167	23	29	21
1:YES	355	64	252	8	4	5	10	11	.	.	1
8:DK	21	.	18	.	1	.	2	.	.	.	.
9:REF	57	1	43	2	6	.	2	2	.	.	1
--- EMPLOYMENT ----											
.	847	514	322	.	5	1	3	1	1	.	.
1:FULL TIME	2079	1	1598	33	122	88	117	87	11	10	12
2:PART TIME	423	.	346	4	17	10	27	12	3	3	1
3:NOT EMPLOYED	1335	1	1060	14	47	27	76	78	7	16	9
9:REF	39	.	32	.	2	.	1	2	1	.	1
--- EDUCATION ----											
.	947	514	406	1	9	3	6	4	2	.	2
1:< HIGH SCHOOL	435	.	309	5	20	17	32	26	7	12	7
2:HIGH SCHOOL GRAD	1359	.	989	21	78	64	98	84	7	11	7
3:< COLLEGE	906	2	701	17	51	25	56	39	4	5	6
4:COLLEGE GRAD.	597	.	524	6	20	11	19	13	2	1	1
5:POST GRAD.	479	.	429	1	15	6	13	14	1	.	.
-- CENSUS REGION --											
1:NORTHEAST	1027	121	721	11	39	22	50	46	8	5	4
2:MIDWEST	1066	102	764	12	52	32	53	33	5	7	6
3:SOUTH	1642	177	1159	16	62	51	81	63	8	14	11
4:WEST	988	116	714	12	40	21	40	38	2	3	2
--- DAY 0F WEEK ---											
1:WEEKDAY	3160	336	2277	32	129	87	134	118	14	18	15
2:WEEKEND	1563	180	1081	19	64	39	90	62	9	11	8
------ SEASON -----											
1:WINTER	1260	153	873	18	53	39	59	42	10	6	7
2:SPRING	1257	152	901	7	51	22	55	54	1	6	8
3:SUMMER	1261	139	896	10	44	33	64	53	7	10	5
4:FALL	945	72	688	16	45	32	46	31	5	7	3
------ ASTHMA -----											
0:NO	4342	470	3100	45	176	112	208	165	20	25	21
1:YES	353	46	234	5	15	14	16	15	3	4	1
8:DK	28	.	24	1	2	.	.	.	.	.	1
------ ANGINA -----											
0:NO	4561	515	3225	49	188	123	217	173	23	26	22
1:YES	125	.	104	1	2	3	5	7	.	3	.
8:DK	37	1	29	1	3	.	2	.	.	.	1
-- BRONCH/EMPHYS --											
0:NO	4458	501	3179	46	179	121	210	159	21	20	22
1:YES	230	15	149	4	12	5	14	20	2	9	.
8:DK	35	.	30	1	2	.	.	1	.	.	1

NOTE: . = MISSING DATA; DK = DON'T KNOW; N = SAMPLE SIZE

Source: Tsang and Klepeis, 1996.

Table 15-39. Number of Cigarettes Smoked by Other People

	ALL	.	0:NONE	1:1-2	2:3-5	3:6-9	4:10-14	5:15-24	6:25-35	7:36+	8:DK
		# OF CIGARETTES THEY SMOKED									
		RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.	RESPOND.
	N	N	N	N	N	N	N	N	N	N	N
OVERALL	4723	898	3209	55	108	78	122	121	19	28	85
----- GENDER ------											
1:MALE	2131	468	1403	21	35	39	61	46	11	12	35
2:FEMALE	2590	428	1806	34	73	39	61	75	8	16	50
9:REF	2	2	.	.	.	.	.	.	.	.	.
------ AGE -------											
.	103	11	82	.	2	.	.	3	.	1	4
1:1-4	236	236	.	.	.	.	.	.	.	.	.
2:5-11	355	355	.	.	.	.	.	.	.	.	.
3:12-17	263	263	.	.	.	.	.	.	.	.	.
4:18-64	3087	32	2506	46	97	74	116	109	16	24	67
5:> 64	679	1	621	9	9	4	6	9	3	3	14
------ RACE -------											
1:WHITE	3817	675	2616	42	89	70	106	107	18	24	70
2:BLACK	482	119	309	7	8	6	9	9	1	2	12
3:ASIAN	80	21	57	1	.	.	1	.	.	.	.
4:SOME OTHERS	86	29	51	.	.	1	3	1	.	1	.
5:HISPANIC	192	50	120	5	9	1	3	1	.	1	2
9:REF	66	4	56	.	2	.	.	3	.	.	1
----- HISPANIC ----											
0:NO	4290	796	2928	49	91	73	114	118	19	25	77
1:YES	355	95	223	5	15	3	7	1	.	1	5
8:DK	21	4	11	1	.	1	1	.	.	2	1
9:REF	57	3	47	.	2	1	.	2	.	.	2
--- EMPLOYMENT ----											
.	847	845	2	.	.	.	.	.	.	.	.
1:FULL TIME	2079	.	1740	28	64	50	73	59	9	10	46
2:PART TIME	423	21	336	6	15	4	14	11	1	3	12
3:NOT EMPLOYED	1335	30	1098	21	28	24	35	48	9	15	27
9:REF	39	2	33	.	1	.	.	3	.	.	.
--- EDUCATION ----											
.	947	897	44	.	1	.	.	4	.	.	1
1:< HIGH SCHOOL	435	.	336	6	18	9	17	16	4	10	19
2:HIGH SCHOOL GRAD	1359	.	1097	25	38	40	47	62	9	9	32
3:< COLLEGE	906	1	748	10	29	22	36	22	5	9	24
4:COLLEGE GRAD.	597	.	536	9	15	5	17	11	.	.	4
5:POST GRAD.	479	.	448	5	7	2	5	6	1	.	5
-- CENSUS REGION --											
1:NORTHEAST	1027	201	690	14	29	18	14	32	3	4	22
2:MIDWEST	1066	196	726	15	28	13	27	25	4	7	25
3:SOUTH	1642	320	1090	17	36	33	58	44	7	15	22
4:WEST	988	181	703	9	15	14	23	20	5	2	16
--- DAY 0F WEEK ---											
1:WEEKDAY	3160	596	2178	33	76	54	77	69	12	14	51
2:WEEKEND	1563	302	1031	22	32	24	45	52	7	14	34
------ SEASON -----											
1:WINTER	1260	266	841	17	23	19	29	34	7	6	18
2:SPRING	1257	270	821	14	35	22	27	32	4	10	22
3:SUMMER	1261	240	863	13	25	18	35	30	3	6	28
4:FALL	945	122	684	11	25	19	31	25	5	6	17
------ ASTHMA -----											
0:NO	4342	802	2989	52	97	69	117	104	15	22	75
1:YES	353	95	196	3	10	9	5	16	4	6	9
8:DK	28	1	24	.	1	.	.	1	.	.	1
------ ANGINA -----											
0:NO	4561	894	3068	53	104	78	121	116	19	26	82
1:YES	125	1	110	2	3	.	1	4	.	2	2
8:DK	37	3	31	.	1	.	.	1	.	.	1
-- BRONCH/EMPHYS --											
0:NO	4458	875	3016	53	99	75	115	108	17	23	77
1:YES	230	21	163	2	8	3	7	12	2	5	7
8:DK	35	2	30	.	1	.	.	1	.	.	1

NOTE: . = MISSING DATA; DK = DON'T KNOW; N = SAMPLE SIZE

Source: Tsang and Klepeis, 1996.

Table 15-40. Number of Minutes Spent Smoking

			PERCENTILES											
GROUP NAME	**GROUP CODE**	**N**	**1**	**2**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**	**100**
OVERALL		9386	0	0	0	0	0	0	240.0	615	795	930.0	1035	1440
GENDER	1:MALE	4294	0	0	0	0	0	0	310.0	685	840	983.0	1095	1440
GENDER	2:FEMALE	5088	0	0	0	0	0	0	180.0	545	725	870.0	960	1440
AGE	1:1-4	499	0	0	0	0	0	0	75.0	455	735	975.0	1095	1440
AGE	2:5-11	703	0	0	0	0	0	0	82.0	370	625	975.0	1140	1440
AGE	3:12-17	589	0	0	0	0	0	0	130.0	377	542	810.0	864	1260
AGE	4:18-64	6059	0	0	0	0	0	0	345.0	675	830	950.0	1045	1440
AGE	5:> 64	1349	0	0	0	0	0	0	10.0	340	622	825.0	910	1440
RACE	1:WHITE	7591	0	0	0	0	0	0	250.0	630	805	940.0	1035	1440
RACE	2:BLACK	945	0	0	0	0	0	0	225.0	540	715	910.0	1071	1440
RACE	3:ASIAN	157	0	0	0	0	0	0	60.0	375	494	565.0	790	800
RACE	4:SOME OTHERS	182	0	0	0	0	0	0	255.0	680	815	1140.0	1305	1328
RACE	5:HISPANIC	385	0	0	0	0	0	0	175.0	481	652	813.0	845	1095
HISPANIC	0:NO	8534	0	0	0	0	0	0	243.0	625	800	940.0	1035	1440
HISPANIC	1:YES	702	0	0	0	0	0	0	175.0	518	680	850.0	920	1440
EMPLOYMENT	1:FULL TIME	4096	0	0	0	0	0	0	360.0	687	835	945.0	1005	1440
EMPLOYMENT	2:PART TIME	802	0	0	0	0	0	0	295.0	630	793	930.0	1054	1440
EMPLOYMENT	3:NOT EMPLOYED	2644	0	0	0	0	0	0	144.5	555	768	915.0	1045	1440
EDUCATION	1:< HIGH SCHOOL	834	0	0	0	0	0	0	420.0	790	880	1004.0	1105	1440
EDUCATION	2:HIGH SCHOOL GRAD	2612	0	0	0	0	0	5	390.0	710	840	956.0	1060	1440
EDUCATION	3:< COLLEGE	1801	0	0	0	0	0	0	288.0	630	805	945.0	1045	1435
EDUCATION	4:COLLEGE GRAD.	1247	0	0	0	0	0	0	135.0	480	660	860.0	970	1140
EDUCATION	5:POST GRAD.	924	0	0	0	0	0	0	60.0	380	595	795.0	860	1205
CENSUS REGION	1:NORTHEAST	2075	0	0	0	0	0	0	259.0	610	775	915.0	990	1440
CENSUS REGION	2:MIDWEST	2102	0	0	0	0	0	0	255.0	630	810	945.0	1054	1440
CENSUS REGION	3:SOUTH	3243	0	0	0	0	0	0	275.0	655	810	950.0	1060	1440
CENSUS REGION	4:WEST	1966	0	0	0	0	0	0	140.0	510	710	885.0	990	1440
DAY OF WEEK	1:WEEKDAY	6316	0	0	0	0	0	0	225.0	595	780	925.0	1015	1440
DAY OF WEEK	2:WEEKEND	3070	0	0	0	0	0	0	260.0	651	810	950.0	1080	1440
SEASON	1:WINTER	2524	0	0	0	0	0	0	210.0	600	790	930.0	1034	1440
SEASON	2:SPRING	2438	0	0	0	0	0	0	240.0	626	785	920.0	1060	1440
SEASON	3:SUMMER	2536	0	0	0	0	0	0	235.0	600	810	940.0	1020	1440
SEASON	4:FALL	1888	0	0	0	0	0	0	285.0	630	791	945.0	1020	1440
ASTHMA	0:NO	8629	0	0	0	0	0	0	240.0	610	790	928.0	1020	1440
ASTHMA	1:YES	694	0	0	0	0	0	0	270.0	668	855	1020.0	1170	1440
ANGINA	0:NO	9061	0	0	0	0	0	0	240.0	615	795	930.0	1034	1440
ANGINA	1:YES	250	0	0	0	0	0	0	125.0	615	835	1007.5	1125	1380
BRONCH/EMPHYS	0:NO	8882	0	0	0	0	0	0	235.0	605	785	928.0	1020	1440
BRONCH/EMPHYS	1:YES	433	0	0	0	0	0	50	405.0	810	900	1040.0	1205	1380

NOTE: "." SIGNIFIES MISSING DATA. DK = RESPONDENTS ANSWERED "DON'T KNOW". REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-41. Range of Time (Minutes) Spent Smoking

	ALL	0 TO 0 RES.	0 TO 60 RES.	60 TO 120 RES.	120 TO 180 RES.	180 TO 240 RES.	240 TO 300 RES.	300 TO 360 RES.	360 TO 420 RES.	420 TO 480 RES.	480 TO 540 RES.	540 TO 600 RES.	600 TO 660 RES.	660 TO 720 RES.	720 TO 780 RES.	780 TO 840 RES.	840 TO 900 RES.	900 TO 960 RES.	960 TO 1020 RES.	1020 TO 1080 RES.
	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
OVERALL	9386	5381	628	444	338	285	258	242	236	192	228	186	185	149	135	162	105	83	53	27
----- GENDER ------																				
1:MALE	4294	2327	280	184	167	141	119	114	128	92	101	92	89	84	76	87	66	48	36	18
2:FEMALE	5088	3053	348	259	171	144	138	128	108	99	127	94	96	65	59	75	39	35	17	9
9:REF	4	1	.	1	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.
------ AGE --------																				
.	187	133	10	6	2	3	2	4	3	6	4	3	3	2	1	1	1	.	2	.
1:1-4	499	344	29	23	14	8	10	7	8	7	8	7	5	3	5	6	3	2	3	2
2:5-11	703	479	40	38	32	23	10	9	6	12	6	11	6	7	2	5	2	.	1	5
3:12-17	589	333	75	31	30	20	22	15	13	7	13	5	3	7	3	5	3	1	1	.
4:18-64	6059	3083	412	305	225	196	195	187	192	143	184	148	154	119	114	129	91	72	44	18
5:> 64	1349	1009	62	41	35	35	19	20	14	17	13	12	14	11	10	16	5	8	2	2
------ RACE -------																				
1:WHITE	7591	4312	496	368	261	233	208	208	186	154	173	160	149	135	118	139	90	74	49	21
2:BLACK	945	550	66	41	37	26	29	18	31	23	33	15	22	7	10	8	9	6	3	5
3:ASIAN	157	109	12	3	7	5	3	2	5	3	3	2	1	.	.	2	.	.	.	.
4:SOME OTHERS	182	103	10	8	9	5	7	3	2	3	5	4	4	3	2	6	2	2	.	.
5:HISPANIC	385	220	39	17	21	13	9	9	10	8	12	5	6	3	3	6	2	1	.	.
9:REF	126	87	5	7	3	3	2	2	2	1	2	.	3	1	2	1	2	.	1	1
---- HISPANIC -----																				
0:NO	8534	4868	573	396	295	267	238	226	213	181	202	173	168	141	127	149	96	81	52	25
1:YES	702	414	48	38	38	16	18	14	21	10	23	11	13	5	6	11	8	2	1	1
8:DK	47	29	3	4	2	.	1	.	1	.	1	2	1	1	1	.	.	.	.	.
9:REF	103	70	4	6	3	2	1	2	1	1	2	.	3	2	1	2	1	.	.	1
--- EMPLOYMENT ----																				
.	1773	1149	143	91	74	50	39	29	26	28	27	22	14	16	10	16	8	3	5	7
1:FULL TIME	4096	2054	286	203	140	141	124	126	134	96	134	109	110	83	82	82	72	50	34	10
2:PART TIME	802	421	51	42	36	25	32	27	17	23	28	12	16	18	11	16	6	10	2	2
3:NOT EMPLOYED	2644	1709	145	105	87	67	61	56	58	43	38	43	44	31	32	48	18	19	12	8
9:REF	71	48	3	3	1	2	2	4	1	2	1	.	1	1	.	.	1	1	.	.
--- EDUCATION -----																				
.	1968	1264	153	98	81	56	49	38	30	31	30	27	18	19	12	18	10	3	7	8
1:< HIGH SCHOOL	834	457	34	28	23	16	15	23	38	15	20	26	12	15	24	34	16	16	7	6
2:HIGH SCHOOL GRAD	2612	1297	160	115	94	86	92	84	69	71	93	64	76	60	64	62	45	33	17	6
3:< COLLEGE	1801	972	114	87	76	62	50	56	49	44	52	35	44	36	22	29	18	23	12	5
4:COLLEGE GRAD.	1247	774	88	70	42	38	32	24	32	23	20	22	21	11	9	12	10	6	8	1
5:POST GRAD.	924	617	79	46	22	27	20	17	18	8	13	12	14	8	4	7	6	2	2	1
-- CENSUS REGION --																				
1:NORTHEAST	2075	1143	150	108	66	73	61	63	54	52	56	40	38	37	34	34	23	20	10	2
2:MIDWEST	2102	1164	145	110	75	65	69	37	63	42	55	51	41	36	28	36	29	15	13	11
3:SOUTH	3243	1834	206	137	116	106	76	92	85	58	87	60	76	52	63	60	37	37	21	11
4:WEST	1966	1240	127	89	81	41	52	50	34	40	30	35	30	24	10	32	16	11	9	3
--- DAY 0F WEEK ---																				
1:WEEKDAY	6316	3655	430	301	227	188	164	146	171	127	169	128	116	95	84	103	63	55	38	17
2:WEEKEND	3070	1726	198	143	111	97	94	96	65	65	59	58	69	54	51	59	42	28	15	10
------ SEASON -----																				
1:WINTER	2524	1478	180	113	91	81	65	68	53	39	60	48	41	30	47	46	26	21	11	7
2:SPRING	2438	1404	154	120	82	73	73	61	61	50	58	40	61	41	36	44	29	10	14	5
3:SUMMER	2536	1477	165	116	88	71	64	64	68	61	52	57	45	38	23	45	31	33	13	11
4:FALL	1888	1022	129	95	77	60	56	49	54	42	58	41	38	40	29	27	19	19	15	4
------ ASTHMA -----																				
0:NO	8629	4942	580	419	308	264	237	223	216	175	213	172	173	134	124	150	92	77	47	24
1:YES	694	396	42	24	29	20	20	17	20	16	13	13	12	15	9	11	13	6	5	3
8:DK	63	43	6	1	1	1	1	2	.	1	2	1	.	.	2	1	.	.	1	.
------ ANGINA -----																				
0:NO	9061	5169	610	430	331	273	252	235	233	187	223	184	181	141	130	157	103	82	48	26
1:YES	250	163	13	11	5	11	5	5	2	5	4	.	4	4	3	4	2	1	4	1
8:DK	75	49	5	3	2	1	1	2	1	.	1	2	.	4	2	1	.	.	1	.
-- BRONCH/EMPHYS --																				
0:NO	8882	5133	593	423	311	267	246	224	219	182	215	177	174	139	128	150	91	75	48	25
1:YES	433	197	30	20	24	17	11	16	17	10	11	7	11	10	5	12	14	8	4	2
8:DK	71	51	5	1	3	1	1	2	.	.	2	2	.	.	2	.	.	.	1	.

NOTE: "." SIGNIFIES MISSING DATA. DK = RESPONDENTS ANSWERED "DON'T KNOW". REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE IN SPECIFIED RANGE OF NUMBER OF MINUTES SPENT.

Table 15-41. Range of Time (Minutes) Spent Smoking (continued)

	1080 TO 1140 RES. N	1140 TO 1200 RES. N	1200 TO 1260 RES. N	1260 TO 1320 RES. N	1320 TO 1380 RES. N	1380 TO 1440 RES. N
OVERALL	21	12	12	3	6	15
----- GENDER ------						
1:MALE	14	9	6	3	3	10
2:FEMALE	7	3	6	.	3	5
9:REF	.	.	.	.	.	.
------ AGE --------						
.	.	.	.	.	.	1
1:1-4	2	1	.	1	.	1
2:5-11	2	2	3	.	.	2
3:12-17	.	.	2	.	.	.
4:18-64	17	9	5	2	5	10
5:> 64	.	.	2	.	1	1
------ RACE -------						
1:WHITE	16	11	11	2	3	14
2:BLACK	2	1	.	.	2	1
3:ASIAN	.	.	.	.	.	.
4:SOME OTHERS	1	.	1	1	1	.
5:HISPANIC	1	.	.	.	.	.
9:REF	1	.	.	.	.	.
---- HISPANIC -----						
0:NO	19	12	11	2	6	13
1:YES	1	.	1	1	.	1
8:DK	.	.	.	.	.	1
9:REF	1	.	.	.	.	.
--- EMPLOYMENT ----						
.	4	3	5	1	.	3
1:FULL TIME	11	5	2	.	2	6
2:PART TIME	3	.	2	.	1	1
3:NOT EMPLOYED	3	4	3	2	3	5
9:REF	.	.	.	.	.	.
--- EDUCATION -----						
.	4	3	5	1	.	3
1:< HIGH SCHOOL	2	1	1	.	2	3
2:HIGH SCHOOL GRAD	5	5	3	1	2	8
3:< COLLEGE	6	3	2	1	2	1
4:COLLEGE GRAD.	4	.	.	.	.	.
5:POST GRAD.	.	.	1	.	.	.
-- CENSUS REGION --						
1:NORTHEAST	4	2	2	.	1	2
2:MIDWEST	8	1	2	1	1	4
3:SOUTH	6	7	5	.	4	7
4:WEST	3	2	3	2	.	2
--- DAY OF WEEK ---						
1:WEEKDAY	12	8	8	2	1	8
2:WEEKEND	9	4	4	1	5	7
------ SEASON -----						
1:WINTER	6	4	1	2	1	5
2:SPRING	5	4	5	1	2	5
3:SUMMER	5	2	3	.	2	2
4:FALL	5	2	3	.	1	3
------ ASTHMA -----						
0:NO	20	9	9	3	5	13
1:YES	1	3	3	.	1	2
8:DK	.	.	.	.	.	.
------ ANGINA -----						
0:NO	20	12	12	2	5	15
1:YES	1	.	.	1	1	.
8:DK	.	.	.	.	.	.
-- BRONCH/EMPHYS --						
0:NO	20	11	9	3	4	15
1:YES	1	1	3	.	2	.
8:DK	.	.	.	.	.	.

NOTE: "." SIGNIFIES MISSING DATA. DK = RESPONDENTS ANSWERED "DON'T KNOW". REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE IN SPECIFIED RANGE OF NUMBER OF MINUTES SPENT.

Source: Tsang and Klepeis, 1996.

Table 15-42. Amount and Frequency of Use of Various Cosmetic and Baby Products							
Product Type	Amount of Product Per Application[a] (grams)	Average Frequency of Use (per day)			Upper 90th Percentile Frequency of Use (per day)		
		Survey Type			Survey Type		
		CTFA	Cosmetic Co.	Market[b] Research Bureau	CTFA	Cosmetic Co.	Market Research Bureau
Baby Lotion - baby use[c]	1.4	0.38	1.0	--	0.57	2.0	--
Baby Lotion - adult use	1.0	0.22	0.19	0.24[d]	0.86	1.0	1.0[d]
Baby Oil - baby use[c]	1.3	0.14	1.2	--	0.14	3.0	--
Baby Oil - adult use	5.0	0.06	0.13	--	0.29	0.57	--
Baby Powder - baby use[c]	0.8	5.36	1.5	0.35[d]	8.43	3.0	1.0[d]
Baby Powder - adult use	0.8	0.13	0.22	--	0.57	1.0	--
Baby Cream - baby use[c]	--	0.43	1.3	--	0.43	3.0	--
Baby Cream - adult use	--	0.07	0.10	--	0.14	0.14[e]	--
Baby Shampoo - baby use[c]	0.5	0.14	--	0.11[f]	0.14	--	0.43[f]
Baby Shampoo - adult use	5.0	0.02	--	--	0.86[e]	--	--
Bath Oils	14.7	0.08	0.19	0.22[g]	0.29	0.86	1.0[g]
Bath Tablets	--	0.003	0.008	--	0.14[e]	0.14[e]	--
Bath Salts	18.9	0.006	0.013	--	0.14[e]	0.14[e]	--
Bubble Baths	11.8	0.088	0.13	--	0.43	0.57	--
Bath Capsules	--	0.018	0.019	--	0.29[e]	0.14[e]	--
Bath Crystals	--	0.006	--	--	0.29[e]	0.14[e]	--
Eyebrow Pencil	--	0.27	0.49	--	1.0	1.0	--
Eyeliner	--	0.42	0.68	0.27	1.43	1.0	1.0
Eye Shadow	--	0.69	0.78	0.40	1.43	1.0	1.0
Eye Lotion	--	0.094	0.34	--	0.43	1.0	--
Eye Makeup Remover	--	0.29	0.45	--	1.0	1.0	--
Mascara	--	0.79	0.87	0.46	1.29	1.0	1.5
Under Eye Cover	--	0.79	--	--	0.29	--	--
Blusher & Rouge	0.011	1.18	1.24	0.55	2.0	1.43	1.5
Face Powders	0.085	0.35	0.67	0.33	1.29	1.0	1.0
Foundations	0.265	0.46	0.78	0.47	1.0	1.0	1.5
Leg and Body Paints	--	0.003	0.011	--	0.14[e]	0.14[e]	--
Lipstick & Lip Gloss	--	1.73	1.23	2.62	4.0	2.86	6.0
Makeup Bases	0.13	0.24	0.64	--	0.86	1.0	--
Makeup Fixatives	--	0.052	0.12	--	0.14	1.0	--
Sunscreen	3.18	0.003	--	0.002	0.14[e]	--	0.005
Colognes & Toilet Water	0.65	0.68	0.85	0.56	1.71	1.43	1.5
Perfumes	0.23	0.29	0.26	0.38	0.86	1.0	1.5

Table 15-42. Amount and Frequency of Use of Various Cosmetic and Baby Products (continued)							
Product Type	Amount of Product Per Application[a] (grams)	Average Frequency of Use (per day)			Upper 90th Percentile Frequency of Use (per day)		
		Survey Type			Survey Type		
		CTFA	Cosmetic Co.	Market[b] Research Bureau	CTFA	Cosmetic Co.	Market Research Bureau
Powders	2.01	0.18	0.39	--	1.0	1.0	--
Sachets	0.2	0.0061	0.034	--	0.14[e]	0.14[e]	--
Fragrance Lotion	--	0.0061	--	--	0.29[e]	--	--
Hair Conditioners	12.4	0.4	0.40	0.27	1.0	1.0	0.86
Hair Sprays	--	0.25	0.55	0.32	1.0	1.0	1.0
Hair Rinses	12.7	0.064	0.18	--	0.29	1.0	--
Shampoos	16.4	0.82	0.59	0.48	1.0	1.0	1.0
Tonics and Dressings	2.85	0.073	0.021	--	0.29	0.14[e]	--
Wave Sets	2.6	0.003[h]	0.040	--	--[h]	0.14	--
Dentifrices	--	1.62	0.67	2.12	2.6	2.0	4.0
Mouthwashes	--	0.42	0.62	0.58	1.86	1.14	1.5
Breath Fresheners	--	0.052	0.43	0.46	0.14	1.0	0.57
Nail Basecoats	0.23	0.052	0.13	--	0.29	0.29	--
Cuticle Softeners	0.66	0.040	0.10	--	0.14	0.29	--
Nail Creams & Lotions	0.56	0.070	0.14	--	0.29	0.43	--
Nail Extenders	--	0.003	0.013	--	0.14[e]	0.14[e]	--
Nail Polish & Enamel	0.28	0.16	0.20	0.07	0.71	0.43	1.0
Nail Polish & Enamel Remover	3.06	0.088	0.19	--	0.29	0.43	--
Nail Undercoats	--	0.049	0.12	--	0.14	0.29	--
Bath Soaps	2.6	1.53	0.95	--	3.0	1.43	--
Underarm Deodorants	0.52	1.01	0.80	1.10	1.29	1.29	2.0
Douches	--	0.013	0.089	0.085	0.14[e]	0.29	0.29
Feminine Hygiene Deodorants	--	0.021	0.084	0.05	1.0[e]	0.29	0.14
Cleansing Products (cold creams, cleansing lotions liquids & pads)	1.7	0.63	0.80	0.54	1.71	2.0	1.5
Depilatories	--	0.0061	0.051	0.009	0.016	0.14	0.033
Face, Body & Hand Preps (excluding shaving preps)	3.5	0.65	--	1.12	2.0	--	2.14
Foot Powder & Sprays	--	0.061	0.079	--	0.57[e]	0.29	--
Hormones	--	0.012	0.028	--	0.57[e]	0.14[e]	--
Moisturizers	0.53	0.98	0.88	0.63	2.0	1.71	1.5
Night Skin Care Products	1.33	0.18	0.50	--	1.0	1.0	--

Table 15-42. Amount and Frequency of Use of Various Cosmetic and Baby Products (continued)							
Product Type	Amount of Product Per Application[a] (g)	Average Frequency of Use (per day)			Upper 90th Percentile Frequency of Use (per day)		
		Survey Type			Survey Type		
		CTFA	Cosmetic Co.	Market[b] Research Bureau	CTFA	Cosmetic Co.	Market Research Bureau
Paste Masks (mud packs)	3.7	0.027	0.20	--	0.14	0.43	--
Skin Lighteners	--	--	0.024	--	--[d]	0.14[d]	--
Skin Fresheners & Astringents	2.0	0.33	0.56	--	1.0	1.43	--
Wrinkle Smoothers (removers)	0.38	0.021	0.15	--	1.0[d]	1.0	--
Facial Cream	0.55	0.0061	--	--	0.0061	--	--
Permanent Wave	101	0.003	--	0.001	0.0082	--	0.005
Hair Straighteners	0.156	0.0007	--	--	0.005[d]	--	--
Hair Dye	--	0.001	--	0.005	0.004[d]	--	0.014
Hair Lighteners	--	0.0003	--	--	0.005[d]	--	--
Hair Bleaches	--	0.0005	--	--	0.02[d]	--	--
Hair Tints	--	0.0001	--	--	0.005[d]	--	--
Hair Rinse (coloring)	--	0.0004	--	--	0.02[d]	--	--
Shampoo (coloring)	--	0.0005	--	--	0.02[d]	--	--
Hair Color Spray	--	--	--	--	--[d]	--	--
Shave Cream	1.73	--	--	0.082	--	--	0.36

[a] Values reported are the averages of the responses reported by the twenty companies interviewed. (--'s) indicate no data available.
[b] The averages shown for the Market Research Bureau are not true averages - this is due to the fact that in many cases the class of most frequent users were indicated by "1 or more" also ranges were used in many cases, i.e., "10-12." The average, therefore, is underestimated slightly. The "1 or more" designation also skew the 90th percentile figures in many instances. The 90th percentile values may, in actuality, be somewhat higher for many products.
[c] Average usage among users only for baby products.
[d] Usage data reflected "entire household" use for both baby lotion and baby oil.
[e] Fewer than 10% of individuals surveyed used these products. Value listed is lowest frequency among individuals reporting usage. In the case of wave sets, skin lighteners, and hair color spray, none of the individuals surveyed by the CTFA used this product during the period of the study.
[f] Usage data reflected "entire household" use.
[g] Usage data reflected total bath product usage.
[h] None of the individuals surveyed reported using this product.

Source: CTFA, 1983.

Table 15-43. Summary of Consumer Products Use Studies				
Study	Study Size	Approach	Relevant Population	Comments
KEY STUDIES				
CPSC, 1992	4,997 product interviews; 527 mailed questionnaires	Direct - interviews and questionnaires	Adults	Random digit dialing method used to select sample. Information on use of 3 products containing methyl chloride was requested.
Westat, 1987a	4,920 individuals	Direct - questionnaire	18+ yrs selected to be representative of US population	Waksberg Method (random digit dialing) used to select sample. Respondents asked to recall use in past 2 months of 32 catagories of household products containing methyl chloride.
Westat, 1987b	193 households	Direct - telephone survey; 2 post-survey validation efforts: 30 reinterviewed, then another 50 reeinterviewed	Adult household members who do cleaning tasks in household	Waksberg Method (random digit dialing) used to select sample. Household use of cleaning products requested. Phone survey during end of year holidays may reflect biased usage data. Two validation resurveys conducted 3 months after survey.
Westat, 1987c	777 households	Direct - telephone survey; 1 post-survey validation effort conducted with 30 reinterviewed	Household members who do painting tasks in household	Waksberg Method (random digit dialing) used to select sample. Painting product use information in past 12 months was requested. One validation resurvey conducted 3 months after survey.
Tsang and Klepeis, 1996	9,386 individuals	Direct - interviews and questionnaires	Representative of U.S. general population	National Human Activity Patterns Survey (NHAPS). Participants selected using random Dial Digit (RDD) and Computer Assisted Telephone Interviewing (CATI). 24-hour diary data, and follow-up questions; nationally representative; represent all seasons, age groups, and genders.
RELEVANT STUDY				
CTFA, 1983	Survey 1: 47 women employees and relatives or employees Survey 2: 1,129 cosmetics purchasers Survey 3: 19,035 females	Survey 1: Direct - 1 wk prospective survey Survey 2: Direct - prospective survey Survey 3: Direct - 9.5 months. prospective survey	Survey 1: 16-61 yr old females Survey 2: Customers of cosmetic manufacturer Survey 3: Market research company sampled female consumers nationwide	Interviewees asked to recall their use of cosmetics and some baby products during a specific past time period. Surveys 1 and 2 had small populations, but Survey 3 had large population selected to be representative of U.S. population

Table 15-24. Number of Minutes Spent in Activities Working With or Near Household Cleaning Agents
Such as Scouring Powders or Ammonia

			PERCENTILES											
GROUP NAME	**GROUP CODE**	**N**	**1**	**2**	**5**	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**	**100**
OVERALL		905	0	0	0	1.0	4.0	10.0	20.0	60.0	121	121	121	121
GENDER	1:MALE	278	0	0	1	2.0	3.0	10.0	20.0	60.0	121	121	121	121
GENDER	2:FEMALE	627	0	0	0	1.0	4.0	10.0	20.0	60.0	120	121	121	121
AGE	1:1-4	21	0	0	0	0.0	5.0	10.0	15.0	20.0	30	121	121	121
AGE	2:5-11	26	1	1	2	2.0	3.0	5.0	15.0	30.0	30	30	30	30
AGE	3:12-17	41	0	0	0	0.0	2.0	5.0	10.0	40.0	60	60	60	60
AGE	4:18-64	672	0	0	1	2.0	5.0	10.0	20.0	60.0	121	121	121	121
AGE	5:> 64	127	0	0	0	1.0	3.0	5.0	15.0	30.0	60	120	121	121
RACE	1:WHITE	721	0	0	1	1.0	4.0	10.0	20.0	60.0	121	121	121	121
RACE	2:BLACK	112	0	0	0	1.0	2.0	5.0	12.0	30.0	90	121	121	121
RACE	3:ASIAN	16	0	0	0	5.0	5.0	10.0	15.0	20.0	30	30	30	30
RACE	4:SOME OTHERS	19	2	2	2	3.0	5.0	10.0	20.0	30.0	60	60	60	60
RACE	5:HISPANIC	30	0	0	1	2.5	10.0	15.0	30.0	60.0	90	121	121	121
HISPANIC	0:NO	838	0	0	0	1.0	3.0	10.0	20.0	60.0	121	121	121	121
HISPANIC	1:YES	58	0	0	1	2.0	5.0	12.5	30.0	60.0	120	121	121	121
EMPLOYMENT	1:FULL TIME	422	0	0	1	1.0	4.0	10.0	30.0	60.0	121	121	121	121
EMPLOYMENT	2:PART TIME	98	0	0	1	2.0	5.0	10.0	20.0	60.0	121	121	121	121
EMPLOYMENT	3:NOT EMPLOYED	296	0	0	0	2.0	3.0	10.0	15.0	60.0	120	121	121	121
EDUCATION	1:< HIGH SCHOOL	76	0	0	1	2.0	2.0	12.5	30.0	120.0	121	121	121	121
EDUCATION	2:HIGH SCHOOL GRAD	304	0	0	0	2.0	5.0	10.0	20.0	60.0	120	121	121	121
EDUCATION	3:< COLLEGE	204	0	0	0	1.0	4.5	10.0	30.0	120.0	121	121	121	121
EDUCATION	4:COLLEGE GRAD.	114	0	1	1	2.0	5.0	10.0	20.0	60.0	90	121	121	121
EDUCATION	5:POST GRAD.	109	0	0	1	1.0	3.0	5.0	15.0	30.0	60	121	121	121
CENSUS REGION	1:NORTHEAST	207	0	0	0	1.0	3.0	5.0	15.0	45.0	120	121	121	121
CENSUS REGION	2:MIDWEST	180	0	0	0	1.0	5.0	10.0	30.0	75.0	121	121	121	121
CENSUS REGION	3:SOUTH	309	0	0	1	2.0	4.0	10.0	20.0	60.0	120	121	121	121
CENSUS REGION	4:WEST	209	0	0	1	1.0	4.0	10.0	20.0	60.0	121	121	121	121
DAY OF WEEK	1:WEEKDAY	580	0	0	0	1.0	3.0	10.0	20.0	60.0	121	121	121	121
DAY OF WEEK	2:WEEKEND	325	0	0	1	2.0	5.0	10.0	20.0	60.0	90	121	121	121
SEASON	1:WINTER	240	0	0	0	2.0	3.0	10.0	20.0	75.0	121	121	121	121
SEASON	2:SPRING	220	0	0	0	1.0	3.0	10.0	17.5	52.5	104	121	121	121
SEASON	3:SUMMER	244	0	0	0	2.0	4.0	10.0	20.0	30.0	60	121	121	121
SEASON	4:FALL	201	0	0	1	2.0	5.0	10.0	30.0	90.0	121	121	121	121
ASTHMA	0:NO	826	0	0	0	1.0	3.0	10.0	20.0	60.0	120	121	121	121
ASTHMA	1:YES	79	0	0	1	2.0	5.0	10.0	30.0	120.0	121	121	121	121
ANGINA	0:NO	868	0	0	0	1.0	4.0	10.0	20.0	60.0	121	121	121	121
ANGINA	1:YES	33	0	0	2	2.0	5.0	5.0	30.0	120.0	121	121	121	121
BRONCH/EMPHYS	0:NO	843	0	0	0	1.0	4.0	10.0	20.0	60.0	120	121	121	121
BRONCH/EMPHYS	1:YES	60	0	0	1	2.0	3.5	10.0	32.5	120.5	121	121	121	121

NOTE: . SIGNIFIES MISSING DATA. A VALUE OF “121” FOR NUMBER OF MINUTES SIGNIFIES THAT MORE THAN 120 MINUTES WERE SPENT. DK = RESPONDENTS ANSWERED “DON’T KNOW”. REF = RESPONDENTS REFUSED TO ANSWER. N = DOER SAMPLE SIZE. PERCENTILES ARE THE PERCENTAGE OF DOERS BELOW OR EQUAL TO A GIVEN NUMBER OF MINUTES.

Source: Tsang and Klepeis, 1996.

Table 15-42. Amount and Frequency of Use of Various Cosmetic and Baby Products

Product Type	Amount of Product Per Application[a] (grams)	Average Frequency of Use (per day)			Upper 90th Percentile Frequency of Use (per day)		
		Survey Type			Survey Type		
		CTFA	Cosmetic Co.	Market[b] Research Bureau	CTFA	Cosmetic Co.	Market Research Bureau
Baby Lotion - baby use[c]	1.4	0.38	1.0	--	0.57	2.0	--
Baby Lotion - adult use	1.0	0.22	0.19	0.24[d]	0.86	1.0	1.0[d]
Baby Oil - baby use[c]	1.3	0.14	1.2	--	0.14	3.0	--
Baby Oil - adult use	5.0	0.06	0.13	--	0.29	0.57	--
Baby Powder - baby use[c]	0.8	5.36	1.5	0.35[d]	8.43	3.0	1.0[d]
Baby Powder - adult use	0.8	0.13	0.22	--	0.57	1.0	--
Baby Cream - baby use[c]	--	0.43	1.3	--	0.43	3.0	--
Baby Cream - adult use	--	0.07	0.10	--	0.14	0.14[e]	--
Baby Shampoo - baby use[c]	0.5	0.14	--	0.11[f]	0.14	--	0.43[f]
Baby Shampoo - adult use	5.0	0.02	--	--	0.86[e]	--	--
Bath Oils	14.7	0.08	0.19	0.22[g]	0.29	0.86	1.0[g]
Bath Tablets	--	0.003	0.008	--	0.14[e]	0.14[e]	--
Bath Salts	18.9	0.006	0.013	--	0.14[e]	0.14[e]	--
Bubble Baths	11.8	0.088	0.13	--	0.43	0.57	--
Bath Capsules	--	0.018	0.019	--	0.29[e]	0.14[e]	--
Bath Crystals	--	0.006	--	--	0.29[e]	0.14[e]	--
Eyebrow Pencil	--	0.27	0.49	--	1.0	1.0	--
Eyeliner	--	0.42	0.68	0.27	1.43	1.0	1.0
Eye Shadow	--	0.69	0.78	0.40	1.43	1.0	1.0
Eye Lotion	--	0.094	0.34	--	0.43	1.0	--
Eye Makeup Remover	--	0.29	0.45	--	1.0	1.0	--
Mascara	--	0.79	0.87	0.46	1.29	1.0	1.5
Under Eye Cover	--	0.79	--	--	0.29	--	--
Blusher & Rouge	0.011	1.18	1.24	0.55	2.0	1.43	1.5
Face Powders	0.085	0.35	0.67	0.33	1.29	1.0	1.0
Foundations	0.265	0.46	0.78	0.47	1.0	1.0	1.5
Leg and Body Paints	--	0.003	0.011	--	0.14[e]	0.14[e]	--
Lipstick & Lip Gloss	--	1.73	1.23	2.62	4.0	2.86	6.0
Makeup Bases	0.13	0.24	0.64	--	0.86	1.0	--
Makeup Fixatives	--	0.052	0.12	--	0.14	1.0	--
Sunscreen	3.18	0.003	--	0.002	0.14[e]	--	0.005
Colognes & Toilet Water	0.65	0.68	0.85	0.56	1.71	1.43	1.5
Perfumes	0.23	0.29	0.26	0.38	0.86	1.0	1.5

Table 15-42. Amount and Frequency of Use of Various Cosmetic and Baby Products (continued)

Product Type	Amount of Product Per Application[a] (grams)	Average Frequency of Use (per day)			Upper 90th Percentile Frequency of Use (per day)		
		Survey Type			Survey Type		
		CTFA	Cosmetic Co.	Market[b] Research Bureau	CTFA	Cosmetic Co.	Market Research Bureau
Powders	2.01	0.18	0.39	--	1.0	1.0	--
Sachets	0.2	0.0061	0.034	--	0.14[e]	0.14[e]	--
Fragrance Lotion	--	0.0061	--	--	0.29[e]	--	--
Hair Conditioners	12.4	0.4	0.40	0.27	1.0	1.0	0.86
Hair Sprays	--	0.25	0.55	0.32	1.0	1.0	1.0
Hair Rinses	12.7	0.064	0.18	--	0.29	1.0	--
Shampoos	16.4	0.82	0.59	0.48	1.0	1.0	1.0
Tonics and Dressings	2.85	0.073	0.021	--	0.29	0.14[e]	--
Wave Sets	2.6	0.003[h]	0.040	--	--[h]	0.14	--
Dentifrices	--	1.62	0.67	2.12	2.6	2.0	4.0
Mouthwashes	--	0.42	0.62	0.58	1.86	1.14	1.5
Breath Fresheners	--	0.052	0.43	0.46	0.14	1.0	0.57
Nail Basecoats	0.23	0.052	0.13	--	0.29	0.29	--
Cuticle Softeners	0.66	0.040	0.10	--	0.14	0.29	--
Nail Creams & Lotions	0.56	0.070	0.14	--	0.29	0.43	--
Nail Extenders	--	0.003	0.013	--	0.14[e]	0.14[e]	--
Nail Polish & Enamel	0.28	0.16	0.20	0.07	0.71	0.43	1.0
Nail Polish & Enamel Remover	3.06	0.088	0.19	--	0.29	0.43	--
Nail Undercoats	--	0.049	0.12	--	0.14	0.29	--
Bath Soaps	2.6	1.53	0.95	--	3.0	1.43	--
Underarm Deodorants	0.52	1.01	0.80	1.10	1.29	1.29	2.0
Douches	--	0.013	0.089	0.085	0.14[e]	0.29	0.29
Feminine Hygiene Deodorants	--	0.021	0.084	0.05	1.0[e]	0.29	0.14
Cleansing Products (cold creams, cleansing lotions liquids & pads)	1.7	0.63	0.80	0.54	1.71	2.0	1.5
Depilatories	--	0.0061	0.051	0.009	0.016	0.14	0.033
Face, Body & Hand Preps (excluding shaving preps)	3.5	0.65	--	1.12	2.0	--	2.14
Foot Powder & Sprays	--	0.061	0.079	--	0.57[e]	0.29	--
Hormones	--	0.012	0.028	--	0.57[e]	0.14[e]	--
Moisturizers	0.53	0.98	0.88	0.63	2.0	1.71	1.5
Night Skin Care Products	1.33	0.18	0.50	--	1.0	1.0	--

Table 15-42. Amount and Frequency of Use of Various Cosmetic and Baby Products (continued)

Product Type	Amount of Product Per Application[a] (g)	Average Frequency of Use (per day)			Upper 90th Percentile Frequency of Use (per day)		
		Survey Type			Survey Type		
		CTFA	Cosmetic Co.	Market[b] Research Bureau	CTFA	Cosmetic Co.	Market Research Bureau
Paste Masks (mud packs)	3.7	0.027	0.20	--	0.14	0.43	--
Skin Lighteners	--	--	0.024	--	--[d]	0.14[d]	--
Skin Fresheners & Astringents	2.0	0.33	0.56	--	1.0	1.43	--
Wrinkle Smoothers (removers)	0.38	0.021	0.15	--	1.0[d]	1.0	--
Facial Cream	0.55	0.0061	--	--	0.0061	--	--
Permanent Wave	101	0.003	--	0.001	0.0082	--	0.005
Hair Straighteners	0.156	0.0007	--	--	0.005[d]	--	--
Hair Dye	--	0.001	--	0.005	0.004[d]	--	0.014
Hair Lighteners	--	0.0003	--	--	0.005[d]	--	--
Hair Bleaches	--	0.0005	--	--	0.02[d]	--	--
Hair Tints	--	0.0001	--	--	0.005[d]	--	--
Hair Rinse (coloring)	--	0.0004	--	--	0.02[d]	--	--
Shampoo (coloring)	--	0.0005	--	--	0.02[d]	--	--
Hair Color Spray	--	--	--	--	--[d]	--	--
Shave Cream	1.73	--	--	0.082	--	--	0.36

[a] Values reported are the averages of the responses reported by the twenty companies interviewed. (--'s) indicate no data available.

[b] The averages shown for the Market Research Bureau are not true averages - this is due to the fact that in many cases the class of most frequent users were indicated by "1 or more" also ranges were used in many cases, i.e., "10-12." The average, therefore, is underestimated slightly. The "1 or more" designation also skew the 90th percentile figures in many instances. The 90th percentile values may, in actuality, be somewhat higher for many products.

[c] Average usage among users only for baby products.

[d] Usage data reflected "entire household" use for both baby lotion and baby oil.

[e] Fewer than 10% of individuals surveyed used these products. Value listed is lowest frequency among individuals reporting usage. In the case of wave sets, skin lighteners, and hair color spray, none of the individuals surveyed by the CTFA used this product during the period of the study.

[f] Usage data reflected "entire household" use.

[g] Usage data reflected total bath product usage.

[h] None of the individuals surveyed reported using this product.

Source: CTFA, 1983.

Table 15-43. Summary of Consumer Products Use Studies

Study	Study Size	Approach	Relevant Population	Comments
KEY STUDIES				
CPSC, 1992	4,997 product interviews; 527 mailed questionnaires	Direct - interviews and questionnaires	Adults	Random digit dialing method used to select sample. Information on use of 3 products containing methyl chloride was requested.
Westat, 1987a	4,920 individuals	Direct - questionnaire	18+ yrs selected to be representative of US population	Waksberg Method (random digit dialing) used to select sample. Respondents asked to recall use in past 2 months of 32 catagories of household products containing methyl chloride.
Westat, 1987b	193 households	Direct - telephone survey; 2 post-survey validation efforts: 30 reinterviewed, then another 50 reeinterviewed	Adult household members who do cleaning tasks in household	Waksberg Method (random digit dialing) used to select sample. Household use of cleaning products requested. Phone survey during end of year holidays may reflect biased usage data. Two validation resurveys conducted 3 months after survey.
Westat, 1987c	777 households	Direct - telephone survey; 1 post-survey validation effort conducted with 30 reinterviewed	Household members who do painting tasks in household	Waksberg Method (random digit dialing) used to select sample. Painting product use information in past 12 months was requested. One validation resurvey conducted 3 months after survey.
Tsang and Klepeis, 1996	9,386 individuals	Direct - interviews and questionnaires	Representative of U.S. general population	National Human Activity Patterns Survey (NHAPS). Participants selected using random Dial Digit (RDD) and Computer Assisted Telephone Interviewing (CATI). 24-hour diary data, and follow-up questions; nationally representative; represent all seasons, age groups, and genders.
RELEVANT STUDY				
CTFA, 1983	Survey 1: 47 women employees and relatives or employees Survey 2: 1,129 cosmetics purchasers Survey 3: 19,035 females	Survey 1: Direct - 1 wk prospective survey Survey 2: Direct - prospective survey Survey 3: Direct - 9.5 months. prospective survey	Survey 1: 16-61 yr old females Survey 2: Customers of cosmetic manufacturer Survey 3: Market research company sampled female consumers nationwide	Interviewees asked to recall their use of cosmetics and some baby products during a specific past time period. Surveys 1 and 2 had small populations, but Survey 3 had large population selected to be representative of U.S. population

APPENDIX 15A
Simmons Market Research Data

Table 15A-1. Volumes Included in 1992 Simmons Study

The volumes included in the Media series are as follows:	
M1	Publications: Total Audiences
M2	Publications: Qualitative Measurements And In-Home Audiences
M3	Publications: Duplication Of Audiences
M4	Multi-Media Audiences: Adults
M5	Multi-Media Audiences: Males
M6	Multi-Media Audiences: Females and Mothers
M7	Business To Business
M8	Multi-Media Reach and Frequency and Television Attentiveness & Special Events
The following volumes are included in the Product series:	
P1	Automobiles, cycles, Trucks & Vans
P2	Automotive Products & Services
P3	Travel
P4	Banking, Investments, Insurance, Credit Cards & Contributions, Memberships & Public Activities
P5	Games & Toys, Children's & Babies' Apparel & Specialty Products
P6	Computers, Books, Discs, Records, Tapes, Stereo, Telephones, TV & Video
P7	Appliances, Garden Care, Sewing & Photography
P8	Home Furnishings & Home Improvements
P9	Sports & Leisure
P10	Restaurants, Stores & Grocery Shopping
P11	Direct Mail & Other In-Home Shopping, Yellow Pages, Florist, Telegrams, Faxes & Greeting Cards
P12	Jewelry, Watches, Luggage, Writing Tools & Men's Apparel
P13	Women's Apparel
P14	Distilled Spirits, Mixed Drinks, Malt Beverages, Wine & Tobacco Products
P15	Coffee, Tea, Cocoa, Milk, Soft Drinks, Juices & Bottled Water
P16	Dairy Products, Desserts, Baking & Bread Products
P17	Cereals & Spreads, Rice, Pasta, Pizza, Mexican Foods, Fruits & Vegetables
P18	Soup, Meat, Fish, Poultry, Condiments & Dressings
P19	Chewing Gum, Candy, Cookies & Snacks
P20	Soap, Laundry, Paper Products & Kitchen Wraps
P21	Household Cleaners, Room Deodorizers, Pest Controls & Pet Foods
P22	Health Care Products & Remedies
P23	Oral Hygiene Products, Skin Care, Deodorants & Drug Stores
P24	Hair Care, Shaving Products & Fragrances
P25	Women's Beauty Aids, Cosmetics & Personal Products
P26	Relative Volume of Consumption

TABLE OF CONTENTS

16. REFERENCE RESIDENCE

16.1. INTRODUCTION

Unlike previous chapters in this handbook which focus on human behavior or characteristics that affect exposure, this chapter focuses on residence characteristics. Assessment of exposure in residential settings requires information on the availability of chemical(s) of concern at the point of exposure, characteristics of the structure and microenvironment that affect exposure, and human presence within the residence. The purpose of this chapter is to provide data that are available on residence characteristics that affect exposure in an indoor environment. Source-receptor relationships in residential exposure scenarios can be complex due to interactions among sources, and transport/transformation processes that result from chemical-specific and building-specific factors. Figure 16-1 illustrates the complex factors that must be considered when conducting exposure assessments in a residential setting. In addition to sources within the building, chemicals of concern may enter the indoor environment from outdoor air, soil, gas, water supply, tracked-in soil, and industrial work clothes worn by the residents. Indoor concentrations are affected by loss mechanisms, also illustrated in Figure 16-1, involving chemical reactions, deposition to surfaces, and transport out of the building. Particle-bound chemicals can enter indoor air through resuspension. Indoor air concentrations of gas-phase organic chemicals are affected by the presence of reversible sinks formed by a wide range of indoor materials. In addition, the activity of human receptors greatly affects their exposure as they move from room to room, entering and leaving the exposure scene.

Inhalation exposure assessments in residential and other indoor settings are modeled by considering the building as an assemblage of one or more well-mixed zones. A zone is defined as one room, a group of interconnected rooms, or an entire building. This macroscopic level, well-mixed perspective forms the basis for interpretation of measurement data as well as simulation of hypothetical scenarios. Exposure assessment models on a macroscopic level incorporate important physical factors and processes. These well-mixed, macroscopic models have been used to perform indoor air quality simulations (Axley, 1989), as well as indoor air exposure assessments (McKone, 1989; Ryan, 1991). Nazzaroff and Cass (1986) and Wilkes et al. (1992) have used code-intensive computer programs featuring finite difference or finite element numerical techniques to model

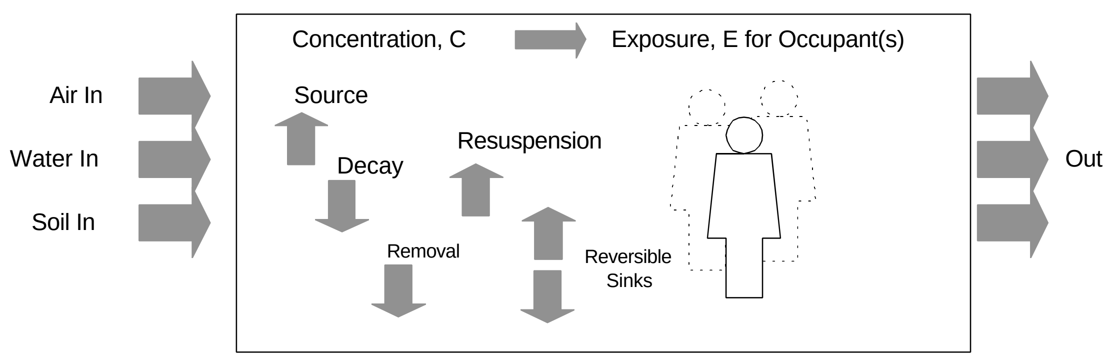


Figure 16-1. Elements of Residential Exposure

mass balance. A simplified approach using desk top spreadsheet programs has been used by Jennings et al. (1985).

In order to model mass balance of indoor contaminants, the indoor air volume is represented as a network of interconnected zones. Because conditions in a given zone are determined by interactions with other connecting zones, the multizone model is stated as a system of simultaneous equations. The mathematical framework for modeling indoor air has been reviewed by Sinden (1978) and Sandberg (1984).

Indoor air quality models typically are not software products that can be purchased as "off-the-shelf" items. Most existing software models are research tools that have been developed for specific purposes and are being continuously refined by researchers. Leading examples of indoor air models implemented as software products are as follows:

- CONTAM -- developed at the National Institute of Standards and Technology (NIST) with support from U.S. EPA and the U.S. Department of Energy (DOE) (Axley, 1988; Grot, 1991; Walton, 1993);

- EXPOSURE -- developed at the Indoor Air Branch of U.S. EPA Air and Energy Engineering Research Laboratory (EPA/AEERL) (Sparks, 1988, 1991);

- MCCEM -- the Multi-Chamber Consumer Exposure Model developed for U.S EPA Office of Pollution Prevention and Toxics (EPA/OPPT) (GEOMET, 1989; Koontz and Nagda, 1991); and

- THERdbASE -- the Total Human Exposure Relational Data Base and Advanced Simulation Environment software developed by researchers at the Harry Reid Center for Environmental Studies at University Nevada, Las Vegas (UNLV) (Pandian et al., 1993).

Section 16.2 of this chapter summarizes existing data on building characteristics (volumes, surface areas, mechanical systems, and types of foundations). Section 16.3 summarizes transport phenomena that affect chemical transport (airflow, chemical-specific deposition and filtration, and effects of water supply and soil tracking). Section 16.4 provides information on various types of indoor sources associated with airborne exposure, waterborne sources, and soil/house dust sources. Section 16.5 summarizes advanced concepts.

16.2. BUILDING CHARACTERISTICS

16.2.1. Volumes of Residences

Key Volumes of Residence Studies

U.S. DOE (1995) - Housing Characteristics 1995, Residential Energy Consumption Survey (RECS) - Measurement surveys have not been conducted to directly characterize the range and distribution of volumes for a random sample of U.S. residences. Related data, however, are regularly collected through the U.S. Department of Energy's Residential Energy Consumption Survey (U.S. DOE, 1995). In addition to collecting information on energy use, this triennial survey collects data on housing characteristics including direct measurements of total and heated floor space for buildings visited by survey specialists. For the most recent survey (1993), a multistage probability sample of over 7,000 residences was surveyed, representing 96 million residences nationwide. The survey response rate was 81.2 percent.

Volumes were estimated from the RECS measurements by multiplying the heated floor space area by an assumed ceiling height of 8 feet, recognizing that this assumed height may not apply universally to all homes. Results for residential volume distributions from this survey (Thompson, 1995) are presented in Table 16-1. The RECS also provides relationships between average residential volumes and factors such as housing type, ownership, household size and structure age. The predominant housing type--single-family detached homes--also has the largest average volume (Table 16-2).

Table 16-1. Summary of Residential Volume Distributions in Cubic Meters[a]

Parameter	RECS[1]	PFT Database[2]
Arithmetic Mean	369	369
Standard Deviation	258	209
10th Percentile	147	167
25th Percentile	209	225
50th Percentile	310	321
75th Percentile	476	473
90th Percentile	672	575

[a] In cubic meters
Sources: (1) Thompson, 1995;(2) Versar, 1990

Table 16-2. Average Estimated Volumes of U.S. Residences, by Housing Type and Ownership

	Ownership					
	Owner-Occupied		Rental		All Units	
Housing Type	Volume[a] (m^3)	Percent of Total	Volume[a] (m^3)	Percent of Total	Volume[a] (m^3)	Percent of Total
Single-Family Detached	471	53.1	323	8.5	451	61.7
Single-Family (Attached)	406	4.6	291	2.9	362	7.5
Multifamily (2-4 units)	362	1.6	216	6.7	243	8.3
Multifamily (5+ Units)	241	1.7	183	15.2	190	16.8
Mobile Home	221	4.6	170	1.2	210	5.8
All Types	441	65.4	233	34.6	369	100.0

[a] Volumes calculated from floor areas assuming a ceiling height of 8 feet.
Source: Adapted from U.S. DOE, 1995.

Multifamily units and mobile homes have volumes averaging about half that of single-family detached homes, with single-family attached homes about halfway between these extremes. Within each category of housing type, owner-occupied residences average about 50 percent greater volume than rental units. The relationship of residential volume to household size (Table 16-3) is of particular interest for purposes of exposure assessment. For example, one-person households would not include children, and the data in the table indicate that multi-person households occupy residences averaging about 50 percent greater volume than residences occupied by one-person households.

Data on year of construction indicate a slight decrease in residential volumes between 1950 and 1984, followed by an increasing trend over the next decade. A ceiling height of 8 feet was assumed in estimating the average volumes, whereas there may have been some time-related trends in ceiling height.

Versar (1990) - Database on Perfluorocarbon Tracer (PFT) Measurements - A database of time-averaged air exchange and interzonal airflow measurements in more than 4,000 residences has been compiled by Versar (1990) to allow researchers to access these data (see Section 16.3.2). These data were collected between 1982 and 1987. The residences that appear in this database are not a random sample of U.S. homes, however, they do represent a compilation of homes visited in about 100 different field studies, some of which involved random sampling. In each study, the house volumes were directly measured or estimated. The collective homes visited in these field projects are not geographically balanced; a large fraction of these homes are located in southern California.

Table 16-3. Residential Volumes in Relation to Household Size and Year of Construction

	Volume[a] (m^3)	Percent of Total
Household Size		
1 Person	269	24.3
2 Persons	386	32.8
3 Persons	387	17.2
4 Persons	431	15.1
5 Persons	433	7.0
6 or More Persons	408	3.6
All Sizes	369	100.0
Year of Construction		
1939 or before	385	21.1
1940 to 1949	338	7.1
1950 to 1959	365	13.5
1960 to 1969	358	15.5
1970 to 1979	350	18.7
1980 to 1984	344	8.8
1985 to 1987	387	5.7
1988 to 1990	419	4.9
1991 to 1993	438	4.7
All Years	369	100.0

[a] Volumes calculated from floor areas assuming a ceiling height of 8 feet.
Source: U.S. DOE, 1995.

Statistical weighting techniques were applied in developing estimates of nationwide distributions (see Section 16.3.2) to compensate for the geographic imbalance.

Estimated parameters of residential volume distributions (in cubic meters) from the PFT database are also summarized in Table 16-1. Additionally, they are compared to the RECS data. The arithmetic means from the two sources are identical (369 cubic meters). The medians (50th percentiles) are very similar: 310 cubic meters for the U.S. DOE survey, and 321 cubic meters for the PFT database. Cumulative frequency distributions from the two sources (Figure 16-2) also are quite similar, especially between the 50th and 75th percentiles.

Murray (1996) - Analysis of RECS and PFT Databases. Using a database from the 1993 RECS and an assumed ceiling height of 8 feet, Murray (1996) estimated a mean residential volume of 382 m^3 using RECS estimates of heated floor space. This estimate is slightly different from the mean of 369 m^3 given in Table 16-1. His sensitivity analysis indicated that when a fixed ceiling height of 8 feet was replaced with a randomly varying height with a mean of 8 feet, there was little effect on the standard deviation of the estimated distribution. From a separate analysis of the PFT database based on 1,751 individual household measurements, Murray estimated an average volume of 369 m^3, the same as previously given in Table 16-1. In performing this analysis, the author carefully reviewed the PFT database in an effort to use each residence only once, for those residences thought to have multiple PFT measurements.

16.2.2. Volumes and Surface Areas of Rooms

Room Volumes - Volumes of individual rooms are dependent on the building size and configuration, and summary data are not readily available. The exposure assessor is advised to define specific rooms, or assemblies of rooms, that best fit the scenario of interest. Most

Figure 16-2. Cumulative Frequency Distributions for Residential Volumes.

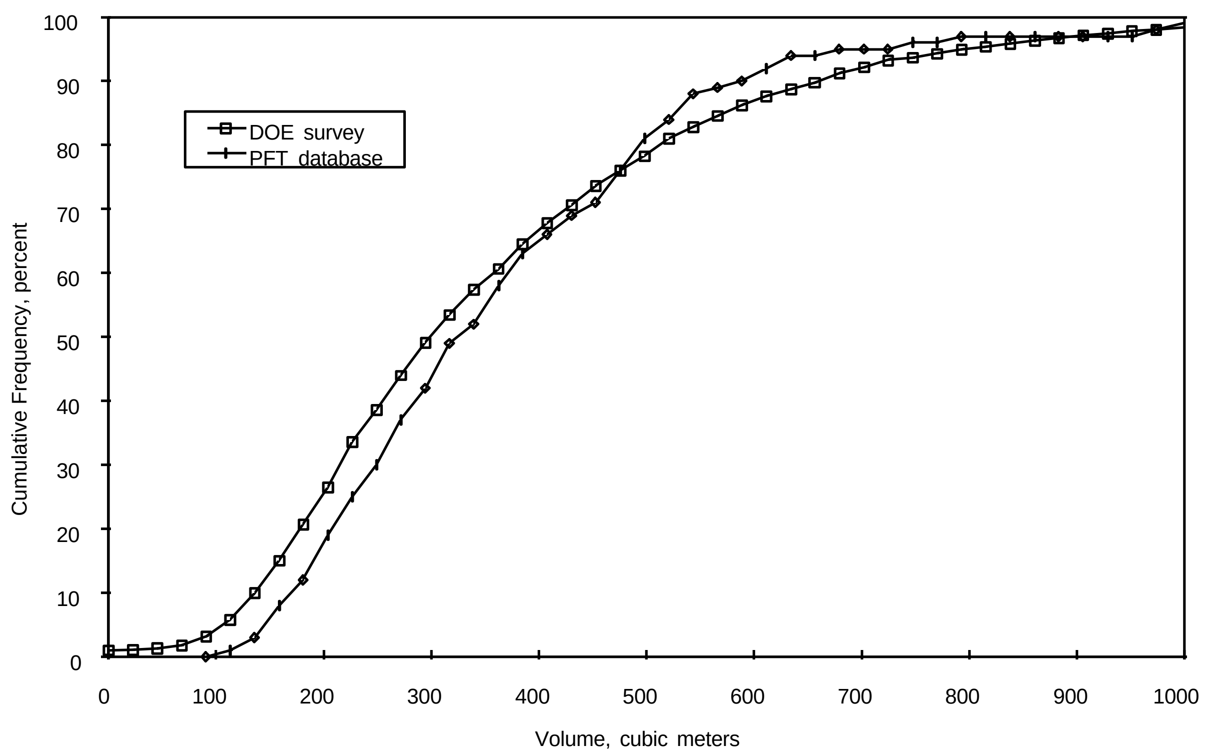


Figure 16-2. Cumulative Frequency Distributions for Residential Volumes

models for predicting indoor-air concentrations specify airflows in cubic meters per hour and, correspondingly, express volumes in cubic meters. A measurement in cubic feet can be converted to cubic meters by multiplying the value by 0.0283 inches. For example, a bedroom that is 9' wide by 12' long by 8' high has a volume of 864 cubic feet or 24.5 cubic meters. Similarly, a living room with dimensions of 12' wide x 20' long x 8' high has a volume of 1920 cubic feet or 54.3 cubic meters, and a bathroom with dimensions of 5' x 12' x 8' has a volume of 480 cubic feet or 13.6 cubic meters.

area-to-volume, or loading, ratio. Table 16-4 provides the basis for calculating loading ratios for typical sized rooms. Constant features in the examples are: a room width of 12 feet and a ceiling height of 8 feet (typical for residential buildings) or ceiling height 12 feet (typical for commercial buildings). The loading ratios for the 8-foot ceiling height range from 0.98 m^2m^{-3} to 2.18 m^2m^{-3} for wall area and from 0.36 m^2m^{-3} to 0.44 m^2m^{-3} for floor area. In comparison, ASTM Standard E 1333 (ASTM, 1990), for large-chamber testing of formaldehyde levels from wood products, specifies the following loading ratios: (1) 0.95 m^2m^{-3} for testing plywood (assumes plywood or paneling on all four walls of a typical size room); and (2) 0.43 m^2m^{-3} for testing particleboard (assumes that particleboard decking or underlayment would be used as a substrate for the entire floor of a structure).

Table 16-4. Dimensional Quantities for Residential Rooms

Nominal Dimensions	Length (m)	Width (m)	Height (m)	Volume (m^3)	Wall Area (m^2)	Floor Area (m^2)	Total Area (m^2)
Eight Foot Ceiling							
12’x15’	4.6	3.7	2.4	41	40	17	74
12’x12’	3.7	3.7	2.4	33	36	13	62
10’x12’	3.0	3.7	2.4	27	33	11	55
9’x12’	2.7	3.7	2.4	24	31	10	51
6’x12’	1.8	3.7	2.4	16	27	7	40
4’x12’	1.2	3.7	2.4	11	24	4	32
Twelve Foot Ceiling							
12’x15’	4.6	3.7	3.7	61	60	17	94
12’x12’	3.7	3.7	3.7	49	54	13	80
10’x12’	3.0	3.7	3.7	41	49	11	71
9’x12’	2.7	3.7	3.7	37	47	10	67
6’x12’	1.8	3.7	3.7	24	40	7	54
4’x12’	1.2	3.7	3.7	16	36	4	44

Murray (1996) analyzed the distribution of selected residential zones (i.e., a series of connected rooms) using the PFT database. The author analyzed the "kitchen zone" and the "bedroom zone" for houses in the Los Angeles area that were labeled in this manner by field researchers, and "basement," "first floor" and "second floor" zones for houses outside of Los Angeles for which the researchers labeled individual floors as zones. The kitchen zone contained the kitchen in addition to any of the following associated spaces: utility room, dining room, living room and family room. The bedroom zone contained all the bedrooms plus any bathrooms and hallways associated with the bedrooms. The following summary statistics (mean ± standard deviation) were reported by Murray (1996) for the volumes of the zones described above: 199 ± 115 m^3 for the kitchen zone, 128 ± 67 m^3 for the bedroom zone, 205 ± 64 m^3 for the basement, 233 ± 72 m^3 for the first floor, and 233 ± 111 m^3 for the second floor.72

Surface Areas - The surface areas of floors are commonly considered in relation to the room or house volume, and their relative loadings expressed as a surface

Products and Materials - Table 16-5 presents examples of assumed amounts of selected products and materials used in constructing or finishing residential surfaces (Tucker, 1991). Products used for floor surfaces include adhesive, varnish and wood stain; and materials used for walls include paneling, painted gypsum board, and wallpaper. Particleboard and chipboard are commonly used for interior furnishings such as shelves or cabinets, but could also be used for decking or underlayment. It should be noted that numbers presented in Table 16-5 for surface area are based on typical values for residences, and they are presented as examples. In contrast to the concept of loading ratios presented above (as a surface area), the numbers in Table 16-5 also are not scaled to any particular residential volume. In some cases it may be preferable for the exposure assessor to use professional judgment in combination with the loading ratios given above. For example, if the exposure scenario involved residential carpeting, either as an indoor source or as an indoor sink, then the ASTM loading ratio of 0.43 m^2m^{-3} for floor materials could be multiplied by an assumed residential volume and assumed fractional coverage of carpeting to derive an estimate of the surface area. More specifically, a residence with a volume of 300 m^3, a loading ratio of 0.43 m^2m^{-3} and coverage of 80% would have 103 m^2 of carpeting. The estimates discussed here relate to macroscopic surfaces; the true surface area for carpeting, for example, would be considerably larger because of the nature of its fibrous material.

Table 16-5. Examples of Products and Materials Associated with Floor and Wall Surfaces in Residences

Material Sources	Assumed Amount of Surface Covered[a]
Silicone caulk	0.2 m^2
Floor adhesive	10.0 m^2
Floor wax	50.0 m^2
Wood stain	10.0 m^2
Polyurethane wood finish	10.0 m^2
Floor varnish or lacquer	50.0 m^2
Plywood paneling	100.0 m^2
Chipboard	100.0 m^2
Gypsum board	100.0 m^2
Wallpaper	100.0 m^2

[a] Based on typical values for a residence.
Source: Adapted from Tucker, 1991.

Furnishings - Information on the relative abundance of specific types of indoor furnishings, such as draperies or upholstered furniture, was not readily available. The exposure assessor is advised to rely on common sense and professional judgment. For example, the number of beds in a residence is usually related to household size, and information has been provided (Table 16-3) on average house volume in relation to household size.

16.2.3. Mechanical System Configurations

Mechanical systems for air movement in residences can affect the migration and mixing of pollutants released indoors and the rate of pollutant removal. Three types of mechanical systems are: (1) systems associated with heating and air conditioning (HAC); (2) systems whose primary function is providing localized exhaust; and (3) systems intended to increase the overall air exchange rate of the residence.

Portable space heaters intended to serve a single room, or a series of adjacent rooms, may or may not be equipped with blowers that promote air movement and mixing. Without a blower, these heaters still have the ability to induce mixing through convective heat transfer. If the heater is a source of combustion pollutants, as with unvented gas or kerosene space heaters, then the combination of convective heat transfer and thermal buoyancy of combustion products will result in fairly rapid dispersal of such pollutants. The pollutants will disperse throughout the floor where the heater is located and to floors above the heater, but will not disperse to floors below.

Central forced-air HAC systems are common in many residences. Such systems, through a network of supply/return ducts and registers, can achieve fairly complete mixing within 20 to 30 minutes (Koontz et al., 1988). The air handler for such systems is commonly equipped with a filter (see Figure 16-3) that can remove particle-phase contaminants. Further removal of particles, via deposition on various room surfaces (see Section 16.3.2), is accomplished through increased air movement when the air handler is operating.

Figure 16-3. Configuration for Residential Forced-air Systems

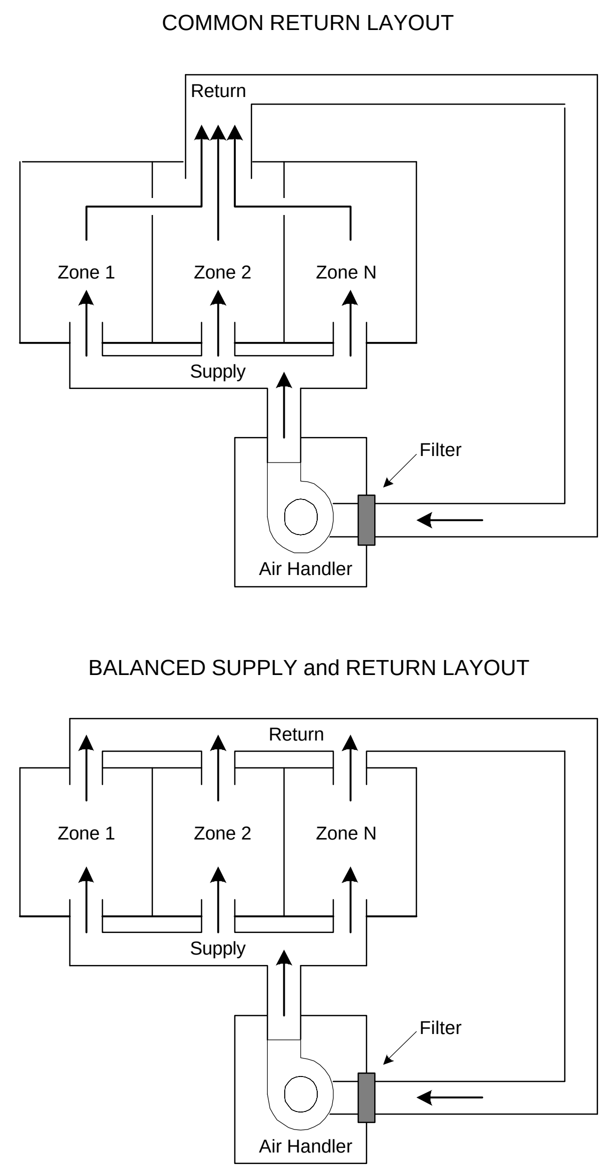


Figure 16-3. Configuration for Residential Forced-air Systems

Figure 16-3 also distinguishes forced-air HAC systems by the return layout in relation to supply registers. The return layout shown in the upper portion of the figure is the type most commonly found in residential settings. On any floor of the residence, it is typical to find one or more supply registers to individual rooms, with one or two centralized return registers. With this layout, supply/return imbalances can often occur in individual rooms, particularly if the interior doors to rooms are closed. In comparison, the supply/return layout shown in the lower portion of the figure by design tends to achieve a balance in individual rooms or zones. Airflow imbalances can also be caused by inadvertent duct leakage to unconditioned spaces such as attics, basements, and crawl spaces. Such imbalances usually depressurize the house, thereby increasing the likelihood of contaminant entry via soil-gas transport or through spillage of combustion products from vented fossil-fuel appliances such as fireplaces and gas/oil furnaces.

Mechanical devices such as kitchen fans, bathroom fans, and clothes dryers are intended primarily to provide localized removal of unwanted heat, moisture, or odors. Operation of these devices tends to increase the air exchange rate between the indoors and outdoors. Because local exhaust devices are designed to be near certain indoor sources, their effective removal rate for locally generated pollutants is greater than would be expected from the dilution effect of increased air exchange. Operation of these devices also tends to depressurize the house, because replacement air usually is not provided to balance the exhausted air.

An alternative approach to pollutant removal is one which relies on an increase in air exchange to dilute pollutants generated indoors. This approach can be accomplished using heat recovery ventilators (HRVs) or energy recovery ventilators (ERVs). Both types of ventilators are designed to provide balanced supply and exhaust airflows and are intended to recover most of the energy that normally is lost when additional outdoor air is introduced. Although ventilators can provide for more rapid dilution of internally generated pollutants, they also increase the rate at which outdoor pollutants are brought into the house. A distinguishing feature of the two types is that ERVs provide for recovery of latent heat (moisture) in addition to sensible heat. Moreover, ERVs typically recover latent heat using a moisture-transfer device such as a desiccant wheel. It has been observed in some studies that the transfer of moisture between outbound and inbound air streams can result in some re-entrainment of indoor pollutants that otherwise would have been exhausted from the house (Anderson et al., 1993). Inadvertent air communication between the supply and exhaust air streams can have a similar effect.

Studies quantifying the effect of mechanical devices on air exchange using tracer-gas measurements are uncommon and typically provide only anecdotal data. The common approach is for the expected increment in the air exchange rate to be estimated from the rated airflow capacity of the device(s). For example, if a device with a rated capacity of 100 cubic feet per minute (cfm), or 170 cubic meters per hour, is operated continuously in a house with a volume of 400 cubic meters, then the expected increment in the air exchange rate of the house would be 170 $m^3 h^{-1}$ / 400 m^3, or approximately 0.4 air changes per hour.

16.2.4. Type of Foundation

The type of foundation of a residence is of interest in residential exposure assessment. It provides some indication of the number of stories and house configuration, and provides an indication of the relative potential for soil-gas transport. For example, such transport can occur readily in homes with enclosed crawl spaces, and homes with basements provide some resistance but still have numerous pathways for soil-gas entry. By comparison, homes with crawl spaces open to the outside have significant opportunities for dilution of soil gases prior to transport into the house.

U.S. DOE (1995) - Housing Characteristics in 1995 - Residential Energy Consumption Survey (RECS) - The most recent RECS (described in Section 16.2.1) was administered in 1993 to over 7,000 households (U.S. DOE, 1995). The type of information requested by the survey questionnaire included was the type of foundation for the residence (i.e., basement, enclosed crawl space, crawl space open to outside or concrete slab). This information was not obtained for multifamily structures with five or more dwelling units and for mobile homes. Table 16-6 presents estimates from the survey of the percentage of residences with each foundation type, by census region, and for the entire U.S. The percentages can add to more than 100 percent because some residences have more than one type of foundation; for example, most split-level structures have a partial basement combined with some crawlspace that typically is enclosed.

The data in Table 16-6 indicate that close to half (45 percent) of residences nationwide have a basement, and that fewer than 10 percent have a crawl space that is open to outside. It also shows that a large fraction of homes have concrete slabs (31 percent). There are also

Table 16-6. Percent of Residences With Certain Foundation Types[a],

Census Region	Percent of Residences			
	Basement	Enclosed Crawlspace	Crawlspace Open to Outside	Concrete Slab
Northeast	78.0	12.6	2.8	15.8
Midwest	78.1	19.5	5.6	14.7
South	18.6	31.8	11.0	44.6
West	19.4	36.7	8.1	43.5
All Regions	45.2	26.0	7.5	31.3

[a] Percentage may add to more than 100 percent because more than one foundation type may apply to a given residence.
Source: U.S. DOE, 1995.

variations by census region. For example, nearly 80 percent of the residences in the Northeast and Midwest regions have basements. In the South and West regions, the predominant foundation types are concrete slabs and enclosed crawl spaces.

National Residential Radon Survey - The survey, sponsored by the U.S. EPA, was conducted by Lucas et al. (1992) in about 5,700 households nationwide. In addition to radon measurements, a number of housing characteristics were collected, including whether each house had a basement. The estimated percentage of homes in the U.S. having basements (Table 16-7) from this survey is the same as found by the RECS (Table 16-6).

Table 16-7. Percent of Residences with Basement, by EPA Region

Region	Percent of Residences with Basements
1	93.4
2	55.9
3	67.9
4	19.3
5	73.5
6	4.1
7	75.3
8	68.5
9	10.3
10	11.5
All Regions	45.2

Source: Lucas et al., 1992.

The radon survey provides data for more refined geographical areas, with a breakdown by the 10 EPA Regions. The New England region, which includes Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont, had the highest prevalence of basements (93 percent). The lowest prevalence (4 percent) was for the South Central region, which includes Arkansas, Louisiana, New Mexico, Oklahoma and Texas. Figure 16-4 illustrates the 10 EPA Regions and the 4 Census Regions.

16.3. TRANSPORT RATES

16.3.1. Background

Major air transport pathways for airborne substances in residences include the following:

- Air exchange - Air leakage through windows, doorways, intakes and exhausts, and "adventitious openings" (i.e., cracks and seams) that combine to form the leakage configuration of the building envelope plus natural and mechanical ventilation;

- Interzonal airflows - Transport through doorways, ductwork, and service chaseways that interconnect rooms or zones within a building; and

- Local circulation - Convective and adjective air circulation and mixing within a room or within a zone.

The distribution of airflows across the building envelope that contribute to air exchange and the interzonal airflows along interior flowpaths is determined by the interior pressure distribution. The forces causing the airflows are temperature differences, the actions of wind, and mechanical ventilation systems. Basic concepts have been reviewed by ASHRAE (1993). Indoor-outdoor and room-to-room temperature differences create density

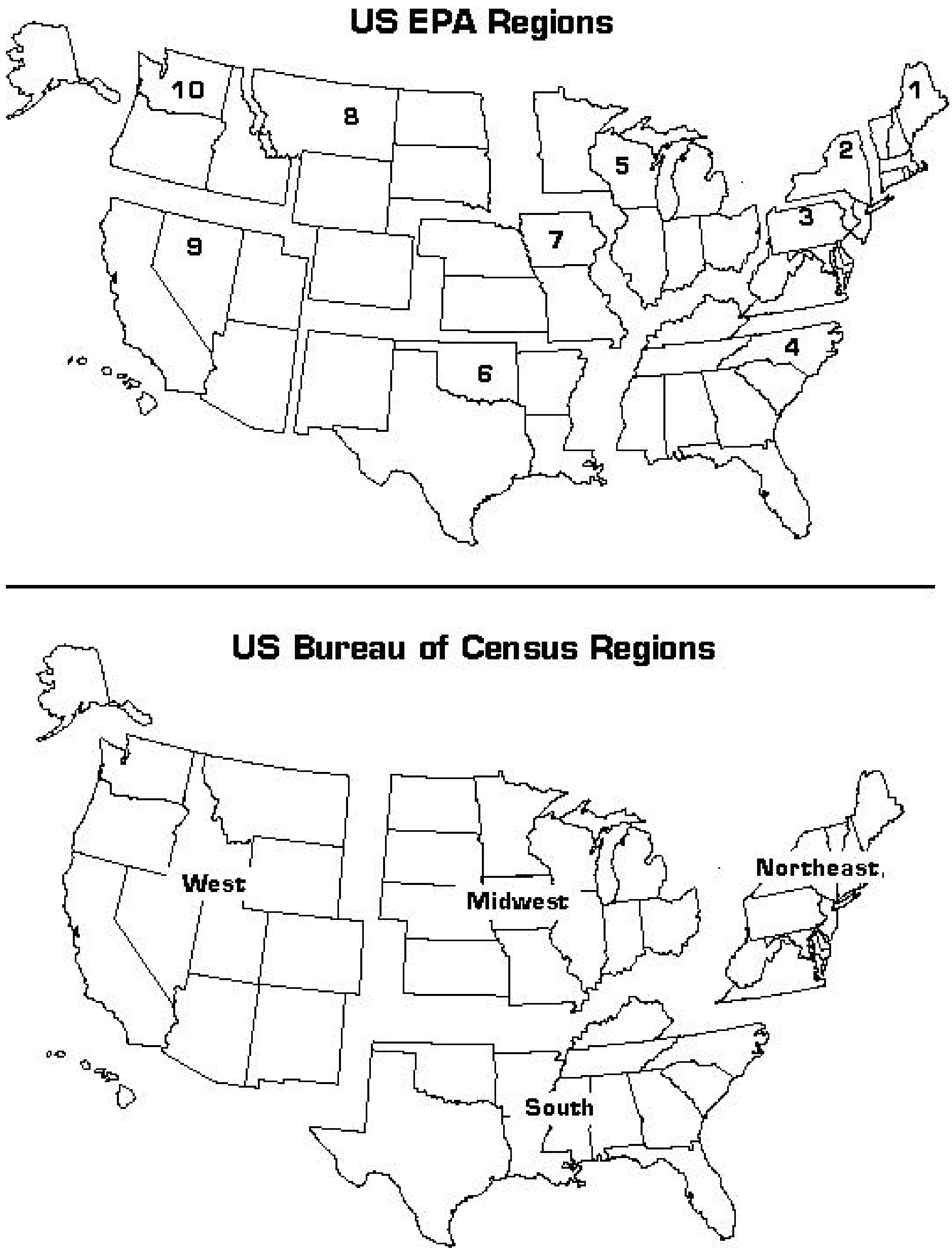


Figure 16-4. EPA Regions and Census Regions

differences that help determine basic patterns of air motion. During the heating season, warmer indoor air tends to rise to exit the building at upper levels by stack action. Exiting air is replaced at lower levels by an influx of colder outdoor air. During the cooling season, this pattern is reversed: stack forces during the cooling season are generally not as strong as in the heating season because the indoor-outdoor temperature differences are not pronounced.

The position of the neutral pressure level (i.e., the point where indoor-outdoor pressures are equal) depends on the leakage configuration of the building envelope. The stack effect arising from indoor-outdoor temperature differences is also influenced by the partitioning of the building interior. When there is free communication between floors or stories, the building behaves as a single volume affected by a generally rising current during the heating season and a generally falling current during the cooling season. When vertical communication is restricted, each level essentially becomes an independent zone. As the wind flows past a building, regions of positive and negative pressure (relative to indoors) are created within the building; positive pressures induce an influx of air, whereas negative pressures induce an outflow. Wind effects and stack effects combine to determine a net inflow or outflow.

The final element of indoor transport involves the actions of mechanical ventilation systems that circulate indoor air through the use of fans. Mechanical ventilation systems may be connected to heating/cooling systems that, depending on the type of building, recirculate thermally treated indoor air or a mixture of fresh air and recirculated air. Mechanical systems also may be solely dedicated to exhausting air from a designated area, as with some kitchen range hoods and bath exhausts, or to recirculating air in designated areas as with a room fan. Local air circulation also is influenced by the movement of people and the operation of local heat sources.

16.3.2. Air Exchange Rates

Air exchange is the balanced flow into and out of a building, and is composed of three processes: (1) infiltration - air leakage through random cracks, interstices and other unintentional openings in the building envelope; (2) natural ventilation - airflows through open windows, doors, and other designed openings in the building envelope; and (3) forced or mechanical ventilation - controlled air movement driven by fans. For nearly all indoor exposure scenarios, air exchange is treated as the principal means of diluting indoor concentrations because outdoor levels are generally assumed to be zero. The air exchange rate is generally expressed in terms of air changes per hour (ACH, with units of h^{-1}), the ratio of the airflow ($m^3 h^{-1}$) to the volume (m^3).

No measurement surveys have been conducted to directly evaluate the range and distribution of residential air exchange rates. Although a significant number of air exchange measurements have been carried out over the years, there has been a diversity of protocols and study objectives. Since the early 1980s, however, an inexpensive perfluorocarbon tracer (PFT) technique has been used to measure time-averaged air exchange and interzonal airflows in thousands of occupied residences using essentially similar protocols (Dietz et al., 1986). The PFT technique utilizes miniature permeation tubes as tracer emitters and passive samplers to collect the tracers. The passive samplers are returned to the laboratory for analysis by gas chromatography. These measurement results have been compiled to allow various researchers to access the data (Versar, 1990).

Key Air Exchange Rate Studies

Versar (1990) - Database of PFT Ventilation Measurements - The residences included in the PFT database do not constitute a random sample across the United States. They represent a compilation of homes visited in the course of about 100 separate field-research projects by various organizations, some of which involved random sampling and some of which involved judgmental or fortuitous sampling. The larger projects in the PFT database are summarized in Table 16-8, in terms of the number of measurements (samples), states where, and months when, samples were taken, and summary statistics for their respective distributions of measured air exchange rates. For selected projects (LBL, RTI, SOCAL), multiple measurements were taken for the same house, usually during different seasons. A large majority of the measurements are from the SOCAL project that was conducted in Southern California. The means of the respective studies generally range from 0.2 to 1.0 ACH, with the exception of two California projects--RTI2 and SOCAL2. Both projects involved measurements in Southern California during a time of year (July) when windows would likely be opened by many occupants.

Koontz and Rector (1995) - Estimation of Distributions for Residential Air Exchange Rates - In analyzing the composite data from various projects (2,971 measurements), Koontz and Rector (1995) assigned weights to the results from each state to compensate for the geographic imbalance in locations where PFT measurements were taken. The results were weighted in

Table 16-8. Summary of Major Projects Providing Air Exchange Measurements in the PFT Database

Project Code	State	Month(s)[a]	Number of Measurements	Mean Air Exchange Rate	SD[b]	Percentiles				
						10th	25th	50th	75th	90th
ADM	CA	5-7	29	0.70	0.52	0.29	0.36	0.48	0.81	1.75
BSG	CA	1,8-12	40	0.53	0.30	0.21	0.30	0.40	0.70	0.90
GSS	AZ	1-3,8-9	25	0.39	0.21	0.16	0.23	0.33	0.49	0.77
FLEMING	NY	1-6,8-12	56	0.24	0.28	0.05	0.12	0.22	0.29	0.37
GEOMET1	FL	1,6-8,10-12	18	0.31	0.16	0.15	0.18	0.25	0.48	0.60
GEOMET2	MD	1-6	23	0.59	0.34	0.12	0.29	0.65	0.83	0.92
GEOMET3	TX	1-3	42	0.87	0.59	0.33	0.51	0.71	1.09	1.58
LAMBERT1	ID	2-3,10-11	36	0.25	0.13	0.10	0.17	0.23	0.33	0.49
LAMBERT2	MT	1-3,11	51	0.23	0.15	0.10	0.14	0.19	0.26	0.38
LAMBERT3	OR	1-3,10-12	83	0.46	0.40	0.19	0.26	0.38	0.56	0.80
LAMBERT4	WA	1-3,10-12	114	0.30	0.15	0.14	0.20	0.30	0.39	0.50
LBL1	OR	1-4,10-12	126	0.56	0.37	0.28	0.35	0.45	0.60	1.02
LBL2	WA	1-4,10-12	71	0.36	0.19	0.18	0.25	0.32	0.42	0.52
LBL3	ID	1-5,11-12	23	1.03	0.47	0.37	0.73	0.99	1.34	1.76
LBL4	WA	1-4,11-12	29	0.39	0.27	0.14	0.18	0.36	0.47	0.63
LBL5	WA	2-4	21	0.36	0.21	0.13	0.19	0.30	0.47	0.62
LBL6	ID	3-4	19	0.28	0.14	0.11	0.17	0.26	0.38	0.55
NAHB	MN	1-5,9-12	28	0.22	0.11	0.11	0.16	0.20	0.24	0.38
NYSDH	NY	1-2,4,12	74	0.59	0.37	0.28	0.37	0.50	0.68	1.07
PEI	MD	3-4	140	0.59	0.45	0.15	0.26	0.49	0.83	1.20
PIERCE	CT	1-3	25	0.80	1.14	0.20	0.22	0.38	0.77	2.35
RTI1	CA	2	45	0.90	0.73	0.38	0.48	0.78	1.08	1.52
RTI2	CA	7	41	2.77	2.12	0.79	1.18	2.31	3.59	5.89
RTI3	NY	1-4	397	0.55	0.37	0.26	0.33	0.44	0.63	0.94
SOCAL1	CA	3	551	0.81	0.66	0.29	0.44	0.66	0.94	1.43
SOCAL2	CA	7	408	1.51	1.48	0.35	0.59	1.08	1.90	3.11
SOCAL3	CA	1	330	0.76	1.76	0.26	0.37	0.48	0.75	1.11
UMINN	MN	1-4	35	0.36	0.32	0.17	0.20	0.28	0.40	0.56
UWISC	WI	2-5	57	0.82	0.76	0.22	0.33	0.55	1.04	1.87

[a] 1 = January, 2 = February, etc.
[b] Standard deviation
Source: Adapted from Versar, 1990.

such a way that the resultant number of cases would represent each state in proportion to its share of occupied housing units, as determined from the 1990 census of population and housing.

Summary statistics from the Koontz and Rector analysis are shown in Table 16-9, for the country as a whole and by census regions. Based on the statistics for all regions combined, the authors suggested that a 10th percentile value of 0.18 ACH would be appropriate as a conservative estimator for air exchange in residential settings, and that the 50th percentile value of 0.45 ACH would be appropriate as a typical air exchange rate. In applying conservative or typical values of air exchange rates, it is important to realize the limitations of the underlying data base. Although the estimates are based on thousands of measurements, the residences represented in the database are not a random sample of the United States housing stock. The sample population is not balanced in terms of geography or time of year. Statistical techniques were applied to compensate for some of these imbalances. Despite such limitations, the estimates in Table 16-9 are believed to represent the best available information on the distribution of air exchange rates across United States residences throughout the year.

Table 16-9. Summary Statistics for Air Exchange Rates (Air Changes Per Hour-ACH), by Region					
	West Region	North Central Region	Northeast Region	South Region	All Regions
Arithmetic Mean	0.66	0.57	0.71	0.61	0.63
Arithmetic Standard Deviation	0.87	0.63	0.60	0.51	0.65
Geometric Mean	0.47	0.39	0.54	0.46	0.46
Geometric Standard Deviation	2.11	2.36	2.14	2.28	2.25
10th Percentile	0.20	0.16	0.23	0.16	0.18
50th Percentile	0.43	0.35	0.49	0.49	0.45
90th Percentile	1.25	1.49	1.33	1.21	1.26
Maximum	23.32	4.52	5.49	3.44	23.32

Source: Koontz and Rector, 1995.

Murray and Burmaster (1995) - Residential Air Exchange Rates in the United States: Empirical and Estimated Parametric Distribution by Season and Climatic Region - Murray and Burmaster (1995) analyzed the PFT database using 2,844 measurements (essentially the same cases as analyzed by Koontz and Rector (1995), but without the compensating weights). These authors summarized distributions for subsets of the data defined by climate region and season. The coldest region was defined as having 7,000 or more heating degree days, the colder region as 5,500-6,999 degree days, the warmer region as 2,500-5,499 degree days, and the warmest region as fewer than 2,500 degree days. The months of December, January and February were defined as winter, March, April and May were defined as spring, and so on. Their results are summarized in Table 16-10. Neglecting the summer results in the colder regions which have only a few observations, the results indicate that the highest air exchange rates occur in the warmest climate region during the summer. The lowest rates generally occur in the colder regions during the fall.

Relevant Air Exchange Rate Study

Nazaroff et al. (1988) - Prior to the Koontz and Rector (1993) study, Nazaroff et al. (1988) aggregated the data from two studies conducted earlier on tracer-gas decay. At the time these studies were conducted, they were the largest U.S. studies to include air exchange measurements. The first (Grot and Clark, 1981) was conducted in 255 dwellings occupied by low-income families in 14 different cities. The geometric mean ±

Table 16-10. Regional and Seasonal Distributions for Residential Air Exchange Rates[a]

Climatic Region	Season	Sample Size	Arithmetic Mean	Standard Deviation	Percentiles 10th	25th	50th	75th	90th
Coldest	Winter	161	0.36	0.28	0.11	0.18	0.27	0.48	0.71
	Spring	254	0.44	0.31	0.18	0.24	0.36	0.53	0.80
	Summer	5	0.82	0.69	0.27	0.41	0.57	1.08	2.01
	Fall	47	0.25	0.12	0.10	0.15	0.22	0.34	0.42
Colder	Winter	428	0.57	0.43	0.21	0.30	0.42	0.69	1.18
	Spring	43	0.52	0.91	0.13	0.21	0.24	0.39	0.83
	Summer	2	1.31	--	--	--	--	--	--
	Fall	23	0.35	0.18	0.15	0.22	0.33	0.41	0.59
Warmer	Winter	96	0.47	0.40	0.19	0.26	0.39	0.58	0.78
	Spring	165	0.59	0.43	0.18	0.28	0.48	0.82	1.11
	Summer	34	0.68	0.50	0.27	0.36	0.51	0.83	1.30
	Fall	37	0.51	0.25	0.30	0.30	0.44	0.60	0.82
Warmest	Winter	454	0.63	0.52	0.24	0.34	0.48	0.78	1.13
	Spring	589	0.77	0.62	0.28	0.42	0.63	0.92	1.42
	Summer	488	1.57	1.56	0.33	0.58	1.10	1.98	3.28
	Fall	18	0.72	1.43	0.22	0.25	0.42	0.46	0.74

[a] In air changes per hour
Source: Murray and Burmaster, 1995.

standard deviation for the air exchange measurements in these homes, with a median house age of 45 years, was 0.90 ± 2.13 ACH. The second study (Grimsrud et al., 1983) involved 312 newer residences, with a median age of less than 10 years. Based on measurements taken during the heating season, the geometric mean ± standard deviation for these homes was 0.53 ± 1.71 ACH. Based on an aggregation of the two distributions with proportional weighting by the respective number of houses studied, Nazaroff et al. (1988) developed an overall distribution with a geometric mean of 0.68 ACH and a geometric standard deviation of 2.01.

16.3.3. Infiltration Models

A variety of mathematical models exist for prediction of air infiltration rates in individual buildings. A number of these models have been reviewed, for example, by Liddament and Allen (1983), and by Persily and Linteris (1984). Basic principles are concisely summarized in the ASHRAE Handbook of Fundamentals (ASHRAE, 1993). These models have a similar theoretical basis; all address indoor-outdoor pressure differences that are maintained by the actions of wind and stack (temperature difference) effects. The models generally incorporate a network of airflows where nodes representing regions of different pressure are interconnected by leakage paths. Individual models differ in details such as the number of nodes they can treat or the specifics of leakage paths (e.g., individual components such as cracks around doors or windows versus a combination of components such as an entire section of a building). Such models are not easily applied by exposure assessors, however, because the required (e.g., leakage areas, crack lengths) for the model are not easy to gather.

Another approach for estimating air infiltration rates is developing empirical models. Such models generally rely on collection of infiltration measurements in a specific building under a variety of weather conditions. The relationship between the infiltration rate and weather conditions can then be estimated through regression analysis, and is usually stated in the following form:

$$A = a + b\,|T_i - T_o| + cU^n \qquad \text{(Eqn. 16-1)}$$

where:

- A = air infiltration rate (h^{-1})
- T_i = indoor temperature (°C)
- T_o = outdoor temperature (°C)
- U = windspeed (ms^{-1})
- n is an exponent with a value typically between 1 and 2
- a, b and c are parameters to be estimated

Relatively good predictive accuracy usually can be obtained for individual buildings through this approach. However, exposure assessors often do not have the information resources required to develop parameter estimates for making such predictions.

A reasonable compromise between the theoretical and empirical approaches has been developed in the model specified by Dietz et al. (1986). The model, drawn from correlation analysis of environmental measurements and air infiltration data, is formulated as follows:

$$A = L\left(0.006\Delta T + \frac{0.03}{C}\,U^{1.5}\right) \qquad \text{(Eqn. 16-2)}$$

where:

- A = average air changes per hour or infiltration rate, h-1
- L = generalized house leakiness factor ($1 < L < 5$)
- C = terrain sheltering factor ($1 < C < 10$)
- ΔT = indoor-outdoor temperature difference (C°)
- U = windspeed (ms^{-1})

The value of L is greater as house leakiness increases and the value of C is greater as terrain sheltering (reflects shielding of nearby wind barrier) increases. Although the above model has not been extensively validated, it has intuitive appeal and it is possible for the user to develop reasonable estimates for L and C with limited guidance. Historical data from various U.S. airports are available for estimation of the temperature and windspeed parameters. As an example application, consider a house that has central values of 3 and 5 for L and C, respectively. Under conditions where the indoor temperature is 20 °C (68 °F), the outdoor temperature is 0 °C (32 ° F) and the windspeed is 5 ms^{-1}, the predicted infiltration rate for that house would be 3 (0.006 x 20 + 0.03/5 x 51.5), or 0.56 air changes per hour. This prediction applies under the condition that exterior doors and windows are closed, and does not include the contributions, if any, from mechanical systems (see

Section 16.2.3). Occupant behavior, such as opening windows, can, of course, overwhelm the idealized effects of temperature and wind speed.

Figure 16-5. Idealized Patterns of Particle Deposition Indoors

Source: Adapted from Nazaroff and Cass, 1989.

16.3.4. Deposition and Filtration

Deposition refers to the removal of airborne substances to available surfaces that occurs as a result of gravitational settling and diffusion, as well as electrophoresis and thermophoresis. Filtration is driven by similar processes, but is confined to material through which air passes. Filtration is usually a matter of design, whereas deposition is a matter of fact.

16.3.4.1. Deposition

The deposition of particulate matter and reactive gas phase pollutants to indoor surfaces is often stated in terms of a characteristic deposition velocity (m h^{-1}) allied to the surface-to-volume ratio (m^2 m^{-3}) of the building or room interior, forming a first order loss rate (h^{-1}) similar to that of air exchange. Theoretical considerations specific to indoor environments have been summarized in comprehensive reviews by Nazaroff and Cass (1989) and Nazaroff et al. (1993).

For airborne particles, deposition rates depend on aerosol properties (size, shape, density) as well as room factors (thermal gradients, turbulence, surface geometry). The motions of larger particles are dominated by gravitational settling; the motions of smaller particles are subject to convection and diffusion. Consequently, larger particles tend to accumulate more rapidly on floors and up-facing surfaces while smaller particles may accumulate on surfaces facing in any direction. Figure 16-5 illustrates the general trend for particle deposition across the size range of general concern for inhalation exposure (< 10 μm). The current thought is that theoretical calculations of deposition rates are likely to provide unsatisfactory results due to knowledge gaps relating to near-surface air motions and other sources of inhomogeneity (Nazaroff et al., 1993).

Wallace (1996) - Indoor Particles: A Review - In a major review of indoor particles, Wallace (1996) cited overall particle deposition rates for respirable ($PM_{2.5}$), inhalable (PM_{10}), and coarse (difference between PM_{10} and $PM_{2.5}$) size fractions determined from EPA's PTEAM study. These values, listed in Table 16-11, were derived from measurements conducted in nearly 200 residences.

Table 16-11. Deposition Rates for Indoor Particles

Size Fraction	Deposition Rate
$PM_{2.5}$	0.39 h^{-1}
PM_{10}	0.65 h^{-1}
Coarse	1.0 h^{-1}

Source: Adapted from Wallace, 1996.

Thatcher and Layton (1995) - Deposition, Resuspension, and Penetration of Particles Within a Residence - Thatcher and Layton (1995) evaluated removal rates for indoor particles in four size ranges (1-5, 5-10, 10-25, and > 25 μm) in a study of one house

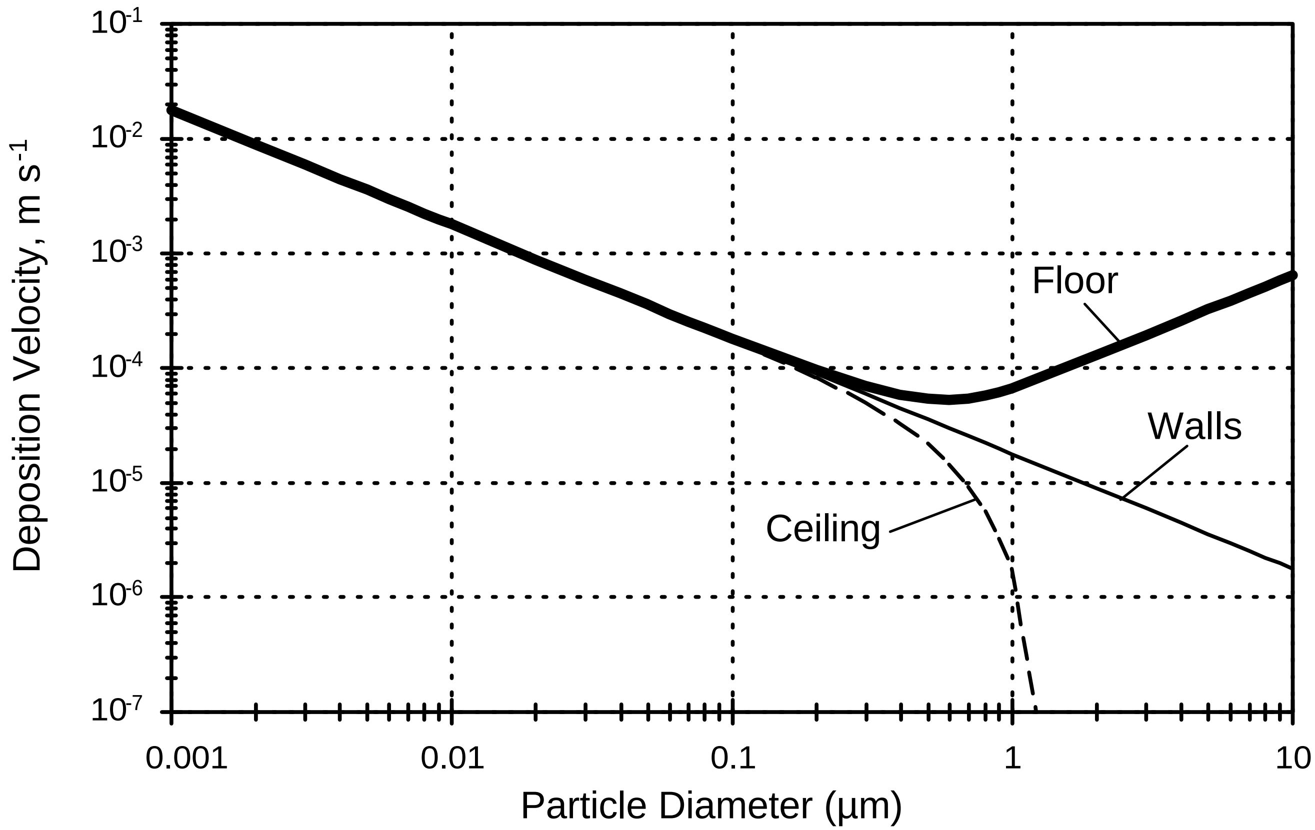


Figure 16-5. Idealized Patterns of Particle Deposition Indoors

Source: Adapted from Nazaroff and Cass, 1989.

occupied by a family of four. These values are listed in Table 16-12. In a subsequent evaluation of data collected in 100 Dutch residences, Layton and Thatcher (1995) estimated settling velocities of 2.7 m h^{-1} for lead-bearing particles captured in total suspended particulate matter (TSP) samples.

Table 16-12. Particle Deposition During Normal Activities

Particle Size Range (μm)	Particle Removal Rate (h^{-1})
1-5	0.5
5-10	1.4
10-25	2.4
> 25	4.1

Source: Adapted from Thatcher and Layton, 1995.

16.3.4.2. Filtration

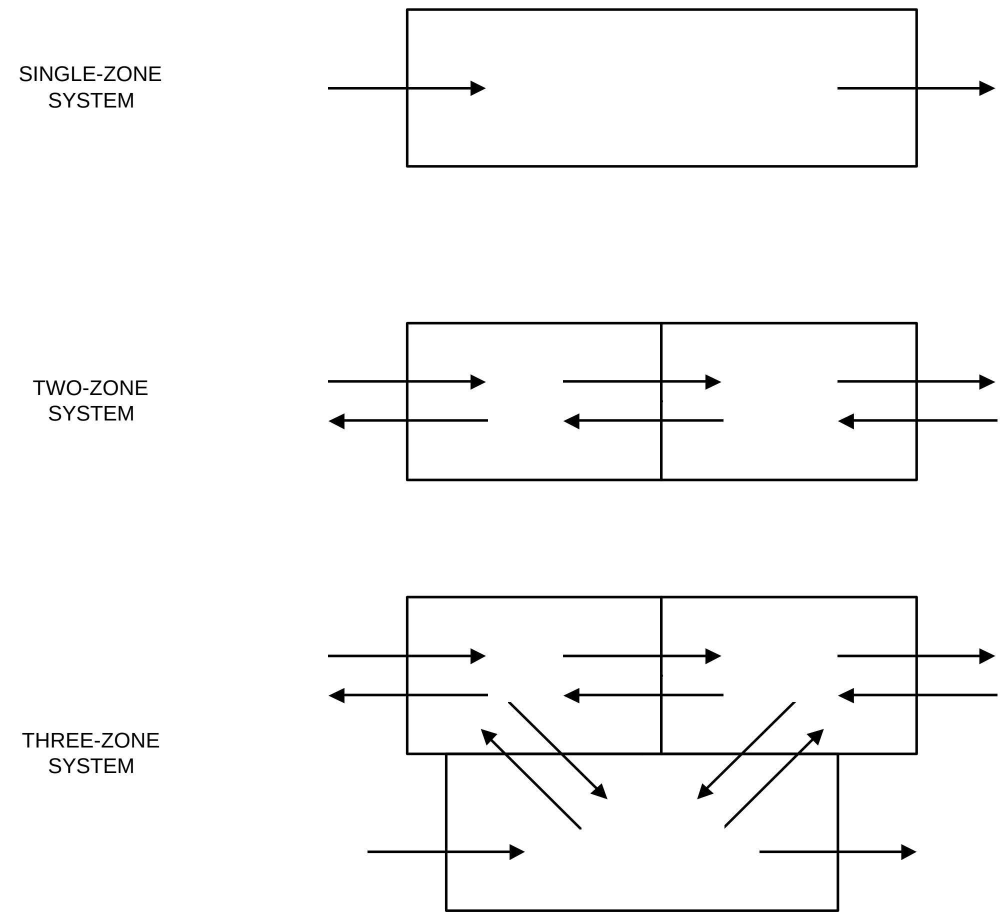
A variety of air cleaning techniques have been applied to residential settings. Basic principles related to residential-scale air cleaning technologies have been summarized in conjunction with reporting early test results (Offerman et al., 1984). General engineering principles are summarized in ASHRAE (1988). In addition to fibrous filters integrated into central heating and air conditioning systems, extended surface filters and High Efficiency Particle Arrest (HEPA) filters as well as electrostatic systems are available to increase removal efficiency. Free-standing air cleaners (portable and/or console) are also being used. Product-by-product test results reported by Hanley et al. (1994); Shaughnessy et al. (1994); and by Offerman et al. (1984) exhibit considerable variability across systems, ranging from ineffectual (< 1% efficiency) to nearly complete removal.

16.3.5. Interzonal Airflows

16.3.5.1. Background

Residential structures consist of a number of rooms that may be connected horizontally, vertically, or both horizontally and vertically. Before considering residential structures as a detailed network of rooms, it is convenient to divide them into one or more zones. At a minimum, each floor is typically defined as a separate zone. For indoor air exposure assessments, further divisions are sometimes made within a floor, depending on (1) locations of specific contaminant sources and (2) the presumed

Figure 16-6. Air Flows for Multiple-zone Systems



N-Zone System Defined by N·(N+1) Airflows

Figure 16-6. Air Flows for Multiple-zone Systems degree of air communication among areas with and without sources.

Defining the airflow balance for a multiple-zone exposure scenario rapidly increases the information requirements as rooms or zones are added. As shown in Figure 16-6, a single zone system (considering the entire building as a single well-mixed volume) requires only two flows to define air exchange. Further, because air exchange is balanced flow (air does not "pile up" in the building, nor is a vacuum formed), only one number (the air exchange rate) is needed. With two zones, six airflows are needed to accommodate interzonal airflows plus air exchange; with three zones, twelve airflows are required. In some cases, the complexity can be reduced using judicious (if not convenient) assumptions. Interzonal airflows connecting nonadjacent rooms can be set to zero, for example, if flow pathways do not exist. Symmetry also can be applied to the system by assuming that each flow pair is balanced.

16.3.5.2. Relationship to House Volume and Air Exchange

A heuristic relationship between interzonal airflows and house volume and air exchange was developed by Koontz and Rector (1995) using selected cases from the PFT database. Situations investigated were: (1) bedrooms, for which communication with the remainder of the house may be restricted by the presence of doorways; and (2) the kitchen, which generally has a more open communication path with adjacent areas. The PFT database contained approximately 1000 cases where researchers labeled a bedroom or the kitchen as separate zones. These cases were analyzed by first normalizing the average interzonal airflows (Q_z, $m^3\ h^{-1}$) into and out of the zone by the volume (V, m^3) of the house (i.e., dividing the airflows by the house volume), and then regressing the normalized airflows against the whole-house air exchange rate. This averaging also served to symmetrically balance each set of inflow-outflow pairs. For the bedroom cases, the relationship between the normalized interzonal airflow (Q_n, $m^3\ h^{-1}\ m^{-3}$) and air exchange rate (N, h^{-1}) was:

$$Q_n = \frac{Q_z}{V} = 0.078 + 0.31N \qquad \text{(Eqn. 16-3)}$$

where:

Qn	=	Normalized interzonal airflow
Q_Z	=	Average interzonal airflow
V	=	Volume of house
N	=	Whole-house air exchange rate

For the kitchen cases, the relationship between the normalized interzonal airflow and the air exchange rate was:

$$Q_n = \frac{Q_z}{V} = 0.046 + 0.39N \qquad \text{(Eqn. 16-4)}$$

Based on typical values and relationships given above, characteristic airflows can be postulated for two-zone situations conceptualized as "bedroom versus remainder of the house" and "living room versus remainder of the house." For example, using Equation (16-3) and assuming a whole-house volume of 408 m^3, an average bedroom volume of 35 m^3, and an air exchange rate of 0.45 h^{-1}, the estimated interzonal airflow (Q_z) for the bedroom would be (0.078 + 0.31 x 0.45 h^{-1}) x 408 m^3, or 88.7 $m^3\ h^{-1}$. The living room, like the kitchen, is assumed to have freer air communication with the rest of the house. Using Equation (16-4), the estimated interzonal airflow for the living room would be (0.046 + 0.39 x 0.45 h^{-1}) x 408 m^3, or 90.4 $m^3\ h^{-1}$. Multiplying the zone-specific volumes by the air exchange rate gives their respective indoor-outdoor airflow rates. For example, the living room volume of 60 m^3, multiplied by 0.45 h^{-1}, gives an indoor-outdoor airflow rate of 27.0 m^3 for the living room. The volumes and estimated airflows for these situations are summarized in Figure 16-7.

It should be noted that some or many of the researchers contributing measurements to the PFT database used for the analysis may have defined a zone as a group of adjacent bedrooms, rather than as an individual bedroom. If so, then the interzonal airflow rate for an individual bedroom is likely to be lower than indicated by the above relationship. Similarly, the living room, which generally has open communication with the rest of the house like the kitchen but also has a larger volume than the kitchen, might be expected to have a higher interzonal airflow rate than indicated by the above relationship.

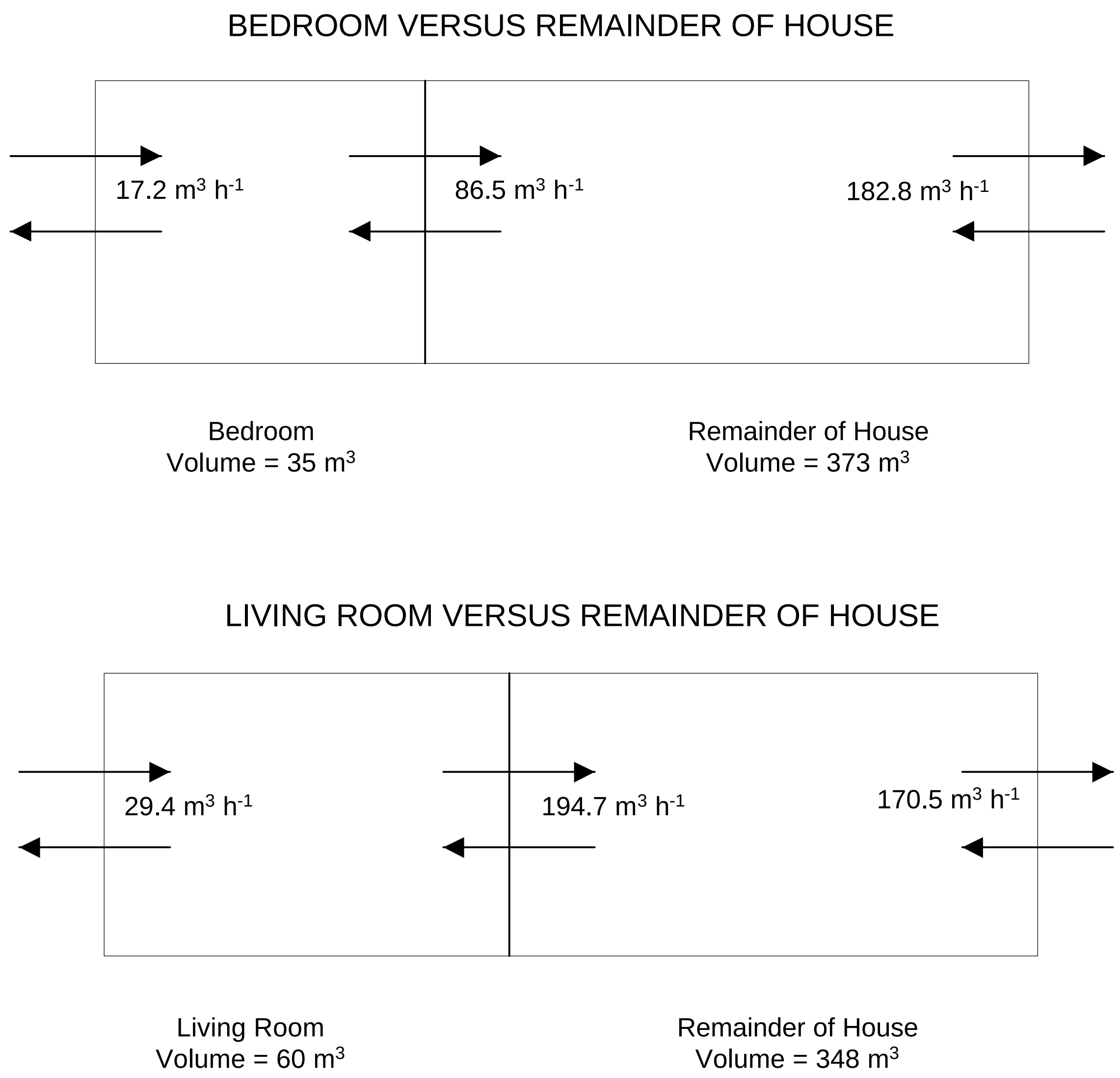


Figure 16-7. Characteristic Volumes and Air Flow Rates for Two-Zone Situations

Figure 16-7. Characteristic Volumes and Air Flow Rates for Two-Zone Situations

The heuristic relationships described above were developed under the simplifying assumption that airflow rate between two zones of a house (e.g., bedroom versus rest of house) are exactly balanced, meaning that the airflow rate from the bedroom to the remainder is the same as from the remainder to the bedroom. In many cases, however, such a balance is not obtained; there is often a net flow in one direction or the other, with infiltration occurring predominantly in some areas of the house and exfiltration predominantly in others. Existing data represent a variety of case studies, but do not point to

any general rules relating to directional airflows. Because existing data represent a variety of case studies, the data are inadequate for defining general characteristics that could represent typical or average conditions. Further, the definition of airflow zones in residential structures can be ambiguous because occupants open and close interior doors on irregular schedules.

16.3.6. Water Uses

Among indoor water uses, showering, bathing and handwashing of dishes or clothes provide the primary opportunities for dermal exposure. Virtually all indoor water uses will result in some volatilization of chemicals, leading to inhalation exposure.

The exposure potential for a given situation will depend on the source of water, the types and extents of water uses, and the extent of volatilization of specific chemicals. According to the results of the 1987 Annual Housing Survey (U.S. Bureau of the Census, 1992), 84.7 percent of all U.S. housing units receive water from a public system or private company (as opposed to a well). Across the four major regions defined by the U.S. Census Bureau (Northeast, South, Midwest, and West), the percentage varies from 82.5 in the Midwest region to 93.2 in the West region (the Northeast and South regions both are very close to the national percentage).

The primary types of water use indoors can be classified as showering/bathing, toilet use, clothes washing, dishwashing, and faucet use (e.g., for drinking, cooking, general cleaning, or washing hands). Substantial information on water use has been collected in California households by the Metropolitan Water District of Southern California (MWD, 1991) and by the East Bay Municipal Utility District (EBMUD, 1992). An earlier study by the U.S. Department of Housing and Urban Development (U.S. DHUD, 1984) monitored water use in 200 households over a 20-month period. The household selection process for this study was not random; it involved volunteers from water companies and engineering organizations, most of which were located in large metropolitan areas. Nazaroff et al. (1988) also assembled the results of several smaller surveys, typically involving between 5 and 50 households each.

A common feature of the various studies cited above is that the results were all reported in gallons per capita per day (gcd), or in units that could be easily converted to gcd. Most studies also provided estimates by type of use--shower/bath, toilet, laundry, dishwashing, and other (e.g., faucets). A summary of the various study results is provided in Table 16-13. There is generally about a threefold variation across studies for total in-house water use as well as each type of use. Central values for total use, were obtained by taking the mean and median across the studies for each type of water use and then summing these means/medians across uses. These central values are shown at the bottom of the table. The means and medians were summed across types of uses to obtain the mean for all uses combined because only a subset of the studies reported values for other uses.

The following sections provide a summary of the water use characteristics for the primary types of water uses indoors. To the extent found in the literature, each water use described in terms of the frequency of use; flowrate during the use; quantity of water used during each occurrence of the water use; and quantity used by an average person. Table 16-14 summarizes the studies by locations, number of study participants, and number of households.

Caution should be exercised when using the data collected in these studies and shown here. The participants in these studies are not a representative sample of the general population. The participants consisted of volunteers, mostly from large metropolitan areas.

Showering and Bathing Water Use Characteristics - The HUD study (U.S. DHUD, 1984) monitored 162 households for shower duration. The individuals were also subdivided by people who only shower. The results are given in Table 16-15. The flowrates of various types of shower heads were also evaluated in the study (Table 16-16).

Table 16-13. In-house Water Use Rates (gcd), by Study and Type of Use

Study	Total, All Uses	Shower or Bath	Toilet	Laundry	Dishwashing	Other
MWD[1]	93	26	30	20	5	12
EBMUD[2]	67	20	28	9	4	6
USDHUD[3]	40	15	10	13	2	--
Cohen[4]	52	6	17	11	18	--
Ligman[4]						
Rural	46	11	18	14	3	--
Urban	43	10	18	11	4	--
Laak[4]	42	9	20	7	4	2
Bennett[4]	45	9	15	11	4	6
Milne[4]	70	21	32	7	7	3
Reid[4]	59	20	24	8	4	3
USEPA[4]	40	10	9	11	5	5
Partridge[4]	52-86	20-40	4-6	20-30	8-10	--
Mean Across Studies[5]	59	17	18	13	6	5
Median Across Studies[5]	53	15	18	11	4	5

[1] Metropolitan Water District of Southern California, 1991.
[2] East Bay Municipal Utility District, 1992.
[3] U.S. Department of Housing and Urban Development, 1984.
[4] Cited in Nazaroff and Nero, 1988.
[5] The average value from each range reported in Partridge, as cited in Nazaroff and Nero (1988), was used to calculate the median across studies. The mean and median for the "Total, all Uses" column were obtained by summing across the means and medians for individual types of water use.

Table 16-14. Summary of Water Use

	Number of Households	Location	Reference
HUD Studies			
MWD	37	Los Angeles, CA	1,2
Brown & Caldwell	7	Sacramento, CA	1,3
Brown & Caldwell	40	Walnut Creek, CA	1,3
Brown & Caldwell Volunteers	7	Washington, DC	1
Office of Water Conservation	21	Sacramento, CA	1
Los Angeles Dept. of Water	19	Los Angeles, CA	1
Power Authority			
Seattle Water Dept.	32	Seattle, WA	1
Denver Water Board	23	Denver, CO	1
Aurora Utilities Dept.	15	Aurora, CO	1
Fairfax County Water	10	Fairfax, VA	1
TOTAL	211		

[1] U.S. Department of Housing and Urban Development, 1984.
[2] Metropolitan Water District of Southern California, 1991.
[3] East Bay Municipal Utility District, 1992.

Table 16-15. Showering and Bathing Water Use Characteristics

Characteristic	Mean Duration	Mean Frequency
Individuals who Shower only	10.4 minutes/shower	0.74 showers/day/person
Individuals who Bath only	NA	0.41 baths/day/person
Individuals who Shower and Bath	NA	NA

Source: Adapted from U. S. DHUD, 1984.

Table 16-16. Showering Characteristics for Various Types of Shower Heads

Shower Head Type	MeanFlow Rate (gpm)
Non-Conserving (> 3 gpm)	3.4
Low Flow (≤ 3 gpm)	1.9
Restrictor (≤ 3 gpm)	2.1
Zinplas	1.8
Turbojector	1.3

Source: Adapted from U.S. DHUD, 1984.

Table 16-17. Toilet Water Use Characteristics

Toilet Type	Average Water Use (gallons/flush)
Non-Conserving	5.5
Bottles	5.0
Bags	4.8
Dams	4.5
Low-flush	3.5

Source: Adapted from U.S. DHUD, 1984.

Toilet Water Use Characteristics - The HUD study (U.S. DHUD, 1984) reported water volume per flush for various types of toilets and monitored 162 households for shower duration. The results of this study are shown in Table 16-17. Since the HUD study was conducted prior to 1984, the newer (post 1984) conserving toilets that are designed to use approximately 1.6 gallons per flush were not tested.

The frequency of use for toilets in households was examined in several studies (U.S. DHUD, 1984; Ligman, et al., 1974; Siegrist, 1976). The observed mean frequencies in these studies are given in Table 16-18. Tables 16-19 through 16-23 present indoor water use frequencies for dishwashers and clothes washers.

Table 16-18. Toilet Frequency Use Characteristics

Study	Flush Frequency (flushes/person/day)
U.S. DHUD, 1984[a]	4.2 flushes/household/day
Ligman, et al., 1984 Rural, M-F	3.6 flushes/person/day
Ligman, et al., 1984 Rural, Sat-Sun	3.8 flushes/person/day
Ligman, et al., 1984 Urban, M-F	3.6 flushes/person/day
Ligman, et al., 1984 Urban, Sat-Sun	3.1 flushes/person/day
Siegrist, 1976	2.29 flushes/person/day
Unweighted Mean	3.43 flushes/person/day

[a] The HUD value may in fact be flushes/household/day

Table 16-19. Dishwasher Frequency Use Characteristics

Study	Use Frequency
U.S. DHUD, 1984	0.47 loads/person/day
Ligman, et al., 1974 Rural	1.3 loads/day
Siegrist, 1976	0.39 loads/person/day
Unweighted Mean	0.92 loads/day

Table 16-20. Dishwasher Water Use Characteristics

Brand	Average Water Use (gallons/regular cycle)	Cycle Duration (minutes) 140°F	120°F
Maytag	11.5	75	--
Frigidaire	12	75	75
General Electric	10.5	80	95
Sears	10	75	95
Whirlpool	9.5	60	110
White/Westinghouse	12	75	75
Waste King	11.5	65	85
Kitchen Aid	9.5	80	80
Magic Chef	11.5	70	--
Unweighted Mean	10.9	72.8	87.9

Source: Adapted from Consumer Reports, 1987.

Table 16-21. Clothes Washer Frequency Use Characteristics

Study	Use Frequency
U.S. DHUD, 1984	0.3 loads/person/day
Ligman, et al., 1974 Rural	0.34 loads/person/day
Ligman, et al., 1974 Urban	0.27 loads/person/day
Siegrist, 1976	0.31 loads/day

Table 16-22. Clothes Washer Water Use Characteristics

Brand	Average Water Use (gallons/regular cycle)	Cycle Duration (minutes)
Maytag	41	32
Frigidaire	48	40
General Electric	51	48
Hotpoint	51	48
Sears	49	40
Whirlpool	53	44
White/Westinghouse	54	47
Kelvinator	46	52
Norge	55	49

Source: Adpated from Consumer Reports, 1982.

Table 16-23. Range of Water Uses for Clothes Washers

Type of Clothes Washer	Range of Water Use
Conventional	27-59 gallons/load
Low Water	16-19 gallons/load
All Clothes Washers	16-59 gallons/load

Source: Adapted from Consumer Reports, 1982.

16.3.7. House Dust and Soil

House dust is a complex mixture of biologically-derived material (animal dander, fungal spores, etc.), particulate matter deposited from the indoor aerosol, and soil particles brought in by foot traffic. House dust may contain VOCs (see, for example, Wolkoff and Wilkins, 1994; Hirvonen et al., 1995), pesticides from imported soil particles as well as from direct applications indoors (see, for example, Roberts et al., 1991), and trace metals derived from outdoor sources (see, for example, Layton and Thatcher, 1995). The indoor abundance of house dust depends on the interplay of deposition from the airborne state, resuspension due to various activities, direct accumulation, and infiltration.

In the absence of indoor sources, indoor concentrations of particulate matter are significantly lower than outdoor levels. For some time, this observation supported the idea that a significant fraction of the outdoor aerosol is filtered out by the building envelope. More recent data, however, have shown that deposition (incompletely addressed in earlier studies) accounts for the indoor-outdoor contrast, and outdoor particles smaller than 10 μm aerodynamic diameter penetrate the building envelope as completely as nonreactive gases (Wallace, 1996).

Thatcher and Layton (1995) - Deposition, Resuspension and Penetration of Particles Within a Residence - Relatively few studies have been conducted at the level of detail needed to clarify the dynamics of indoor aerosols. One intensive study of a California residence (Thatcher and Layton, 1995), however, provides instructive results. Using a model-based analysis for data collected under controlled circumstances, the investigators verified penetration of the outdoor aerosol and estimated rates for particle deposition and resuspension (Table 16-24). The investigators stressed that normal household activities are a significant source of airborne particles larger than 5 μm. During the study, they observed that just walking into and out of a room could momentarily double the concentration. The airborne abundance of submicrometer particles, on the other hand, was unaffected by either cleaning or walking.

Table 16-24. Particle Deposition and Resuspension During Normal Activities

Particle Size Range (μm)	Particle Deposition Rate (h^{-1})	Particle Resuspension Rate (h^{-1})
0.3-0.5	(not measured)	9.9×10^{-7}
0.6-1	(not measured)	4.4×10^{-7}
1-5	0.5	1.8×10^{-5}
5-10	1.4	8.3×10^{-5}
10-25	2.4	3.8×10^{-4}
> 25	4.1	3.4×10^{-5}

Source: Adapted from Thatcher and Layton, 1995.

Mass loading of floor surfaces (Table 16-25) was measured in the study of Thatcher and Layton (1995) by thoroughly cleaning the house and sampling accumulated dust, after one week of normal habitation. Methodology, validated under ASTM F608 (ASTM, 1989), showed fine dust recovery efficiencies of 50 percent with new carpet and 72 percent for linoleum. Tracked areas showed consistently higher accumulations than untracked areas, confirming the importance of tracked-in material. Differences between tracked areas upstairs and downstairs show that tracked-in material is not readily transported upstairs. The consistency of untracked carpeted areas throughout the house, suggests that, in the absence of tracking, particle transport processes are similar on both floors.

Table 16-25. Dust Mass Loading After One Week Without Vacuum Cleaning

Location in Test House	Dust Loading (gm^{-2})
Tracked area of downstairs carpet	2.20
Untracked area of downstairs carpet	0.58
Tracked area of linoleum	0.08
Untracked area of linoleum	0.06
Tracked area of upstairs carpet	1.08
Untracked area of upstairs carpet	0.60
Front doormat	43.34

Source: Adapted from Thatcher and Layton, 1995.

Roberts et al. (1991) - Development and Field Testing of a High Volume Sampler for Pesticides and Toxics in Dust - Dust loadings, reported by Roberts et al. (1991) were also measured in conjunction with the Non-Occupational Pesticide Exposure Study (NOPES). In this study house dust was sampled from a representative grid using a specially constructed high-volume surface sampler (HVS2). The surface sampler collection efficiency was verified in conformance with ASTM F608 (ASTM, 1989). The data summarized in Table 16-26 were collected from carpeted areas in opportunistic (volunteer) households in Florida encountered during the course of NOPES. Seven of the nine sites were single-family detached homes, and two were mobile homes. The authors noted that the two houses exhibiting the highest dust loadings were only those homes where a vacuum cleaner was not used for housekeeping.

Table 16-26. Totalized Dust Loading for Carpeted Areas

Household	Total Dust Load (gm^{-2})	Fine Dust (< 150 μm) Load (gm^{-2})
1	10.8	6.6
2	4.2	3.0
3	0.3	0.1
4	2.2; 0.8	1.2; 0.3
5	1.4; 4.3	1.0; 1.1
6	0.8	0.3
7	6.6	4.7
8	33.7	23.3
9	812.7	168.9

Source: Adapted from Roberts et al., 1991.

16.4. SOURCES

Product- and chemical-specific mechanisms for indoor sources can be described using simple emission factors to represent instantaneous releases, as well as constant releases over defined time periods; more complex formulations may be required for time-varying sources. Guidance documents for characterizing indoor sources within the context of the exposure assessment process are limited (see, for example, Jennings et al., 1987; Wolkoff, 1995). Fairly extensive guidance exists in the technical literature, however, provided that the exposure assessor has the means to define (or estimate) key mechanisms and chemical-specific parameters. Basic concepts are summarized below for the broad source categories that relate to airborne contaminants, waterborne contaminants, and for soil/house dust indoor sources.

16.4.1. Source Descriptions for Airborne Contaminants

Table 16-27 summarizes simplified indoor source descriptions for airborne chemicals for direct discharge sources (e.g., combustion, pressurized propellant products), as well as emanation sources (e.g., evaporation from "wet" films, diffusion from porous media), and transport-related sources (e.g., infiltration of outdoor air contaminants, soil gas entry).

Direct discharge sources can be approximated using simple formulas that relate pollutant mass released to characteristic process rates. Combustion sources, for example, may be stated in terms of an emission factor, fuel content (or heating value), and fuel consumption (or carrier delivery) rate. Emission factors for combustion products of general concern (e.g., CO, NO_x) have been measured for a number of combustion appliances using room-sized chambers (see, for example, Relwani et al., 1986). Other direct discharge sources would include volatiles released from water use and from pressurized consumer products. Resuspension of house dust (see Section 16.3.7), would take on a similar form by combining an activity-specific rate constant with an applicable dust mass.

Emanation sources represent probably the greatest challenge in source characterization for indoor air quality. Vapor-phase organics dominate this group, offering great complexity because (1) there is a fairly long list of chemicals that could be of concern, (2) ubiquitous consumer products, building materials, coatings, and furnishings contain varying amounts of different chemicals, (3) source dynamics may include nonlinear mechanisms, and (4) for many of the chemicals, emitting

Table 16-27. Simplified Source Descriptions for Airborne Contaminants

Description	Components	Dimensions
Direct Discharge		
Combustion	$E_f H_f M_f$	g h^{-1}
	E_f = emission factor	g J^{-1}
	H_f = fuel content	J mol^{-1}
	M_f = fuel consumption rate	mol h^{-1}
Volume Discharge	$Q_p C_p \epsilon$	g h^{-1}
	Q_p = volume delivery rate	m^3 h^{-1}
	C_p = concentration in carrier	g m^{-3}
	ϵ = transfer efficiency	g g^{-1}
Mass Discharge	$M_p w_e \epsilon$	g h^{-1}
	M_p = mass delivery rate	g h^{-1}
	w_e = weight fraction	g g^{-1}
	ϵ = transfer efficiency	g g^{-1}
Emanation		
Mass Transfer	$(D_f \delta^{-1})(C_s - C_i)A_i$	g h^{-1}
	D_f = diffusivity	m^2 h^{-1}
	= boundary layer thickness	m
	C_s = vapor pressure of surface	g m^{-3}
	C_i = room concentration	g m^{-3}
	A_i = area	m^2
Exponential	$A_i E_o e^{-ks\,t}$	g h^{-1}
	A_i = area	m^2
	E_o = initial unit emission rate	g h^{-1} m^{-2}
	k_s = emission decay factor	h^{-1}
	t = time	h
Transport		
Infiltration	$Q_{ji} C_j$	g h^{-1}
Interzonal	Q_{ji} = air flow from zone j	m^3 h^{-1}
Soil Gas	C_j = air concentration in zone j	g m^{-3}

as well as non-emitting materials evident in realistic settings may promote reversible and irreversible sink effects. Very detailed descriptions for emanation sources can be constructed to latch specific properties of the chemical, the source material, and the receiving environment to calculate expected behavior (see, for example, Schwope et al., 1992; Cussler, 1984). Validation to actual circumstances, however, suffers practical shortfalls because many parameters simply cannot be measured directly.

The exponential formulation listed in Table 16-27 was derived based on a series of papers generated during the development of chamber testing methodology by EPA (Dunn, 1987; Dunn and Tichenor, 1988; Dunn and Chen, 1993). This framework represents an empirical alternative that works best when the results of chamber tests are available. Estimates for the initial emission rate (E_o) and decay factor (k_s) can be developed for hypothetical sources from information on pollutant mass available for release (M) and supporting assumptions.

Assuming that a critical time period (t_c) coincides with reduction of the emission rate to a critical level (E_c) or with the release of a critical fraction of the total mass

(M_c), the decay factor can be estimated by solving either of these relationships:

$$\frac{E_c}{E_o} = e^{-k_s t_c}, \vee \frac{M_c}{M} = 1 - e^{-k_s t_c} \qquad \text{(Eqn. 16-5)}$$

The critical time period can be derived from product-specific considerations (e.g., equating drying time for a paint to 90 percent emissions reduction). Given such an estimate for k_s, the initial emission rate can be estimated by integrating the emission formula to infinite time under the assumption that all chemical mass is released:

$$M = \int_o^{\infty} E_o e^{-k_s t} dt = \frac{E_o}{k_s} \qquad \text{(Eqn. 16-6)}$$

The basis for the exponential source algorithm has also been extended to the description of more complex diffusion-limited sources. With these sources, diffusive or evaporative transport at the interface may be much more rapid than diffusive transport from within the source material, so that the abundance at the source/air interface becomes depleted, limiting the transfer rate to the air. Such effects can prevail with skin formation in "wet" sources like stains and paints (see, for example, Chang and Guo, 1992). Similar emission profiles have been observed with the emanation of formaldehyde from particleboard with "rapid" decline as formaldehyde evaporates from surface sites of the particleboard over the first few weeks. It is then followed by a much slower decline over ensuing years as formaldehyde diffuses from within the matrix to reach the surface (see, for example, Zinn et al., 1990).

Transport-based sources bring contaminated air from other areas into the airspace of concern. Examples include infiltration of outdoor contaminants, and soil gas entry. Soil gas entry is a particularly complex phenomenon, and is frequently treated as a separate modeling issue (Little et al., 1992; Sextro, 1994). Room-to-room migration of indoor contaminants would also fall under this category, but this concept is best considered using the multiple-zone model.

16.4.2. Source Descriptions for Waterborne Contaminants

Residential water supplies may convey chemicals to which occupants can be exposed through ingestion, dermal contact, or inhalation. These chemicals may appear in the form of contaminants (e.g., trichloroethylene) as well as naturally-occurring byproducts of water system history (e.g., chloroform, radon). Among indoor water uses, showering, bathing and handwashing of dishes or clothes provide the primary opportunities for dermal exposure. The escape of volatile chemicals to the gas phase associates water use with inhalation exposure. The exposure potential for a given situation will depend on the source of water, the types and extents of water uses, and the extent of volatilization of specific chemicals. Primary types of residential water use (summarized in Section 16.3) include showering/bathing, toilet use, clothes washing, dishwashing, and faucet use (e.g., for drinking, cooking, general cleaning, or washing hands).

Upper bounding estimates of chemical release rates from water use can be formulated as simple emission factors combining the concentration in the feed water (g m^{-3}) with the flow rate for the water use (m^3 h^{-1}), and assuming that the chemical escapes to the gas phase. For some chemicals, however, not all of the chemical escapes in realistic situations due to diffusion-limited transport and solubility factors. For inhalation exposure estimates, this may not pose a problem because the bounding estimate would overestimate emissions by no more than approximately a factor of two. For multiple exposure pathways, the chemical mass remaining in the water may be of importance. Refined estimates of volatile emissions are usually considered under two-resistance theory to accommodate mass transport aspects of the water-air system (see, for example, Little, 1992; Andelman, 1990; McKone, 1987). Release rates are formulated as:

$$S = K_m F_W \left[C_w - \frac{C_a}{H} \right] \qquad \text{(Eqn. 16-7)}$$

where:

S	=	chemical release rate (g h^{-1})
K_m	=	dimensionless mass-transfer coefficient
F_w	=	water flow rate (m^3 h^{-1})
C_w	=	concentration in feed water (g m^{-3})
C_a	=	concentration in air (g m^{-3})
H	=	dimensionless Henry's Law constant

Because the emission rate is dependent on the air concentration, recursive techniques are required. The mass transfer coefficient is a function of water use characteristics (e.g., water droplet size spectrum, fall distance, water film) and chemical properties (diffusion in gas and liquid phases). Estimates of practical value are based on empirical tests to incorporate system characteristics into a single parameter (see, for example, Giardino et al., 1990). Once characteristics of one chemical-water use system are known (reference chemical, subsrcipt (r)), the mass transfer coefficient for another chemical (index chemical, subscripted i) delivered by the same system can be estimated using formulations identified in the review by Little (1992):

$$\frac{1}{K}\left(\frac{D_{Li}}{D_{Lr}}\right)^{1/2} = \frac{1}{k_{Lr}} = \frac{1}{K_{Gr}} - \frac{1}{H}\left(\frac{D_{Gr}}{D_{Gi}}\right)^{2/3}\left(\frac{D_{Li}}{D_{Lr}}\right)^{1/2} \quad \text{(Eqn. 16-8)}$$

where:

D_L	=	liquid diffusivity ($m^2\ s^{-1}$)
D_G	=	gas diffusivity ($m^2\ s^{-1}$)
K_L	=	liquid-phase mass transfer coefficient
K_G	=	gas-phase mass transfer coefficient

16.4.3. Soil and House Dust Sources

The rate process descriptions compiled for soil and house dust in Section 16.3 provide inputs for estimating indoor emission rates (S_d, g h^{-1}) in terms of dust mass loading (M_d, g m^{-2}) combined with resuspension rates (R_d, h^{-1}) and floor area (A_f, m^2):

$$S_d = M_d\ R_d \quad \text{(Eqn. 16-9)}$$

Because house dust is a complex mixture, transfer of particle-bound constituents to the gas phase may be of concern for some exposure assessments. For emission estimates, one would then need to consider particle mass residing in each reservoir (dust deposit, airborne).

16.5. ADVANCED CONCEPTS

16.5.1. Uniform Mixing Assumption

Many exposure measurements are predicated on the assumption of uniform mixing within a room or zone of a house. Mage and Ott (1994) offers an extensive review of the history of use and misuse of the concept. Experimental work by Baughman et al. (1994) and Drescher et al. (1995) indicates that, for an instantaneous release from a point source in a room, fairly complete mixing is achieved within 10 minutes when convective flow is induced by solar radiation. However, up to 100 minutes may be required for complete mixing under quiescent (nearly isothermal) conditions. While these experiments were conducted at extremely low air exchange rates (< 0.1 ACH), based on the results, attention is focused on mixing within a room.

The situation changes if a human invokes a point source for a longer period and remains in the immediate vicinity of that source. Personal exposure in the near vicinity of a source can be much higher than the well-mixed assumption would suggest. A series of experiments conducted by GEOMET (1989) for the U.S. EPA involved controlled point-source releases of carbon monoxide tracer (CO), each for 30 minutes. "Breathing-zone" measurements located within 0.4 m of the release point were ten times higher than for other locations in the room during early stages of mixing and transport.

Similar investigations conducted by Furtaw et al. (1994) involved a series of experiments in a controlled-environment room-sized chamber. Furtaw et al. (1994) studied spatial concentration gradients around a continuous point source simulated by sulfur hexafluoride (SF_6) tracer with a human moving about the room. Average breathing-zone concentrations when the subject was near the source exceeded those several meters away by a factor that varied inversely with the ventilation intensity in the room. At typical room ventilation rates, the ratio of source-proximate to slightly-removed concentration was on the order of 2:1.

16.5.2. Reversible Sinks

For some chemicals, the actions of reversible sinks are of concern. For an initially “clean” condition in the sink material, sorption effects can greatly deplete indoor concentrations. However, once enough of the chemical has been adsorbed, the diffusion gradient will reverse, allowing the chemical to escape. For persistent indoor sources, such effects can serve to reduce indoor levels initially but once the system equilibrates, the net effect on the average concentration of the reversible sink is negligible. Over suitably short time frames, this can also affect integrated exposure. For indoor sources whose emission profile declines with time (or ends abruptly), reversible sinks can serve to extend the emissions period as the chemical desorbs long after direct emissions are finished. Reversible sink effects have been observed for a number of chemicals in the presence of carpeting, wall coverings, and other materials commonly found in residential environments.

Interactive sinks (and models of the processes) are of a special importance: while sink effects can greatly reduce indoor air concentrations, re-emission at lower rates over longer time periods could greatly extend the exposure period of concern. For completely reversible sinks, the extended time could bring the cumulative exposure to levels approaching the sink-free case. Recent publications (Axley, 1993; Tichenor et al., 1991) show that first principles provide useful guidance in postulating models and setting assumptions for reversible/irreversible sink models. Sorption/desorption can be described in terms of Langmuir (monolayer) as well as Brunauer-Emmet-Teller (BET, multilayer) adsorption.

16.6 RECOMMENDATIONS

Table 16-28 presents a summary of volume of residence surveys and Table 16-29 presents a summary of air exchange rates surveys. Tables 16-30 and 16-31 provide the confidence in recommendations for house volume and air exchange rates, respectively. Key studies or analyses described in this chapter were used in selecting recommended values for residential volume and air exchange rate. Both central and conservative values are provided. These two parameters -- volume and air exchange rate -- can be used by exposure assessors in modeling indoor-air concentrations as one of the inputs to exposure estimation. Other inputs to the modeling effort include rates of indoor pollutant generation and losses to (and, in some cases, re-emissions from) indoor sinks. Other things being equal (i.e., holding constant the pollutant generation rate and effect of indoor sinks), lower values for either the indoor volume or the air exchange rate will result in higher indoor-air concentrations. Thus, values near the lower end of the distribution (e.g., 10th percentile) for either parameter are appropriate in developing conservative estimates of exposure.

For the volume of a residence, both key studies (U.S. DOE survey and PFT database) have the same mean value -- 369 m^3 (see Table 16-1). This mean value is recommended as a central estimate residential volume. Intuitively, the 10th percentile of the distribution from either study -- 147 m^3 for U.S. DOE survey or 167 m^3 for the PFT database -- is too conservative a value, as both these values are lower than the mean volume for multifamily dwelling units (see Table 16-2). Instead, the 25th percentile -- 209 m^3 for U.S. DOE survey or 225 m^3 for PFT database, averaging 217 m^3 across the two key studies -- is recommended.

For the residential air exchange rate, the median value of 0.45 air changes per hour (ACH) from the PFT database (see Table 16-9) is recommended as a typical value (Koontz and Rector, 1995). This median value is very close to the geometric mean of the measurements in the PFT database analyzed by Koontz and Rector (1995). The arithmetic mean is not preferred because it is influenced fairly heavily by extreme values at the upper tail of the distribution. For a conservative value, the 10th percentile for the PFT database -- 0.18 ACH -- is recommended (Table 16-9).

16.7. REFERENCES FOR CHAPTER 16

Andelman, J.B. (1990) Total Exposure to Volatile Organic Compounds in Potable Water. IN: Ram, N, et al., eds. Significance and Treatment of Volatile Organic Compounds in Water Supplies. pp 485-504, Lewis Publishers, Chelsea, MI.

Andersson, B., K. Andersson, J. Sundell, and P.-A. Zingmark. (1993) Mass Transfer of Contaminants in Rotary Enthalpy Heat Exchangers, Indoor Air, 3:143-148.

ASHRAE. (1988) ASHRAE Handbook: Equipment. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA.

ASHRAE. (1993) ASHRAE Handbook: Fundamentals. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA.

ASTM (1990). Test Method for Determining Formaldehyde Levels from Wood Products Under Defined Conditions Using a Large Chamber; Standard E 1333 90, American Society for Testing and Materials: Philadelphia.

ASTM (1989) Standard Laboratory Test Method for Evaluation of Carpet-Embedded Dirt Removal Effectiveness of Household Vacuum Cleaners. Designation: F 608-89. American Society for Testing and Materials, Philadelphia, PA.

Axley, J.W. (1988) Progress Toward a General Analytical Method for Predicting Indoor Air Pollution in Buildings: Indoor Air Quality Modeling Phase III Report. NBSIR 88-3814. National Bureau of Standards, Gaithersberg, MD.

Axley, J.W. (1989) Multi-Zone Dispersal Analysis by Element Assembly. Building and Environment, 24(2):113-130.

Axley, J.W.; Lorenzetti, D. (1993) Sorption Transport Models for Indoor Air Quality Analysis. IN: Nagda, N.L. Ed., Modeling of Indoor Air Quality and

Exposure, ASTM STP 1205, American Society for Testing and Materials, Philadelphia, PA, pp. 105-127.

Baughman, A.V.; Gadgil, A.J.; Nazaroff, W.W. (1994) Mixing of a point source pollutant by natural convection flow within a room, Indoor Air, 4:114-122.

Chang, J.C.S.; Guo, Z. (1992) Characterization of Organic Emissions From a Wood Finishing Product -- Wood Stain, Indoor Air, 2(3):146-53.

Consumer Reports. (1982) Washing Machines. Consumer Reports Magazine, 47(10).

Consumer Reports, (1987) Dishwashers. Consumer Reports Magazine, 52(6).

Cussler, E.L. (1984) Diffusion. Cambridge University Press, New York, NY.

Dietz, R.N.; Goodrich, R.W.; Cote, E.A.; Wieser, R.F. (1986) Detailed description and performance of a passive perfluorocarbon tracer system for building ventilation and air exchange measurements. Measured Air Leakage of Buildings, ASTM STP 904, H.R. Trechsel and P.L. Lagus, Eds., American Society for Testing and Materials, Philadelphia, PA, pp. 203-264.

Drescher, A.C.; Lobascio, C.; Gadgil, A.J.; Nazaroff, W.W. (1995) Mixing of a Point-Source Indoor Pollutant by Forced Convection. Indoor Air, 5:204-214.

Dunn, J.E., 1987. Models And Statistical Methods For Gaseous Emission Testing Of Finite Sources In Well-Mixed Chambers, Atmospheric Environment, (21)2:425-430.

Dunn, J.E.; Chen, T. (1993) Critical Evaluation of the Diffusion Hypothesis in the Theory of Porous Media Volatile Organic Compounds (VOC) Sources and Sinks. IN: Nagda, N.L. Ed., Modeling of Indoor Air Quality and Exposure, ASTM STP 1205, American Society for Testing and Materials, Philadelphia, PA, pp. 64-80.

Dunn, J.E.; Tichenor, B.A. (1988) Compensating For Sink Effects In Emissions Test Chambers By Mathematical Modeling, Atmospheric Environment, 22(5)885-894.

EBMUD. (1992) Urban water management plan. East Bay Municipal Utility Water District, in written communication to J.B. Andelman, July 1992.

Emmerich, S.J.; Persily, A.K. (1994) Indoor Air Quality Impacts of Residential HVAC Systems Phase I Report: Computer Simulation Plan. Report No. NISTR 5346, National Institute of Standards and Technology, Gaithersburg, MD.

Furtaw, E.J.; Pandian, M.D.; Nelson, D.R; Behar, J.V. (1995) Modeling Indoor Air Concentrations Near Emission Sources in Perfectly Mixed Rooms. Engineering Solutions to Indoor Air Quality Problems. Presented at Sixth Conference of the International Society for Environmental Epidemiology and Fourth Conference of the International Society for Exposure Analysis (Joint Conference), Research Triangle Park, NC, September 1994.

GEOMET. (1982) Energy use, infiltration, and indoor air quality in tight, well-insulated residences: Characterization of test site and facilities. Contract RP-2042, Electric Power Research Institute, Palo Alto, CA.

GEOMET. (1989) Assessment of indoor air pollutant exposure within building zones. Report Number IE-2149, prepared for USEPA Office of Health and Environmental Assessment under Contract No. 68-02-4254, Task No. 235. GEOMET Technologies, Inc., Germantown, MD.

Giardino, N.J.; Gummerman, E.; Andelman, J.B.; Wilkes, C.R.; Small, M.J. (1990) Real-time Measurements of Trichloroethylene in Domestic Bathrooms Using Contaminated Water. Proceedings of the 5th International Conference on Indoor Air Quality and Climate, Toronto, 2:707-712.

Grot, R.A. (1991) User Manual NBS/AVIS CONTAM88. NISTIR 4585, National Institute of Standards and Technology, Gaithersberg, MD.

Grot, R.A.; Clark, R.E. (1981) Air leakage characteristics and weatherization techniques for low-income housing. In: Proceedings of the American Society of Heating, Refrigerating and Air-Conditioning Engineers Conference. Thermal Performance of Exterior Envelopes of Buildings. ASHRAE SP28, Atlanta, GA, pp. 178-194.

Grimsrud, D.T.; Sherman, M.H.; Sondereggen, R.C. (1983) Calculating Infiltration: implications for a construction quality standard. In: Proceedings of the American Society of Heating, Refrigerating and Air-Conditioning Engineers Conference. Thermal Performance of Exterior Envelopes of Buildings II. ASHRAE SP38, Atlanta, GA, pp. 422-449.

Hanley, J.T.; Ensor, D.S.; Smith, D.D.; Sparks, L.E. (1994) Fractional aerosol filtration efficiency of in-duct ventilation air cleaners. Indoor Air. 4(3):179-188.

Hirvonen, A.; Pasanen, P.; Tarhanen, J.; Ruuskanen, J. (1995) Thermal Desorption of Organic

Compounds Associated with Settled Household Dust. Indoor Air, 5:255-264.

Jennings, P.D.; Carpenter, C.E.; Krishnan, M.S. (1985) Methods for Assessing Exposure to Chemical Substances Volume 12: Methods for Estimating the Concentration of Chemical Substances in Indoor Air. EPA 560/5-85-016, U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances, Washington, DC.

Jennings, P.D.; Hammerstrom, K.A.; Adkins, L.C.; Chambers, T.; Dixon, D.A. (1987) Methods for Assessing Exposure to Chemical Substances Volume 7: Methods for Assessing Consumer Exposure to Chemical Substances. EPA 560/5-85-007, U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances, Washington, DC.

Koontz, M.D.; Rector, H.E. (1995) Estimation of distributions for residential air Exchange rates, EPA Contract No. 68-D9-0166, Work Assignment No. 3-19, U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, Washington, DC.

Koontz, M.D.; Nagda, N.L. (1989) Experimental Design and Protocols for Research at GEOMET's Test Houses: A Case Study. Design and Protocol for Monitoring Indoor Air Quality, ASTM STP 1002, N.L. Nagda and J.P. Harper, Eds., American Society for Testing and Materials, Philadelphia, PA, pp. 148-165.

Koontz, M.D.; Nagda, N.L. (1991) A Multichamber Model for Assessing Consumer Inhalation Exposure. Indoor Air, 1(4):593-605.

Koontz, M.D.; Rector, H.E.; Fortmann, R.C.; Nagda, N.L. (1988) Preliminary Experiments in a Research House to Investigate Contaminant Migration in Indoor Air. EPA 560/5-88-004. U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances, Washington, DC.

Layton, D.W.; Thatcher, T.L. (1995) Movement of Outdoor Particles to the Indoor Environment: An Analysis of the Arnhem Lead Study. Paper no. 95-MP4.02. Annual Meeting of the Air & Waste Management Association, San Antonio, TX.

Liddament, M.; Allen, C. (1983) Validation and comparison of mathematical models of air infiltration. Technical Note AIC 11. Air Infiltration Centre, Great Britain.

Ligman, K.; Hutzler, N.; Boyle, W.C. (1974) Household wastewater characterization. Journal of Environmental Engineering, 100:201-213.

Laak, R., (1974) Relative pollution strengths of undiluted waste materials discharged in households and the dilution waters used for each, Manual of Grey Water Treatment Practice.

Little, J.C. (1992) Applying the Two-Resistance Theory to Contaminant Volatilization in Showers. Environmental Science & Technology, 26(7):1341-1349.

Little, J.C.; Daisey, J.M.; Nazaroff, W.W. (1992) Transport of Subsurface Contaminants Into Buildings -- An exposure Pathway for Volatile Organics. Environmental Science & Technology, (26)11:2058-2066.

Lucas, R.M.; Grillo, R.B.; Perez-Michael, A.; Kemp, S. (1992) National residential Radon Survey Statistical Analysis -- Volume 2: Summary of the Questionnaire Data. RTI/5158/49-2F. Research Triangle Institute, Research Triangle Park, NC.

Mage, D.T.; Ott, W.R. (1994) The Correction for Nonuniform Mixing in Indoor Environments. ASTM Symposium on Methods for Characterizing Indoor Sources and Sinks, Washington, DC.

McKone, T.E. (1987) Human Exposure to Volatile Organic Compounds in Household Tap Water: The Inhalation Pathway. Environmental Science & Technology, 21(12):1194-1201.

McKone, T.E. (1989) Household Exposure Models. Toxicology Letters, 49:321-339.

MWD. (1991) Urban water use characteristics in the metropolitan water district of southern california. Draft Report, Metropolitan Water District of Southern California, August 1991.

Murray, D.M. (1996) Residential House and Zone Volumes in the United States: Empirical and Estimated Parametric Distributions. Submitted to Risk Analysis in 1996.

Murray, D.M.; Burmaster, D.E. (1995) Residential Air Exchange Rates in the United States: Empirical and Estimated Parametric Distribution by Season and Climatic Region. Submitted to Risk Analysis in 1995.

Nazaroff, W.W.; Cass, G.R. (1986) Mathematical Modeling of Chemically Reactive Pollutants in Indoor Air," Environmental Science & Technology, 20:924-934.

Nazaroff, W.W.; Cass, G.R. (1989) Mass-Transport Aspects Of Pollutant Removal At Indoor Surfaces, Environment International, 15:567-584.

Nazaroff, W.W.; Doyle, S.M.; Nero, A.V.; Sextro, R.G. (1988). Radon Entry Via Potable Water. In:

Nazaroff, W.W. and Nero, A.V., Eds., Radon and Its Decay Products in Indoor Air. John Wiley and Sons, NY. pp. 131-157.

Nazaroff, W.W.; Gadgil, A.J.; Weschler, C.J. (1993) Critique of the Use of Deposition Velocity in Modeling Indoor Air Quality. IN: Nagda, N.L. Ed., Modeling of Indoor Air Quality and Exposure, ASTM STP 1205, American Society for Testing and Materials, Philadelphia, PA, pp. 148-165.

Nazaroff, W.W.; Nero, A.V. (eds.). (1988) Radon and its decay products in indoor air, John Wiley & Sons, New York, NY.

Offerman, F.J.; Sextro, R.G.; Fisk, W.; Nazaroff, W.W.; Nero, A.V.; Revzan, K.L.; Yater, J. (1984) Control of respirable particles and radon progeny with portable air cleaners. Report No. LBL-16659, Lawrence Berkley Laboratory, Berkley, CA.

Pandian, M.H.; Behar, J.V.; Thomas, J. (1993) Use of a Relational Database to Predict Human Population Exposures for Different Time Periods. Proceedings of Indoor Air ‘93, Helsinki, 3:283-288.

Persily, A.K.; Linteris, G.T. (1983) A comparison of measured and predicted infiltration rates. ASHRAE Transactions. 89(2):183-199.

Rector, H.E.; Koontz, M.D. (1987) Scoping and Feasibility Study: Room-to-room contaminant migration and OTS indoor air exposure assessments. Report Number IE-1820, prepared for USEPA Office of Toxic Substances under Contract No. 68-02-4254, Task No. 59. Germantown, MD, GEOMET Technologies, Inc.

Relwani, S.M.; Moschandreas, D.J.; Billick, I.H. (1986) Effects of Operational Factors on Pollutant Emission Rates from Residential Gas Appliances, Journal of the Air Pollution Control Association, 36:1233-1237.

Roberts, J.W.; Budd, W.T.; Ruby, M.G.; Bond, A.E.; Lewis, R.G.; Wiener, R.W.; Camann, D.E. (1991) Development and Field Testing of a High Volume Sampler for Pesticides and Toxics in Dust. Journal of Exposure Analysis and Environmental Epidemiology, (1)2:143-155

Rodes, C.E.; Kamens, R.M.; Wiener, R.W. (1991) The Significance And Characteristics Of The Personal Activity Cloud On Exposure Assessment Measurements For Indoor Contaminants, Indoor Air, (1)2:123-145.

Ryan, P.B. (1991) An Overview of Human Exposure Modeling. Journal of Exposure Analysis and Environmental Epidemiology, (1)4:453-474.

Sandberg, M. (1984) The Multi-Chamber Theory Reconsidered From The Viewpoint Of Air Quality Studies, Building and Environment, (19)4:221-233.

Sextro, R.G. (1994) Radon and the Natural Environment. IN: Nagda, N.L. Ed., Radon -- Prevalence, Measurements, Health Risks and Control, ASTM MNL 15, American Society for Testing and Materials, Philadelphia, PA, pp. 9-32.

Shaughnessy, R.J.; Levetin, E.; Blocker, J.; Sublette, K.L. (1994) Effectiveness of portable air cleaners: sensory testing results. Indoor Air. 4(3):179-188.

Siegrist, R. (1976) Characteristics of Rural Household Wastewater. Journal of Environmental Engineering, 1:533-548.

Sinden, F.W. (1978) Multi-Chamber Theory of Infiltration, Building and Environment, 13:21-28.

Sparks, L.E. (1988) Indoor Air Quality Model Version 1.0. Report No. EPA-600/8-88-097a., Research Triangle Park, NC, U.S. Environmental Protection Agency.

Sparks, L.E. (1991) Exposure - Version 2., U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC

Swope, A.D.; Goydan, R.; Reid, R.C. (1992) Methods for Assessing Exposure to Chemical Substances Volume 11: Methodology for Estimating the Migration of Additives and Impurities from Polymeric Substances. EPA 560/5-85-015, U.S. Environmental Protection Agency, Office of Pollution Prevention, Pesticides, and Toxic Substances, Washington, DC.

Thatcher, T.L.; Layton, D.W. (1995) Deposition, Resuspension, and Penetration of Particles Within a Residence. Atmospheric Environment, 29(13):1487-1497.

Thompson, W. (1995) U.S. Department of Energy and Energy Information Administration, Personal Communication on distribution of heated floor space area from the 1993 RECS, December 1995.

Tichenor, B.A.; Sparks, L.A.; White, J.B.; Jackson, M.D. (1990) Evaluating sources of indoor air pollution. The Journal of the Air and Waste Management Association, 40:487-492.

Tichenor, B.A.; Guo, Z.; Dunn, J.E.; Sparks, L.E.; Mason, M.A., 1991. The Interaction of Vapor

Phase Organic Compounds with Indoor Sinks, Indoor Air, 1:23-35.

Tucker, W.G. (1991) Emission of organic substances from indoor surface materials. Environment International, 17:357-363.

U.S. Bureau of the Census. (1992) Statistical Abstract of the United States: 1992 (112th edition). Table No. 1230, p. 721, Washington, DC.

U.S. DHUD. (1984) Residential water conservation projects: summary report. Report Number HUD-PDR-903, Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research.

U.S. DOE. (1995) Housing Characteristics 1995, Report No. DOE/EIA-0314 (93), Washington, DC: U.S. Department of Energy, Energy Information Administration.

U.S. EPA. (1992) Guidelines For Exposure Assessment, Federal Register, vol. 57, no. 104, pp. 22888-22938 (May 29).

Versar. (1990) Database of PFT Ventilation Measurements: Description and User's Manual, USEPA Contract No. 68-02-4254, Task No. 39, Washington, D.C: U.S.Environmental Protection Agency, Office of Toxic Substances.

Wallace, L.A. (1996) Indoor Particles: A Review. The Journal of the Air & Waste Management Association, (46)2:98-126.

Walton, G.N. (1993) CONTAM 93 User Manual. NISTIR 5385. National Institute of Standards and Technology, Gaithersburg, MD.

Wilkes, C.R. (1994) Modeling human inhalation exposure to VOCs due to volatilization from a contaminated water supply. Doctoral Dissertation, Department of Civil Engineering, Carnegie Mellon University, Pittsburgh, PA, April 1994.

Wilkes, C.R.; Small, M.J.; Andelman, J.B.; Giardino, N.J.; Marshall, J. (1992) Inhalation Exposure Model for Volatile Chemicals from Indoor Uses of Water. Atmospheric Environment, (26A)12:2227-2236.

Wolkoff, P. (1995) Volatile Organic Compounds: Sources, Measurements, Emissions, and the Impact on Indoor Air Quality. Indoor Air, Supplement No. 3/95, pp 1-73.

Wolkoff, P.; Wilkins, C.K. (1994) Indoor VOCs from Household Floor Dust: Comparison of Headspace with Desorbed VOCs; Method for VOC Release Determination. Indoor Air, 4:248-254.

Zinn, T.W.; Cline, D.; Lehmann, W.F. (1990) Long-Term Study of Formaldehyde Emission Decay from Particleboard. Forest Products Journal, (40)6:15-18.

Table 16-28. Volume of Residence Surveys

Study	Number of Residences	Survey Type	Areas Surveyed	Comments
Key Studies				
Residential Energy Consumption Survey (RECS)	Over 7,000	Direct measurement of surface area; estimation of volume	Nationwide (random sample)	Volumes were estimated assuming 8 ft. ceiling height. Provides relationships between average residential volumes and facilities such as housing type, ownership, household size, and structure age.
Versar, 1990 (PFT database)	Over 2,000	Direct measurement and estimated	Nationwide (not random sample); a large fraction located in CA	Sample was not geographically balanced; statistical weighting were applied to develop nationwide distributions
Murray, 1996	7,041 (RECS) 1,751 (PFT	Direct measurements and estimated	Nationwide (not random sample); PFT - large fraction located in CA	Duplicate measurement were eliminated; tested the effects of using 8 ft. assumption on ceiling height to calculate volume; data from both databases were analyzed.

Table 16-29. Air Exchange Rates Surveys

Study	Number of Residences/Measurements	Survey Type	Areas Surveyed	Comments
Key Studies				
Versar, 1990 (PFT database)	Over 2,000	Measurements using PFT technique	Nationwide (not random sample); large fraction located in CA	Multiple measurements on the same home were included.
Koontz & Rector, 1995 (PFT database)	2,971 measurements	Measurements using PFT technique	Nationwide (not random sample); a large fraction located in CA	Multiple measurements on the same home were included. Compensated for geographic imbalances. Data are presented by region of the country and season.
Murray and Burmaster, 1995	2,944 measurement	Measurements using PFT technique	Nationwide (not random sample); a large fraction located in CA	Multiple measurements on the same home were included. Did not compensate for geographical imbalances. Data are presented by climate region and season.
Relevant Studies				
Nazaroff et al., 1988	255 (Grot and Clark, 1987)	Direct measurement	255, low-income families in 14 cities	Sample size was small and not representative of the U.S.
	312 (Grimrud, 1983)	Direct measurement	321, newer residences, median age < 10 years	Sample size was small and not representative of the U.S.

Table 16-30. Confidence in House Volume Recommendation

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	All key studies are from peer review literature.	High
• Accessibility	Papers are widely available from peer review journals.	High
• Reproducibility	Methodology was clearly presented.	High
• Focus on factor of interest	The focus of the studies was on estimating house volume as well as other factors.	High
• Data pertinent to U.S.	Residences in the U.S. was the focus of the key studies.	High
• Primary data	All the studies were based on primary data.	High
• Currency	Measurements in the PFT database were taken between 1982-1987. The RECS survey was conducted in 1993.	Medium
• Adequacy of data collection period	Not applicable	
• Validity of approach	For the RECS survey, volumes were estimated assuming 8 ft. ceiling height. The effect of this assumption has been tested by Murray (1996) assuming and determined, based on a sensitivity analysis, that it does not have a significant effect in the results.	Medium
• Study size	The sample sizes used in the key studies were fairly large, although only 1 study (RECS) was representative of the whole U.S. Not all samples were selected at random; however, RECS samples were selected at random.	Medium
• Representativeness of the population	RECS sample is representative of the U.S.	Medium
• Characterization of variability	Distributions are presented by housing type and regions; although some of the sample sizes for the subcategories were small.	Medium
• Lack of bias in study design (high rating is desirable)	Selection of residences was random for RECS.	Medium
• Measurement error	Some measurement error may exist since surface areas were estimated using the assumption of 8 ft. ceiling height.	Medium
Other Elements		
• Number of studies	There are 3 key studies; however there are only 2 data sets.	Low
• Agreement between researchers	There is good agreement among researchers.	High
Overall Rating	Results were consistent; 1 study (RECS) was representative of residences in the whole U.S.; volumes were estimated rather than measured in some cases.	Medium

Table 16-31. Confidence in Air Exchange Rates Recommendation		
Considerations	Rationale	Rating
Study Elements		
• Level of peer review	The key studies appear in peer reviewed literature. Although there are 3 key studies, they are all based on the same database (PFT database).	High
• Accessibility	Papers are widely available from government reports and peer review journals.	High
• Reproducibility	Methodology was clearly presented.	High
• Focus on factor of interest	The focus of the studies was on estimating air exchange rates as well as other factors.	High
• Data pertinent to U.S.	Residences in the U.S. was the focus of the PFT database.	High
• Primary data	All the studies were based on primary data.	High
• Currency	Measurements in the PFT database were taken between 1982-1987.	Medium
• Adequacy of data collection period	Only short term data were collected; some residences were measured during different seasons; however, long term air exchange rates are not well characterized.	Medium
• Validity of approach	The methodology used is the most practical for measuring air exchange rates.	Medium
• Study size	The sample sizes used in the key studies were fairly large, although not representative of the whole U.S. Not all samples were selected at random.	Medium
• Representativeness of the population	Sample is not representative of the U.S..	Low
• Characterization of variability	Distributions are presented by U.S. regions, seasons, and climatic regions; although some of the sample sizes for the subcategories were small.	Medium
• Lack of bias in study design (high rating is desirable)	Bias may result since the selection of residences were not random.	Low
• Measurement error	Some measurement error may exist.	Medium
Other Elements		
• Number of studies	There are 3 key studies; however there are only 1 data set. However, the database contains results of 20 projects of varying scope.	Medium
• Agreement between researchers	Not applicable	
Overall Rating	Sample was not representative of residences in the whole U.S., but covered the range of occurrence.	Medium

TABLE OF CONTENTS

17. INTAKE OF GRAIN PRODUCTS

Consumption of grain products is a potential pathway of exposure to toxic chemicals. These food sources can become contaminated by absorption or deposition of ambient air pollutants onto the plants, contact with chemicals dissolved in rainfall or irrigation waters, or absorption of chemicals through plant roots from soil and ground water. The addition of pesticides, soil additives, and fertilizers may also result in contamination of grain products.

The U.S. Department of Agriculture's (USDA) Nationwide Food Consumption Survey (NFCS) and Continuing Survey of Food Intakes by Individuals (CSFII) are the primary sources of information of intake rates of grain products in the United States. Data from the NFCS have been used in various studies to generate consumer-only and per capita intake rates for both individual grain products and total grains. CSFII 1989-1991 survey data have been analyzed by EPA to generate per capita intake rates for various food items and food groups. As described in Volume II, Chapter 9, consumer-only intake is defined as the quantity of grain products consumed by individuals who ate these food items during the survey period. Per capita intake rates are generated by averaging consumer-only intakes over the entire population of users and non-users. In general, per capita intake rates are appropriate for use in exposure assessments for which average dose estimates for the general population are of interest because they represent both individuals who ate the foods during the survey period and individuals who may eat the food items at some time, but did not consume them during the survey period.

This Chapter provides intake data for individual grain products and total grains. Recommendations are based on average and upper-percentile intake among the general population of the U.S. Available data have been classified as being either a key or a relevant study based on the considerations discussed in Volume I, Section 1.3.1 of the Introduction. Recommendations are based on data from the CSFII survey, which was considered the only key intake study for grain products. Although Pao et al. (1982) was not considered a key study for intake of grain products because it is based on data from NFCS 1977-1978, it was included as a key study for serving size. Other relevant studies are also presented to provide the reader with added perspective on this topic. It should be noted that most of the key and relevant studies presented in this Chapter are based on data from USDA's NFCS and CSFII. The USDA NFCS and CSFII are described below.

17.1. INTAKE STUDIES

17.1.1. U.S. Department of Agriculture Nationwide Food Consumption Survey and Continuing Survey of Food Intake by Individuals

The NFCS and CSFII are the basis of much of the data on grain intake presented in this section. Data from the 1977-78 NFCS are presented because the data have been published by USDA in various reports and reanalyzed by various EPA offices according to the food items/groups commonly used to assess exposure. Published one-day data from the 1987-88 NFCS are also presented. Recently, EPA conducted an analysis of USDA's 1989/91 CSFII. These data are the most recent food survey data that are available to the public. The results of EPA's analyses are presented here. Detailed descriptions of the NFCS and CSFII data are presented in Volume II, Chapter 9 - Intake of Fruits and Vegetables.

Individual average daily intake rates calculated from NFCS data are based on averages of reported individual intakes over one day or three consecutive days. Such short term data are suitable for estimating average daily intake rates representative of both short-term and long-term consumption. However, the distribution of average daily intake rates generated using short term data (e.g., 3-day) do not necessarily reflect the long-term distribution of average daily intake rates. The distributions generated from short term and long term data will differ to the extent that each individual's intake varies from day to day; the distributions will be similar to the extent that individuals' intakes are constant from day to day.

Day-to-day variation in intake among individuals will be great for food item/groups that are highly seasonal and for items/groups that are eaten year around, but that are not typically eaten every day. For these foods, the intake distribution generated from short term data will not be a good reflection of the long term distribution. On the other hand, for broad categories of foods (e.g., total grains) which are eaten on a daily basis throughout the year with minimal seasonality, the short term distribution may be a reasonable approximation of the true long term distribution, although it will show somewhat more variability. In this Chapter, distributions are shown for the various grain categories. Because of the increased variability of the short-term distribution, the short-term upper percentiles shown will overestimate somewhat the corresponding percentiles of the long-term distribution.

17.1.2. Key Grain Products Intake Studies Based on the CSFII

U.S. EPA Analysis of 1989/91 USDA CSFII Data - EPA conducted an analysis of USDA's 1989-91 CSFII data set. The general methodology used in analyzing the data is presented in Volume II, Chapter 9 (Fruits and Vegetables) of this handbook. Intake rates were generated for the following grain products: total grains, breads, sweets, snacks, breakfast foods, pasta, cooked cereals, rice, ready-to-eat cereals, and baby cereals. Appendix 17A provides the food codes and descriptions used in this grain analysis. The data for total grains have been corrected to account for mixtures as described in Volume II, Chapter 9 and Appendix 9A using an assumed grain content of 31 percent for grain mixtures and 13 percent for meat mixtures. Per capita intake rates for total grains are presented in Tables 17-1. Table 17-2 through 17-10 present per capita intake data for individual grain products. The results are presented in units of g/kg-day. Thus, use of these data in calculating potential dose does not require the body weight factor to be included in the denominator of the average daily dose (ADD) equation. It should be noted that converting these intake rates into units of g/day by multiplying by a single average body weight is inappropriate, because individual intake rates were indexed to the actual body weights of the survey respondents. However, if there is a need to compare the total intake data presented here to other intake data in units of g/day, a body weight less than 70 kg (i.e., approximately 60 kg; calculated based on the number of respondents in each age category and the average body weights for these age groups, as presented in Volume I, Chapter 7) should be used because the total survey population included children as well as adults.

The advantages of using the CSFII data set are that the data are expected to be representative of the U.S. population and that it includes data on a wide variety of food types. The data set is the most recent of a series of publicly available data sets (i.e., NFCS 1977/78; NFCS 1987/88; CSFII 1989-91) from USDA, and should reflect current eating patterns in the United States. The data set includes three years of intake data combined. However, the CSFII data are based on a three day survey period. Short-term dietary data may not accurately reflect long-term eating patterns. This is particularly true for the tails of the distribution of food intake. In addition, the adjustment for including mixtures adds uncertainty to the intake rate distributions. The calculation for including mixtures assumes that intake of any mixture includes grains in the proportions specified in Appendix Table 9A-1. This assumption yields valid estimates of per capita consumption, but results in overestimates of the proportion of the population consuming total grains; thus, the quantities reported in Table 17-1 should be interpreted as upper bounds on the proportion of the population consuming grain products, not as valid point estimates.

17.1.3. Key Grain Products Serving Size Study Based on the USDA NFCS

Pao et al. (1982) - Foods Commonly Eaten by Individuals - Using data gathered in the 1977-78 USDA NFCS, Pao et al. (1982) calculated percentiles for the quantities of grain products consumed per eating occasion by members of the U.S. population. The data were collected during NFCS home interviews of 37,874 respondents, who were asked to recall food intake for the day preceding the interview, and record food intake the day of the interview and the day after the interview. Quantities consumed per eating occasion, are presented in Table 17-11.

The advantages of using these data are that they were derived from the USDA NFCS and are representative of the U.S. population. This data set provides distributions of serving sizes for a number of commonly eaten grain products, but the list of foods is limited and does not account for grain products included in complex food dishes. Also, these data are based on short-term dietary recall and may not accurately reflect long-term consumption patterns. Although these data are based on the NFCS 1977-78 survey, serving size data have been collected, but not published, for the more recent USDA surveys.

17.1.4. Relevant Grain Products Intake Studies

The U.S. EPA's Dietary Risk Evaluation System (DRES) - USEPA, Office of Pesticide Programs (OPP) - EPA OPP's DRES contains per capita intake rate data for various grain products for 22 subgroups (age, regional, and seasonal) of the population. As described in Volume II, Chapter 9 - Fruits and Vegetables, intake data in DRES were generated by determining the composition of NFCS food items and disaggregating complex food dishes into their component raw agricultural commodities (RACs) (White et al., 1983). The DRES per capita, as consumed intake rates for all age/sex/demographic groups combined are presented in Table 17-12. These data are based on both consumers and non-consumers of these food items. Data for specific subgroups of the population are not presented in this section, but are available through OPP via direct request. The data in Table 17-12 may be useful for estimating the risks of exposure associated with the consumption of the various grain products presented. It should be noted that these data are indexed to the actual body weights of the survey respondents and are expressed in units of grams of food consumed per kg body weight per day. Consequently, use of these data in calculating potential dose does not require the body weight factor in the denominator of the average daily dose (ADD) equation. It should also be noted that conversion of these intake rates into units of g/day by multiplying by a single average body weight is not appropriate because the DRES data base did not rely on a single body weight for all individuals. Instead, DRES used the body weights reported by each individual surveyed to estimate consumption in units of g/kg-day.

The advantages of using these data are that complex food dishes have been disaggregated to provide intake rates for a variety of grains. These data are also based on the individual body weights of the respondents. Therefore, the use of these data in calculating exposure to toxic chemicals may provide more representative estimates of potential dose per unit body weight. However, because the data are based on NFCS short-term dietary recall, the same limitations discussed previously for other NFCS data sets also apply here. In addition, consumption patterns may have changed since the data were collected in 1977-78. OPP is in the process of translating consumption information from the USDA CSFII 1989-91 survey to be used in DRES.

Food and Nutrient Intakes of Individuals in One Day in the U.S., USDA (1980, 1993a) -USDA (1980; 1993a) calculated mean per capita intake rates for total and individual grain products using NFCS data from 1977-78 and 1987-88. The mean intake rates for grain products are presented in Tables 17-13 and 17-14 for the two survey years, respectively.

The advantages of using these data are that they provide mean intake estimates for various grain products. The consumption estimates are based on short-term (i.e., 1-day) dietary data which may not reflect long-term consumption.

U.S. EPA - Office of Radiation Programs - The U.S. EPA Office of Radiation Programs (ORP) has also used the USDA 1977-1978 NFCS to estimate daily food intake. ORP uses food consumption data to assess human intake of radionuclides in foods (U.S. EPA, 1984a; 1984b). The 1977-1978 NFCS data have been reorganized by ORP, and food items have been classified according to the characteristics of radionuclide transport. The mean dietary per capita intake of grain products, grouped by age, for the U.S. population are presented in Table 17-15. The mean daily intake rates of grain products for the U.S. population grouped by regions are presented in Table 17-16. Because this study was based on the USDA NFCS, the limitations and advantages associated with the USDA-NFCS data also apply to this data set.

U.S. EPA - Office of Science and Technology - The U.S. EPA Office of Science and Technology (OST) within the Office of Water (formerly the Office of Water Regulations and Standards) used data from the FDA revision of the Total Diet Study Food Lists and Diets (Pennington, 1983) to calculate food intake rates. OST uses these consumption data in its risk assessment model for land application of municipal sludge. The FDA data used are based on the combined results of the USDA 1977-1978 NFCS and the second National Health and Nutrition Examination Survey (NHANES II), 1976-1980 (U.S. EPA, 1989). Because food items are listed as prepared complex foods in the FDA Total Diet Study, each item was broken down into its component parts so that the amount of raw commodities consumed could be determined. Table 17-17 presents intake rates for grain products for various age groups. Estimated lifetime ingestion rates derived by U.S. EPA (1989) are also presented in Table 17-17. Note that these are per capita intake rates tabulated as grams dry weight/day. Therefore, these rates differ from those in the previous tables because USDA (1980; 1992) and U.S. EPA (1984a, 1984b) report intake rates on an as consumed basis.

The EPA-OST analysis provides intake rates for additional food categories and estimates of lifetime average daily intake on a per capita basis. In contrast to the other analyses of USDA NFCS data, this study reports the data in terms of dry weight intake rates. Thus, conversion is not required when contaminants are provided on a dry weight basis.

USDA (1993b) - Food Consumption, Prices, and Expenditures, 1970-92 - The USDA's Economic Research Service (ERS) calculates the amount of food available for human consumption in the United States annually. Supply and utilization balance sheets were generated. These were based on the flow of food items from production to end uses. Total available supply was estimated as the sum of production (i.e., some products were measured at the farm level or during processing), starting inventories, and imports (USDA, 1993). The availability of food for human use commonly termed as "food disappearance" was determined by subtracting exported foods, products used in industries, farm inputs (seed and feed) and end-of-the year inventories from the total available supply (USDA, 1993). USDA (1993) calculated the per capita food consumption by dividing the total food disappearance by the total U.S. population.

USDA (1993) estimated per capita consumption data for grain products from 1970-1992 (1992 data are preliminary). In this section, the 1991 values, which are the most recent final data, are presented. Table 17-18 presents per capita consumption in 1991 for grains.

One of the limitations of this study is that disappearance data do not account for losses from the food supply from waste, spoilage, or foods fed to pets. Thus, intake rates based on these data may overestimate daily consumption because they are based on the total quantity of marketable commodity utilized. Therefore, these data may be useful for estimating bounding exposure estimates. It should also be noted that per capita estimates based on food disappearance are not a direct measure of actual consumption or quantity ingested, instead the data are used as indicators of changes in usage over time (USDA, 1993). An advantage of this study is that it provides per capita consumption rates for grains which are representative of long-term intake because disappearance data are generated annually. Daily per capita intake rates are generated by dividing annual consumption by 365 days/year.

17.2. RECOMMENDATIONS

The CSFII data described in this section was used in selecting recommended grain, product intake rates for the general population and various subgroups of the United States population. The general design of both key and relevant studies are summarized in Table 17-19. The recommended values for intake of grain products are summarized in Table 17-20 and the confidence ratings for the recommended values for grain intake rates are presented in Table 17-21. Per capita intake rates for specific grain items, on a g/kg-day basis, may be obtained from Tables 17-2 through 17-10. Percentiles of the intake rate distribution in the general population for total grains, are presented in Tables 17-1. From these tables, the mean and 95th percentile intake rates for grains are 4.1 g/kg-day and 10.8 g/kg-day, respectively. It is important to note that the distributions presented in Tables 17-1 through 17-10 are based on data collected over a 3-day period and may not necessarily reflect the long-term distribution of average daily intake rates. However, for the broad categories of foods (i.e., total grains, breads), because they may be eaten on a daily basis throughout the year with minimal seasonality, the short-term distribution may be a reasonable approximation of the long-term distribution, although it will display somewhat increased variability. This implies that the upper percentiles shown will tend to overestimate the corresponding percentiles of the true long-term distribution.

This section also presents recommendations for serving size for various grains. These recommendations are based on the USDA NFCS 1977-78 data. The confidence rating for serving size recommendations are presented in Table 17-22. Percentiles of the serving size, as well as mean values, can be obtained from Table 17-11.

The advantage of using the CSFII and USDA NFCS data set is they are the largest publicly available data source on food intake patterns in the United States. Data are available for a wide variety of grain products and are intended to be representative of the U.S. population.

17.3. REFERENCES FOR CHAPTER 17

Pao, E.M.; Fleming, K.H.; Guenther, P.M.; Mickle, S.J. (1982) Foods commonly eaten by individuals: amount per day and per eating occasion. U.S. Department of Agriculture. Home Economics Report No. 44.

Pennington, J.A.T. (1983) Revision of the total diet study food list and diets. J. Am. Diet. Assoc. 82:166-173.

USDA. (1980) Food and nutrient intakes of individuals in one day in the United States, Spring 1977. U.S. Department of Agriculture. Nationwide Food Consumption Survey 1977-1978. Preliminary Report No. 2.

USDA. (1993a) Food and nutrient intakes by individuals in the United States, 1 day, 1987-88. U.S. Department of Agriculture, Human Nutrition Information Service. Nationwide Food Consumption Survey 1987-88, NFCS Rpt. No. 87-I-1.

USDA. (1993b) Food consumption prices and expenditures (1970-1992) U.S. Department of Agriculture, Economic Research Service. Statistical Bulletin, No. 867.

U.S. EPA. (1984a) An estimation of the daily average food intake by age and sex for use in assessing the radionuclide intake of individuals in the general population. EPA-520/1-84-021.

U.S. EPA. (1984b) An estimation of the daily food intake based on data from the 1977-1978 USDA Nationwide Food Consumption Survey.

Washington, DC: Office of Radiation Programs. EPA-520/1-84-015.

U.S. EPA. (1989) Development of risk assessment methodologies for land application and distribution and marketing of municipal sludge. Washington, DC: Office of Science and Technology. EPA 600/-89/001.

White, S.B.; Peterson, B.; Clayton, C.A.; Duncan, D.P. (1983) Interim Report Number 1: The construction of a raw agricultural commodity consumption data base. Prepared by Research Triangle Institute for EPA Office of Pesticide Programs.

Table 17-1. Intake of Total Grains Including Mixtures (g/kg-day)[a]

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	97.5%	4.061	0.033	0	0.74	1.16	1.90	3.06	4.96	8.04	10.77	18.53	42.98
Age													
< 01	80.4%	7.049	0.361	0	0	0	1.46	6.05	10.18	16.75	19.50	27.61	37.41
1-2	95.8%	10.567	0.285	0	2.86	4.34	6.55	9.59	14.06	18.92	21.57	28.22	42.98
3-5	97.5%	9.492	0.201	0	3.13	4.35	6.09	8.91	11.88	15.13	19.14	23.87	33.08
6-11	97.7%	6.422	0.117	0	2.14	2.88	4.07	5.70	7.82	10.26	12.85	21.40	31.93
12-19	98.2%	3.764	0.065	0	1.15	1.52	2.16	3.31	4.81	6.46	8.03	10.92	19.30
20-39	98.4%	3.095	0.035	0	0.70	1.08	1.75	2.73	4.00	5.47	6.55	9.57	25.71
40-69	98.3%	2.792	0.031	0	0.69	0.98	1.59	2.47	3.54	4.96	6.09	8.40	20.34
70 +	98.7%	3.263	0.066	0.38	0.89	1.24	1.86	2.72	4.04	5.81	7.63	10.47	21.45
Season													
Fall	97.9%	4.282	0.066	0	0.84	1.24	2.07	3.19	5.19	8.54	11.88	19.10	37.77
Spring	97.0%	3.983	0.071	0	0.70	1.10	1.79	2.95	4.73	7.78	10.52	23.87	31.93
Summer	97.5%	3.948	0.062	0	0.74	1.13	1.82	2.99	4.96	7.98	10.16	15.34	30.13
Winter	97.6%	4.031	0.063	0	0.70	1.17	1.95	3.17	4.99	8.00	10.48	16.86	42.98
Urbanization													
Central City	97.6%	4.159	0.061	0	0.75	1.13	1.91	3.06	5.07	8.71	11.61	17.69	37.77
Nonmetropolitan	96.9%	4.013	0.067	0	0.60	1.11	1.85	3.12	4.93	7.81	10.08	21.05	31.93
Suburban	97.8%	4.02	0.049	0	0.80	1.18	1.90	3.04	4.91	7.79	10.63	18.53	42.98
Race													
Asian	94.0%	6.479	0.402	0	0	1.46	3.02	5.44	9.07	14.13	14.63	20.65	23.78
Black	96.9%	4.372	0.103	0	0.55	0.94	1.81	3.05	5.69	9.47	12.47	18.96	40.07
Native American	87.7%	3.98	0.276	0	0	0.61	1.63	3.67	5.81	6.90	9.00	20.43	21.84
Other/NA	97.1%	4.561	0.208	0	0	1.21	2.26	3.56	5.36	8.87	11.72	22.07	30.51
White	97.9%	3.962	0.035	0	0.79	1.18	1.90	3.03	4.80	7.79	10.20	18.07	42.98
Region													
Midwest	97.3%	4.016	0.07	0	0.79	1.17	1.90	2.92	4.69	7.80	11.04	20.36	31.93
Northeast	97.6%	4.255	0.079	0	0.78	1.26	2.02	3.19	5.37	8.44	11.61	17.73	42.98
South	97.9%	3.943	0.052	0	0.71	1.10	1.83	3.06	4.89	8.13	10.20	16.42	40.07
West	97.2%	4.116	0.072	0	0.69	1.13	1.92	3.13	5.03	7.98	10.90	19.50	25.89

[a] Includes breads; sweetsuch as cakes, pie, and pastries; snack and breakfast foods made with grains; pasta; cooked ready-to-eat, and baby cereals, rice and grain mixtures.
Note: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analysis of the 1989/91 CSFII.

Table 17-2. Intake of Breads (g/kg-day)[a]

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	91.6%	1.133	0.010	0	0	0.19	0.48	0.90	1.50	2.31	3.04	4.67	12.99
Age													
< 01	50.9%	1.072	0.102	0	0	0	0	0.34	1.65	3.29	4.06	6.09	12.99
1-2	88.9%	2.611	0.089	0	0	0.44	1.17	2.39	3.86	4.68	5.42	8.23	10.29
3-5	91.9%	2.217	0.063	0	0	0.44	1.19	2.03	3.04	4.01	5.14	6.95	12.35
6-11	93.4%	1.668	0.037	0	0	0.40	0.88	1.44	2.18	3.16	3.98	5.95	9.17
12-19	91.8%	1.068	0.025	0	0	0.21	0.45	0.91	1.46	2.15	2.78	3.43	7.44
20-39	92.9%	0.936	0.012	0	0	0.18	0.43	0.81	1.27	1.81	2.27	3.41	7.04
40-69	93.7%	0.915	0.011	0	0	0.20	0.46	0.81	1.25	1.77	2.08	2.83	11.16
70 +	95.1%	0.976	0.021	0	0.15	0.29	0.56	0.87	1.31	1.76	2.15	2.76	11.81
Season													
Fall	91.3%	1.181	0.020	0	0	0.17	0.50	0.94	1.57	2.45	3.16	5.27	11.81
Spring	91.4%	1.095	0.018	0	0	0.18	0.48	0.89	1.45	2.18	2.91	4.54	12.35
Summer	92.4%	1.126	0.018	0	0	0.21	0.48	0.90	1.51	2.24	2.98	4.43	9.17
Winter	91.2%	1.129	0.019	0	0	0.19	0.47	0.89	1.50	2.37	3.07	4.66	12.99
Urbanization													
Central City	91.2%	1.127	0.017	0	0	0.18	0.49	0.91	1.50	2.33	2.98	4.50	11.81
Nonmetropolitan	91.7%	1.184	0.020	0	0	0.18	0.48	0.93	1.54	2.51	3.24	4.97	12.99
Suburban	91.8%	1.113	0.014	0	0	0.19	0.49	0.89	1.49	2.20	2.89	4.68	12.35
Race													
Asian	78.5%	0.981	0.078	0	0	0	0.34	0.86	1.51	2.57	2.61	3.34	3.34
Black	88.8%	1.159	0.030	0	0	0.11	0.37	0.84	1.55	2.59	3.29	5.58	8.94
Native American	81.3%	1.336	0.133	0	0	0.13	0.41	0.72	1.80	2.91	4.13	9.09	11.71
Other/NA	89.1%	1.333	0.067	0	0	0	0.62	1.11	1.70	2.66	3.79	6.16	9.98
White	92.5%	1.121	0.010	0	0	0.20	0.51	0.91	1.48	2.23	2.95	4.51	12.99
Region													
Midwest	91.2%	1.109	0.018	0	0	0.20	0.50	0.90	1.49	2.22	2.91	4.43	7.97
Northeast	91.1%	1.104	0.021	0	0	0.18	0.51	0.90	1.48	2.26	2.83	4.50	9.98
South	91.8%	1.155	0.017	0	0	0.18	0.46	0.92	1.54	2.41	3.13	4.89	12.99
West	92.1%	1.153	0.022	0	0	0.19	0.49	0.91	1.48	2.35	3.12	5.14	12.35

[a] Includes breads, rolls, muffins, bagels, biscuits, cornbread, and tortillas.
Note: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analysis of the 1989/91 CSFII.

Table 17-3. Intake of Sweets (g/kg-day) [a]

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	50.2%	0.508	0.011	0	0	0	0	0.13	0.71	1.50	2.12	3.96	13.39
Age													
< 01	28.1%	0.447	0.096	0	0	0	0	0	0.41	1.42	2.26	5.51	9.35
1-2	49.6%	1.144	0.111	0	0	0	0	0.43	1.75	3.32	4.87	6.51	13.39
3-5	59.2%	1.139	0.079	0	0	0	0	0.56	1.82	3.01	4.33	6.78	9.25
6-11	63.7%	0.881	0.046	0	0	0	0	0.43	1.29	2.33	3.28	5.39	12.97
12-19	54.0%	0.511	0.030	0	0	0	0	0.22	0.75	1.47	1.99	3.25	9.65
20-39	45.0%	0.383	0.015	0	0	0	0	0	0.59	1.24	1.66	2.48	7.45
40-69	49.1%	0.381	0.015	0	0	0	0	0.08	0.55	1.13	1.58	2.70	5.70
70 +	56.3%	0.444	0.029	0	0	0	0	0.16	0.63	1.29	1.64	2.73	6.94
Season													
Fall	52.9%	0.533	0.022	0	0	0	0	0.14	0.76	1.55	2.21	3.82	13.39
Spring	48.3%	0.466	0.021	0	0	0	0	0.10	0.65	1.36	1.82	3.58	9.35
Summer	48.5%	0.527	0.025	0	0	0	0	0.06	0.70		2.35	4.54	8.73
Winter	51.2%	0.508	0.022	0	0	0	0	0.19	0.71	1.50	2.00	4.00	10.84
Urbanization													
Central City	45.3%	0.495	0.021	0	0	0	0	0.11	0.65	1.55	2.12	4.24	9.94
Nonmetropolitan	52.3%	0.593	0.025	0	0	0	0	0.25	0.82	1.58	2.34	4.52	13.39
Suburban	52.4%	0.477	0.015	0	0	0	0	0.10	0.69	1.42	2.00	3.55	9.65
Race													
Asian	37.6%	0.515	0.101	0	0	0	0	0.05	0.78	1.82	2.22	2.52	4.06
Black	39.3%	0.387	0.030	0	0	0	0	0	0.46	1.20	1.71	3.51	9.67
Native American	33.9%	0.325	0.075	0	0	0	0	0	0.33	1.47	1.48	2.44	3.78
Other/NA	32.3%	0.283	0.088	0	0	0	0	0	0.21	0.64	1.45	3.04	9.94
White	53.2%	0.537	0.012	0	0	0	0	0.17	0.77	1.55	2.17	4.09	13.39
Region													
Midwest	53.0%	0.573	0.024	0	0	0	0	0.17	0.79	1.65	2.41	4.00	12.97
Northeast	55.9%	0.587	0.027	0	0	0	0	0.22	0.83	1.63	2.21	4.60	13.39
South	47.5%	0.471	0.018	0	0	0	0	0.09	0.65	1.39	1.98	3.89	10.84
West	46.7%	0.416	0.022	0	0	0	0	0	0.55	1.25	1.91	3.33	9.65

[a] Includes cakes, cookies, pies, pastries, doughnuts, breakfast bars, and coffee cakes.

NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analysis of the 1989/91 CSFII.

Table 17-4. Intake of Snacks Containing Grain (g/kg-day) [a]

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	40.3%	0.160	0.005	0	0	0	0	0	0.18	0.47	0.78	1.74	6.73
Age													
< 01	31.4%	0.321	0.064	0	0	0	0	0	0.35	1.24	1.82	4.66	5.73
1-2	46.7%	0.398	0.040	0	0	0	0	0.10	0.65	1.30	1.61	2.03	6.73
3-5	48.9%	0.393	0.034	0	0	0	0	0.12	0.58	1.22	1.65	2.20	4.76
6-11	43.1%	0.269	0.023	0	0	0	0	0	0.32	0.86	1.24	2.43	4.00
12-19	40.2%	0.170	0.016	0	0	0	0	0	0.21	0.50	0.74	1.94	3.51
20-39	38.2%	0.123	0.007	0	0	0	0	0	0.15	0.41	0.60	1.21	4.60
40-69	40.3%	0.104	0.006	0	0	0	0	0	0.14	0.33	0.46	1.06	2.85
70 +	40.9%	0.074	0.007	0	0	0	0	0	0.10	0.20	0.36	0.70	1.47
Season													
Fall	41.6%	0.180	0.012	0	0	0	0	0	0.18	0.50	0.87	1.99	6.73
Spring	38.3%	0.136	0.009	0	0	0	0	0	0.15	0.43	0.67	1.29	3.43
Summer	37.5%	0.165	0.010	0	0	0	0	0	0.18	0.52	0.86	1.72	5.73
Winter	43.9%	0.160	0.010	0	0	0	0	0	0.19	0.44	0.76	1.77	4.60
Urbanization													
Central City	36.5%	0.158	0.010	0	0	0	0	0	0.16	0.46	0.81	1.81	3.70
Nonmetropolitan	39.8%	0.144	0.009	0	0	0	0	0	0.17	0.44	0.66	1.32	4.76
Suburban	43.3%	0.169	0.008	0	0	0	0	0	0.18	0.50	0.80	1.75	6.73
Race													
Asian	22.1%	0.077	0.035	0	0	0	0	0	0.04	0.27	0.37	1.09	1.34
Black	25.9%	0.107	0.014	0	0	0	0	0	0.07	0.33	0.59	1.19	4.76
Native American	30.4%	0.142	0.050	0	0	0	0	0	0.16	0.32	0.44	1.29	4.60
Other/NA	28.3%	0.139	0.026	0	0	0	0	0	0.17	0.43	0.69	1.27	1.91
White	43.7%	0.170	0.006	0	0	0	0	0	0.19	0.49	0.81	1.80	6.73
Region													
Midwest	45.2%	0.202	0.012	0	0	0	0	0	0.23	0.57	0.99	1.95	6.73
Northeast	35.8%	0.113	0.010	0	0	0	0	0	0.10	0.35	0.61	1.28	5.73
South	39.8%	0.162	0.008	0	0	0	0	0	0.19	0.46	0.80	1.63	4.76
West	39.4%	0.155	0.011	0	0	0	0	0	0.16	0.46	0.76	1.81	4.60

[a] Includes grain snacks such as crackers, salty snacks, popcorn, and pretzels.

NOTE: SE = Standard error
P = Percentile of the distribution

Source: Based on EPA's analysis of the 1989/91 CSFII.

Table 17-5. Intake of Breakfast Foods (g/kg-day) [a]

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	15.0%	0.144	0.012	0	0	0	0	0	0	0.46	0.95	2.46	13.61
Age													
< 01	13.2%	0.255	0.108	0	0	0	0	0	0	0.57	2.08	3.82	5.72
1-2	20.9%	0.418	0.103	0	0	0	0	0	0.37	1.54	2.50	4.62	9.92
3-5	24.5%	0.446	0.078	0	0	0	0	0	0.56	1.63	2.33	3.92	11.90
6-11	25.0%	0.307	0.045	0	0	0	0	0	0.31	1.12	1.69	2.82	13.61
12-19	18.4%	0.193	0.038	0	0	0	0	0	0	0.65	1.16	3.06	5.38
20-39	13.2%	0.086	0.014	0	0	0	0	0	0	0.31	0.61	1.53	4.41
40-69	10.8%	0.063	0.011	0	0	0	0	0	0	0.23	0.51	0.95	2.98
70 +	12.5%	0.096	0.025	0	0	0	0	0	0	0.41	0.65	1.37	3.09
Season													
Fall	15.1%	0.146	0.021	0	0	0	0	0	0	0.49	0.93	2.61	6.83
Spring	13.2%	0.120	0.023	0	0	0	0	0	0	0.34	0.71	2.32	6.23
Summer	14.8%	0.145	0.022	0	0	0	0	0	0	0.53	0.98	2.02	7.41
Winter	17.0%	0.168	0.027	0	0	0	0	0	0	0.55	1.04	2.94	13.61
Urbanization													
Central City	15.1%	0.142	0.021	0	0	0	0	0	0	0.42	0.93	2.61	7.17
Nonmetropolitan	13.3%	0.120	0.020	0	0	0	0	0	0	0.39	0.85	1.97	7.41
Suburban	15.9%	0.157	0.019	0	0	0	0	0	0	0.52	1.06	2.45	13.61
Race													
Asian	10.1%	0.076	0.060	0	0	0	0	0	0	0.24	0.61	1.04	1.46
Black	11.9%	0.114	0.032	0	0	0	0	0	0	0.20	0.78	2.46	7.41
Native American	18.7%	0.156	0.073	0	0	0	0	0	0.21	0.53	0.61	1.23	6.83
Other/NA	13.7%	0.079	0.037	0	0	0	0	0	0	0.40	0.43	1.40	2.33
White	15.6%	0.152	0.013	0	0	0	0	0	0	0.51	0.97	2.56	13.61
Region													
Midwest	14.7%	0.121	0.020	0	0	0	0	0	0	0.38	0.75	2.06	7.41
Northeast	15.2%	0.158	0.034	0	0	0	0	0	0	0.43	1.02	2.61	13.61
South	12.3%	0.130	0.019	0	0	0	0	0	0	0.42	0.92	2.33	4.59
West	19.7%	0.184	0.024	0	0	0	0	0	0	0.67	1.14	2.58	6.96

[a] Includes breakfast foods made with grains such as pancakes, waffles, and french toast.

NOTE: SE = Standard error
P = Percentile of the distribution

Source: Based on EPA's analysis of the 1989/91.

Table 17-6. Intake of Pasta (g/kg-day)

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	13.6%	0.233	0.018	0	0	0	0	0	0	0.90	1.60	3.67	24.01
Age													
< 01	7.3%	0.172	0.124	0	0	0	0	0	0	0.00	1.18	3.79	6.43
1-2	14.0%	0.569	0.212	0	0	0	0	0	0	1.72	5.14	6.68	24.01
3-5	15.3%	0.543	0.142	0	0	0	0	0	0	2.19	3.37	6.51	7.72
6-11	15.9%	0.338	0.063	0	0	0	0	0	0	1.47	2.35	3.43	7.72
12-19	14.3%	0.194	0.047	0	0	0	0	0	0	0.77	1.47	3.36	7.24
20-39	15.2%	0.232	0.027	0	0	0	0	0	0	0.96	1.57	2.83	7.17
40-69	12.5%	0.172	0.028	0	0	0	0	0	0	0.62	1.32	2.67	10.20
70 +	9.9%	0.083	0.029	0	0	0	0	0	0	0.03	0.76	1.57	2.62
Season													
Fall	14.0%	0.239	0.038	0	0	0	0	0	0	0.94	1.72	3.77	24.01
Spring	13.9%	0.250	0.036	0	0	0	0	0	0	0.96	1.65	3.28	9.47
Summer	13.6%	0.251	0.039	0	0	0	0	0	0	0.97	1.72	3.80	11.12
Winter	12.9%	0.193	0.034	0	0	0	0	0	0	0.68	1.33	3.22	8.73
Urbanization													
Central City	12.9%	0.197	0.034	0	0	0	0	0	0	0.65	1.34	3.43	24.01
Nonmetropolitan	11.4%	0.171	0.032	0	0	0	0	0	0	0.63	1.33	2.48	11.12
Suburban	15.4%	0.286	0.028	0	0	0	0	0	0	1.12	1.96	3.92	10.20
Race													
Asian	18.8%	0.918	0.355	0	0	0	0	0	0.70	3.80	5.78	6.51	10.20
Black	6.6%	0.138	0.054	0	0	0	0	0	0	0.00	1.08	3.27	5.14
Other/NA	8.6%	0.115	0.083	0	0	0	0	0	0	0.00	1.16	2.43	3.86
White	15.1%	0.243	0.019	0	0	0	0	0	0	0.94	1.65	3.46	24.01
Region													
Midwest	12.8%	0.182	0.030	0	0	0	0	0	0	0.74	1.24	2.76	9.46
Northeast	21.9%	0.367	0.043	0	0	0	0	0	0	1.47	2.14	4.62	24.01
South	9.2%	0.179	0.035	0	0	0	0	0	0	0.45	1.32	3.63	11.12
West	14.7%	0.252	0.038	0	0	0	0	0	0	1.07	1.63	3.25	10.20

NOTE: SE = Standard error
P = Percentile of the distribution

Source: Based on EPA's analysis of the 1989/91 CSFII.

Table 17-7. Intake of Cooked Cereals (g/kg-day)

Populatio n Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	17.1%	0.441	0.035	0	0	0	0	0	0	1.37	2.79	8.18	28.63
Age													
< 01	17.9%	1.350	0.417	0	0	0	0	0	0	7.17	8.60	20.47	24.16
1-2	23.6%	1.783	0.365	0	0	0	0	0	1.39	7.00	9.41	14.84	28.63
3-5	21.2%	1.335	0.258	0	0	0	0	0	0	4.99	8.18	12.51	18.66
6-11	18.1%	0.669	0.142	0	0	0	0	0	0	2.32	4.49	10.76	16.42
12-19	11.0%	0.156	0.065	0	0	0	0	0	0	0	1.26	3.34	11.85
20-39	10.5%	0.166	0.040	0	0	0	0	0	0	0	1.33	3.33	13.18
40-69	18.3%	0.307	0.036	0	0	0	0	0	0	1.30	2.20	3.97	18.23
70 +	35.3%	0.782	0.079	0	0	0	0	0	1.08	2.71	3.80	7.37	10.03
Season													
Fall	21.2%	0.573	0.066	0	0	0	0	0	0	1.90	3.71	9.15	28.63
Spring	15.8%	0.439	0.082	0	0	0	0	0	0	1.07	2.29	12.28	21.84
Summer	12.1%	0.288	0.069	0	0	0	0	0	0	0.55	1.98	5.37	24.16
Winter	19.1%	0.463	0.062	0	0	0	0	0	0	1.57	3.12	7.00	24.34
Urbanization													
Central City	19.3%	0.523	0.068	0	0	0	0	0	0	1.52	3.27	10.03	28.63
Nonmetropolitan	20.0%	0.483	0.066	0	0	0	0	0	0	1.52	2.72	7.41	20.94
Suburban	13.9%	0.369	0.052	0	0	0	0	0	0	1.09	2.35	7.37	24.34
Race													
Black	30.3%	0.838	0.092	0	0	0	0	0	0.65	2.95	4.45	10.03	28.63
Native American	17.5%	0.372	0.196	0	0	0	0	0	0	2.15	2.99	4.80	5.73
Other/NA	12.6%	0.510	0.293	0	0	0	0	0	0	1.12	3.18	7.60	20.94
White	15.1%	0.382	0.039	0	0	0	0	0	0	1.11	2.32	7.38	24.34
Region													
Midwest	15.5%	0.507	0.083	0	0	0	0	0	0	1.39	3.01	10.32	21.85
Northeast	13.2%	0.395	0.093	0	0	0	0	0	0	1.00	2.73	7.02	24.34
South	21.4%	0.396	0.044	0	0	0	0	0	0	1.40	2.48	5.53	28.63
West	15.2%	0.483	0.086	0	0	0	0	0	0	1.45	3.12	9.41	16.47

NOTE: SE = Standard error
P = Percentile of the distribution

Source: Based on EPA's analysis of the 1989/91 CSFII.

Table 17-8. Intake of Rice (g/kg-day)

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	20.0%	0.357	0.022	0	0	0	0	0	0	1.26	2.15	4.85	17.59
Age													
< 01	11.8%	0.405	0.209	0	0	0	0	0	0	1.40	2.89	7.87	15.54
1-2	24.4%	0.811	0.192	0	0	0	0	0	0.36	3.36	4.52	9.81	17.59
3-5	25.0%	0.736	0.127	0	0	0	0	0	0.76	2.83	3.77	6.70	14.35
6-11	20.8%	0.504	0.090	0	0	0	0	0	0	1.71	3.33	7.86	13.39
12-19	20.1%	0.316	0.052	0	0	0	0	0	0	1.26	1.91	3.74	9.60
20-39	21.3%	0.341	0.037	0	0	0	0	0	0	1.20	1.90	5.02	12.69
40-69	19.6%	0.259	0.028	0	0	0	0	0	0	0.94	1.64	3.35	12.00
70 +	14.9%	0.229	0.050	0	0	0	0	0	0	0.81	1.73	3.12	7.97
Season													
Fall	18.8%	0.307	0.041	0	0	0	0	0	0	0.94	2.13	4.92	16.74
Spring	21.5%	0.395	0.046	0	0	0	0	0	0	1.34	2.47	5.05	15.54
Summer	19.3%	0.376	0.045	0	0	0	0	0	0	1.31	2.05	5.02	12.55
Winter	20.5%	0.350	0.041	0	0	0	0	0	0	1.37	2.09	4.17	17.59
Urbanization													
Central City	26.1%	0.449	0.039	0	0	0	0	0	0.18	1.51	2.51	5.54	16.74
Nonmetropolitan	15.9%	0.311	0.046	0	0	0	0	0	0	1.04	1.90	5.02	12.91
Suburban	18.3%	0.320	0.031	0	0	0	0	0	0	1.16	2.01	4.30	17.59
Race													
Asian	72.5%	2.353	0.316	0	0	0	0	1.32	2.83	6.20	10.39	15.06	17.59
Black	37.2%	0.603	0.048	0	0	0	0	0	0.87	2.08	2.93	5.16	12.91
Other/NA	37.7%	0.655	0.116	0	0	0	0	0	0.80	2.15	3.78	6.06	10.71
White	15.9%	0.281	0.023	0	0	0	0	0	0	0.94	1.79	4.30	15.54
Region													
Midwest	12.3%	0.207	0.046	0	0	0	0	0	0	0.62	1.25	3.59	13.39
Northeast	20.3%	0.378	0.050	0	0	0	0	0	0	1.45	2.15	4.65	16.74
South	25.2%	0.455	0.036	0	0	0	0	0	0	1.62	2.71	5.21	15.54
West	20.4%	0.349	0.045	0	0	0	0	0	0	1.25	1.84	4.52	17.59

NOTE: SE = Standard error
P = Percentile of the distribution

Source: Based on EPA's analysis of the 1989/91 CSFII.

Table 17-9. Intake of Ready-to-Eat Cereals (g/kg-day)[a]

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	45.6%	0.306	0.007	0	0	0	0	0	0.42	0.92	1.37	2.61	7.12
Age													
< 01	38.9%	0.431	0.059	0	0	0	0	0	0.64	1.55	1.94	3.40	4.40
1-2	70.7%	0.954	0.057	0	0	0	0	0.74	1.46	2.28	2.89	4.77	6.47
3-5	77.3%	1.026	0.044	0	0	0	0.31	0.83	1.48	2.35	2.99	3.67	5.65
6-11	69.0%	0.631	0.025	0	0	0	0	0.45	0.92	1.55	1.97	3.12	7.12
12-19	50.8%	0.317	0.019	0	0	0	0	0.16	0.48	0.90	1.14	2.61	4.06
20-39	34.3%	0.174	0.010	0	0	0	0	0	0.23	0.61	0.88	1.51	5.11
40-69	37.1%	0.166	0.008	0	0	0	0	0	0.25	0.55	0.74	1.32	3.36
70 +	52.4%	0.222	0.013	0	0	0	0	0.08	0.36	0.64	0.83	1.55	2.71
Season													
Fall	45.2%	0.293	0.014	0	0	0	0	0	0.40	0.94	1.42	2.38	7.12
Spring	45.6%	0.320	0.015	0	0	0	0	0	0.44	0.95	1.42	2.69	5.88
Summer	46.6%	0.330	0.016	0	0	0	0	0	0.45	0.99	1.42	2.82	5.65
Winter	44.8%	0.280	0.014	0	0	0	0	0	0.39	0.81	1.22	2.61	6.47
Urbanization													
Central City	46.6%	0.319	0.014	0	0	0	0	0	0.43	0.94	1.42	2.86	5.11
Nonmetropolitan	43.6%	0.283	0.014	0	0	0	0	0	0.38	0.85	1.33	2.52	7.12
Suburban	46.0%	0.307	0.011	0	0	0	0	0	0.44	0.93	1.36	2.46	6.47
Race													
Asian	33.6%	0.218	0.065	0	0	0	0	0	0.24	0.81	1.28	2.79	3.12
Black	41.1%	0.269	0.018	0	0	0	0	0	0.40	0.82	1.16	2.50	4.46
Native American	38.6%	0.298	0.078	0	0	0	0	0	0.32	0.76	1.23	3.26	4.40
Other/NA	42.9%	0.340	0.050	0	0	0	0	0	0.43	1.12	1.59	2.69	4.18
White	46.7%	0.311	0.008	0	0	0	0	0	0.42	0.94	1.39	2.61	7.12
Region													
Midwest	48.7%	0.328	0.015	0	0	0	0	0	0.47	0.98	1.37	2.55	7.12
Northeast	46.9%	0.286	0.017	0	0	0	0	0	0.38	0.89	1.33	2.70	6.47
South	41.4%	0.284	0.012	0	0	0	0	0	0.40	0.81	1.26	2.34	5.88
West	47.7%	0.336	0.016	0	0	0	0	0	0.46	1.05	1.47	2.84	5.11

[a] Incluldes dry ready-to-eat corn, rice, wheat, and bran cereals in the form of flakes, puffs, etc.
NOTE: SE = Standard error
P = Percentile of the distribution

Source: Based on EPA's analysis of the 1989/91 CSFII.

Table 17-10. Intake of Baby Cereals(g/kg-day)

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total	1.1%	0.037	0.051	0	0	0	0	0	0	0	0	0	22.57
Age[a]													
< 01	28.5%	1.205	0.280	0	0	0	0	0	0.64	4.59	6.94	16.99	22.57
Season													
Fall	1.1%	0.036	0.075	0	0	0	0	0	0	0	0	0.69	14.94
Spring	1.1%	0.059	0.138	0	0	0	0	0	0	0	0	0.13	16.99
Summer	1.0%	0.017	0.068	0	0	0	0	0	0	0	0	0	12.03
Winter	1.0%	0.035	0.107	0	0	0	0	0	0	0	0	0	22.57
Urbanization													
Central City	1.3%	0.048	0.088	0	0	0	0	0	0	0	0	1.05	22.57
Nonmetropolitan	0.9%	0.011	0.040	0	0	0	0	0	0	0	0	0	9.41
Suburban	1.0%	0.042	0.093	0	0	0	0	0	0	0	0	0	16.99
Race													
Asian	0.7%	0.017	0.137	0	0	0	0	0	0	0	0	1.10	1.10
Black	2.1%	0.092	0.151	0	0	0	0	0	0	0	0	4.59	22.57
Native American	1.2%	0.010	0.088	0	0	0	0	0	0	0	0	0	1.63
Other/NA	3.1%	0.050	0.133	0	0	0	0	0	0	0	0	2.94	13.42
White	0.8%	0.029	0.059	0	0	0	0	0	0	0	0	0	16.99
Region													
Midwest	1.1%	0.020	0.050	0	0	0	0	0	0	0	0	0	12.50
Northeast	1.0%	0.084	0.208	0	0	0	0	0	0	0	0	1.25	16.99
South	1.0%	0.016	0.060	0	0	0	0	0	0	0	0	0	22.57
West	1.1%	0.046	0.101	0	0	0	0	0	0	0	0	1.18	10.18

[a] Data presented only for children less than 1 year of age. Available data for other age groups was based on a very small number of observations
NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analysis of the 1989/91 CSFII.

Table 17-11. Quantity (as consumed) of Grain Products Consumed per Eating Occasion and the Percentage of Individuals Using These Foods in 3 Days

Food category	% Indiv. using food in 3 days	Quantity consumed per eating occasion (g)		Consumers-only Quantity consumed per eating occasion at specified percentiles (g)						
		Average	Standard Deviation	5	25	50	75	90	95	99
Yeast Breads	93.7	46	26	21	25	44	50	75	100	140
Pancakes	8.3	113	85	27	54	81	146	219	282	438
Waffles	2.9	87	74	20	40	78	100	158	200	400
Tortillas	2.9	69	39	28	30	60	90	120	140	210
Cakes and Cupcakes	25.5	79	59	23	41	63	99	144	184	284
Cookies	30.8	32	30	7	14	26	40	60	84	144
Pies	11.9	129	60	57	97	120	150	195	236	360
Doughnuts	9.9	64	40	26	42	43	84	106	126	208
Crackers	26.2	22	21	6	12	15	24	42	57	113
Popcorn	5.6	19	22	5	9	15	18	36	45	108
Pretzels	2.2	29	28	3	12	21	36	57	85	160
Corn-based Salty Snacks	5.9	33	30	9	18	21	40	60	80	156
Pasta	11.4	153	108	35	70	140	210	280	320	560
Rice	18.5	147	91	41	88	165	175	263	350	438
Cooked Cereals	17.4	203	110	31	123	240	245	360	480	490
Ready-to-Eat Cereals	43.4	36	25	8	22	29	45	60	84	120

Source: Pao et al., 1982.

Table 17-12. Mean Per Capita Intake Rates for Grains Based on All Sex/Age/Demographic Subgroups

Raw Agricultural Commodity[a]	Average Consumption (Grams/Kg Body Weight-Day)	Standard Error
Oats	0.0825748	0.0026061
Rice-rough	0.0030600	0.0004343
Rice-milled	0.1552627	0.0083546
Rye-rough	0.0000010	--
Rye-germ	0.0002735	0.0000483
Rye-flour	0.0040285	0.0002922
Wheat-rough	0.1406118	0.0050410
Wheat-germ	0.0008051	0.0000789
Wheat-bran	0.0121575	0.0004864
Wheat-flour	1.2572489	0.0127412
Millet	0.0000216	0.0000104

[a] Consumed in any raw or prepared form
Source: DRES data base.

Table 17-13 - Mean Grain Intake per Individual in a Day by Sex And Age (g/day as consumed)[a] for 1977-1978

Group Age (years)	Total Grains	Breads, Rolls, Biscuits	Other Baked Goods	Cereals, Pasta	Mixtures, Mainly Grain[b]
Males and Females					
Under 1	42	4	5	30	3
1-2	158	27	24	44	63
3-5	181	46	37	54	45
6-8	206	53	56	60	38
Males					
9-11	238	67	56	51	64
12-14	288	76	80	57	74
15-18	303	91	77	53	82
19-22	253	84	53	64	52
23-34	256	82	60	40	74
35-50	234	82	58	44	50
51-64	229	78	57	48	46
65-74	235	71	60	69	35
75 and Over	196	70	50	58	19
Females					
9-11	214	58	59	44	53
12-14	235	57	61	45	72
15-18	196	57	43	41	55
19-22	161	44	36	33	48
23-34	163	49	38	32	44
35-50	161	49	37	32	43
51-64	155	52	40	36	27
65-74	175	57	42	47	29
75 and Over	178	54	44	58	22
Males and Females					
All Ages	204	62	49	44	49

[a] Based on USDA Nationwide Food Consumption Survey (1977-1978) data for one day.
[b] Includes mixtures containing grain as the main ingredient.
Source: USDA, 1980.

Table 17-14 - Mean Grain Intakes per Individual in a Day by Sex and Age (g/day)[a] for 1987-1988

Group Age (years)	Total Grains	Yeast Breads and Rolls	Quick Breads, Pancakes, French Toast	Cakes, Cookies, Pastries, Pies	Crackers, Popcorn, Pretzels, Corn Chips	Cereals and Pastas	Mixtures, Mostly Grain[b]
Males and Females 5 and Under	167	30	8	22	4	52	51
Males						74	83
6-11	268	51	16	37	8	72	82
12-19	304	65	28	45	10	58	83
20 and Over	272	65	20	37	8		
Females							
6-11	231	43	19	30	6	66	68
12-19	239	45	13	29	7	52	91
20 and Over	208	45	14	28	6	53	62
All Individuals	237	52	16	32	7	57	72

[a] Based on USDA Nationwide Food Consumption Survey (1987 to 1988) data for one day.
[b] Includes mixtures containing grain as the main ingredient.
Source: USDA, 1993a.

Table 17-15. Mean and Standard Error for the Daily Per Capita Intake of Grains, by Age (grams/day as consumed)

Age (years)	Breads	Cereals	Other Grains
All ages	147.3±1.4	29.9±1.3	22.9±1.7
Under 1	16.2±9.2	37.9±8.2	1.8±10.9
1 to 4	104.6±4.5	38.4±4.0	14.8±5.4
5 to 9	154.3±3.8	39.5±3.4	22.7±4.5
10 to 14	186.2±3.6	36.4±3.2	25.6±4.2
15 to 19	188.5±3.7	28.8±3.3	27.8±4.4
20 to 24	166.5±4.9	20.2±4.3	25.0±5.8
25 to 29	170.0±5.0	18.2±4.4	26.6±5.9
30 to 39	156.8±3.9	18.8±3.5	26.4±4.6
40 to 59	144.4±3.1	24.7±2.7	23.3±3.6
60 and over	122.1±3.4	42.5±3.0	19.3±4.0

Source: U.S. EPA, 1984a.

Table 17-16. Mean and Standard Error for the Daily Intake of Grains, by Region (grams/day as consumed)

Region	Total Grains	Breads	Cereals	Other Grains
All Regions	200.0±3.0	147.3±1.4	29.9±1.3	22.9±1.7
Northeast	203.5±5.8	153.1±2.8	24.6±2.5	25.9±3.3
North Central	192.8±5.6	150.9±2.7	28.7±2.4	13.3±3.2
South	202.2±4.7	143.9±2.3	34.6±2.0	23.7±2.7
West	202.6±6.9	139.5±3.3	30.9±3.0	32.1±4.0

NOTE: Northeast = Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania.

North Central = Ohio, Illinois, Indiana, Wisconsin, Michigan, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas.

South = Maryland, Delaware, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Texas, and Oklahoma.

West = Montana, Idaho, Wyoming, Utah, Colorado, New Mexico, Arizona, Nevada, Washington, Oregon, and California.

Source: U.S. EPA, 1984b.

Table 17-17. Consumption of Grains (g dry weight/day) for Different Age Groups and Estimated Lifetime Average Daily Food Intakes for a US Citizen (averaged across sex) Calculated from the FDA Diet Data

	Age (in years)						Estimated lifetime[a]
	(0-1)	(1-5)	(6-13)	(14-19)	(20-44)	(45-70)	
Wheat	27.60	42.23	60.80	79.36	65.86	55.13	60.30
Corn	4.00	15.35	19.28	23.21	17.83	14.82	17.01
Rice	2.22	4.58	5.24	5.89	5.78	4.21	5.03
Oats	3.73	2.65	2.27	1.89	1.32	2.00	1.85
Other Grain	0.01	0.08	0.41	0.73	13.45	4.41	6.49
Total Grain	37.56	64.82	87.58	110.34	90.59	76.17	84.19

[a] The estimated lifetime dietary intakes were estimated by:

$$\text{Estimated lifetime} = \frac{\text{IR(0-1)} + \text{5yrs * IR (1-5)} + \text{8 yrs * IR (6-13)} + \text{6 yrs * IR (14-19)} + \text{25 yrs * IR (20-44)} + \text{25 yrs * IR (45-70)}}{\text{70 years}}$$

where IR = the intake rate for a specific age group.
Source: U.S. EPA, 1989.

Table 17-18. Per Capita consumption of Flour and Cereal Products in 1991[a]

Flour and Cereal Products	
Food Item	Per Capita Consumption (g/day)[a]
Total Wheat Flour[b]	169.8
Rye Flour	0.7
Rice[c]	20.9
Total Corn Products[d]	27.2
Oat Products[e]	10.7
Barley Products[f]	1.1
Total Flour and Cereal Products[g]	230.6

[a] Original data were presented in lbs/yr; data were converted to g/day by multiplying by a factor of 454 g/lb and dividing by 365 days/yr. Consumption of most items at the processing level. Excludes quantities used in alcoholic beverages and fuel.
[b] Includes white, whole wheat, and durum flour.
[c] Milled basis.
[d] Includes corn flour and meal, hominy and grits, and corn starch.
[e] Includes rolled oats, ready-to-eat cereals, oat flour, and oat bran.
[f] Includes barley flour, pearl barley, and malt and malt extract used in food processing.
[g] Excludes wheat not ground into flour, for example, shredded wheat breakfast cereals.
Source: USDA, 1993b.

Table 17-19. Summary of Grain Intake Studies

Study	Survey Population Used in Calculating Intake	Types of Data Used	Units	Food Items
KEY STUDIES				
EPA Analysis of 1989/91 CSFII Data	Per capita	1989/91 CSFII data; Based on 3-day average individual intake rates.	g/kg-day; as consumed	Distributions of intake rates for total grain; individual grain items
Pao et al., 1982	Consumers only serving size data provided	1977/78 NFCS 3-day individual intake data	g; as consumed	Distributions of serving sizes for grain products
RELEVANT STUDIES				
EPA's DRES (White et al., 1983)	Per capita (i.e., consumers and nonconsumers)	1977/78 NFCS 3-day individual intake data	g/kg-day; as consumed	Intake for a wide variety of grain products presented; complex food groups were disaggregated
USDA, 1980; 1993a	Per capita and consumer only grouped by age and sex	1977/78 and 1987/88 NFCS 1-day individual intake data	g/day; as consumed	Total grains and various grain products
USDA, 1993b	Per capita consumption based on "food disappearance"	Based on food supply and utilization data	g/day; as consumed	Intake rates of grain products
U.S. EPA/ORP, 1984a; 1984b	Per capita	1977/78 NFCS Individual intake data	g/day; as consumed	Mean intake rates for total grain products, and individual grain items.
U.S. EPA/OST, 1989	Estimated lifetime dietary intake	Based on FDA Total Diet Study Food List which used 1977/78 NFCS data, and NHANES II data	g/day; dry weight	Various food groups; complex foods disaggregated

Table 17-20. Summary of Recommended Values for Per Capita Intake of Grain Products and Serving Size

Mean	95th Percentile	Multiple Percentiles	Study
Total Grain Intake			
4.1 g/kg-day	10.8 g/kg-day	see Table 17-1	EPA Analysis of CSFII 1989-91 Data
Individual Grain Products			
see Tables 17-2 to 17-10	see Tables 17-2 to 17-10	see Table 17-2 to 17-10	EPA Analysis of CSFII 1989-91 Data
Serving Size			
see Table 17-11	see Table 17-11	see Table 17-11	Pao et al., 1982

Table 17-21. Confidence in Grain Products Intake Recommendation		
Considerations	**Rationale**	**Rating**
Study Elements		
• Level of peer review	USDA CSFII survey receives high level of peer review. EPA analysis of these data has not been peer reviewed outside the Agency. (Peer review will be conducted as part of the peer review of this Handbook)	Medium (This will become a "high" once the Handbook's peer review is completed)
• Accessibility	CSFII data is publicly available	High
• Reproducibility	Enough information is included to reproduce results	High
• Focus on factor of interest	Analysis is specifically designed to address food intake	High
• Data pertinent to U.S.	Data focuses on the U.S. population	High
• Primary data	This is new analysis of primary data	High
• Currency	Is the most current data publicly available	High
• Adequacy of data collection period	Survey is designed to collect short-term data.	Medium confidence for average values; Low confidence for long term percentile distribution
• Validity of approach	Survey methodology was adequate	High
• Study size	Study size was very large and therefore adequate	High
• Representativeness of the population	The population studied was the U.S. population.	High
• Characterization of variability	Survey was not designed to capture long term day-to-day variability. Short term distributions are provided for various age groups, regions, etc.	Medium
• Lack of bias in study design (high rating is desirable)	Response rate was adequate?	Medium
• Measurement error	No measurements were taken. The study relied on survey data.	N/A
Other Elements		
• Number of studies	1 CSFII is the most recent data publicly available. Therefore, it was the only study classified as key study.	Low
• Agreement between researchers	Although the CSFII was the only study classified as key study, the results are in good agreement with earlier data.	High
Overall Rating	The survey is representative of U.S. population; Although there was only one study considered key, these data are the most recent and are in agreement with earlier data; the approach used to analyzed the data was adequate. However, due to the limitations of the survey design estimation of long-term percentile values (especially the upper percentiles) is uncertain.	High confidence in the average; Low confidence in the long-term upper percentiles

Table 17-22. Confidence in Grain Serving Size Recommendations		
Considerations	Rationale	Rating
Study Elements		
• Level of peer review	USDA NFCS survey receives high level of peer review.	High
• Accessibility	The NFCS data are publicly available	High
• Reproducibility	Methodology is clearly explained	High
• Focus on factor of interest	Analysis is specifically designed to address food intake	High
• Data pertinent to U.S.	Data focuses on the U.S. population	High
• Primary data	The study analyzed primary data	High
• Currency	The data are old (i.e. 1977-78)	Low
• Adequacy of data collection period	Survey is designed to collect short-term data.	Medium
• Validity of approach	Survey methodology was adequate	High
• Study size	Study size was very large and therefore adequate	High
• Representativeness of the population	The population studied was the U.S. population.	High
• Characterization of variability	Survey was not designed to capture long term day-to-day variability. Short term distributions are provided	Medium
• Lack of bias in study design (high rating is desirable)	Response rate was adequate	Medium
• Measurement error	No measurements were taken. The study relied on survey data.	N/A
Other Elements		
• Number of studies	1	Low
• Agreement between researchers	Although serving size data may have been collected in other surveys, they have not been reported in any other study.	Low
Overall Rating	The survey is representative of U.S. population; the approach used to analyzed the data was adequate. However, due to the limitations of the survey design estimation of long-term percentile values (especially the upper percentiles) is uncertain.	Medium

APPENDIX 17-A

FOOD CODES AND DEFINITIONS USED IN THE ANALYSIS OF THE 1989/91 USDA CSFII GRAINS DATA

Table 17A-1. Food Codes and Definitions Used in the Analysis of the 1989/91 USDA CSFII Grains Data

Food Product	Food Codes and Descriptions	Food Product	Food Codes and Descriptions
Total Grains	51- breads 52- tortillas 53- sweets 54- snacks 55- breakfast foods 561- pasta 562- cooked cereals and rice 57- ready-to-eat and baby cereals Also includes the average portion of grain mixtures (i.e., 31 percent) and the average portion of meat mixtures (i.e., 13 percent) made up by grain.	Pasta	561- macaroni noodles spaghetti
Breads	51- breads rolls muffins bagel biscuits corn bread 52- tortillas	Cooked Cereals	56200- 56201- 56202- 56203- 562069- 56207- 56208- 56209- includes grits,oatmeal, cornmeal mush, millet, etc.
Sweets	53- cakes cookies pies pastries doughnuts breakfast bars coffee cakes	Rice	56204- 56205- 5620601 includes all varieties of rice
Snacks	54- crackers salty snacks popcorn pretzels	Ready-to-eat Cereals	570- 571- 572- 573- 574- 575- 576- includes all varieties of ready-to-eat cereals
Breakfast Foods	55- pancakes waffles french toast	Baby Cereals	578- baby cereals
Grain Mixtures	58- grain mixtures	Meat Mixtures	27- 28- meat mixtures

GLOSSARY

Absorption fraction (percent absorbed) - The relative amount of a substance that penetrates through a barrier into the body, reported as a unitless fraction.

Accuracy - The measure of the correctness of data, as given by the difference between the measured value and the true or standard value.

Activity pattern (time use) data - Information on activities in which various individuals engage, length of time spent performing various activities, locations in which individuals spend time and length of time spent by individuals within those various environments.

Air exchange rate - Rate of air leakage through windows, doorways, intakes and exhausts, and "adventitious openings" (i.e., cracks and seams) that combine to form the leakage configuration of the building envelope plus natural and mechanical ventilation.

Ambient - The conditions surrounding a person, sampling location, etc.

Analytical uncertainty propagation - Examines how uncertainty in individual parameters affects the overall uncertainty of the exposure assessment. The uncertainties associated with various parameters may propagate through a model very differently, even if they have approximately the same uncertainty. Since uncertainty propagation is a function of both the data and the model structure, this procedure evaluates both input variances and model sensitivity.

As consumed intake rates - Intake rates that are based on the weight of the food in the form that it is consumed.

Average daily dose - Dose rate averaged over a pathway-specific period of exposure expressed as a daily dose on a per-unit-body-weight basis. The ADD is used for exposure to chemicals with non-carcinogenic non-chronic effects. The ADD is usually expressed in terms of mg/kg-day or other mass/mass-time units.

Best Tracer Method (BTM) - Method for estimating soil ingestion that allows for the selection of the most recoverable tracer for a particular subject or group of subjects. Selection of the best tracer is made on the basis of the food/soil (F/S) ratio.

Boneless equivalent - Weights of meat (pork, veal, beef) and poultry, excluding all bones, but including separable fat sold on retail cuts of red meat.

Carcass weight - Weight of the chilled hanging carcass, which includes the kidney and attached internal fat (kidney, pelvic, and heart fat), excludes the skin, head, feet, and unattached internal organs. The pork carcass weight includes the skin and feet but excludes the kidney and attached internal fat.

Chronic intake - The long term period over which a substance crosses the outer boundary of an organism without passing an absorption barrier.

Comparability - The ability to describe likenesses and differences in the quality and relevance of two or more data sets.

Consumer-only intake rate - The average quantity of food consumed per person in a population composed only of individuals who ate the food item of interest during a specified period.

Contaminant concentration - Contaminant concentration is the concentration of the contaminant in the medium (air, food, soil, etc.) contacting the body and has units of mass/volume or mass/mass.

Creel Census - Approach used by fishery managers to obtain harvest data collected onsite from single anglers or from larger-scale commercial type operations.

Deposition - The removal of airborne substances to available surfaces that occurs as a result of gravitational settling and diffusion, as well as electrophoresis and thermophoresis.

Diary study - Survey in which individuals are asked to record food intake, activities, or other factors in a diary which is later used to evaluate exposure factors associated with specific populations.

Distribution - A set of values derived from a specific population or set of measurements that represents the range and array of data for the factor being studied.

Dose - The amount of a substance available for interaction with metabolic processes or biologically significant receptors after crossing the outer boundary of an organism. The potential dose is the amount ingested, inhaled, or applied to the skin. The applied dose is the amount of a substance presented to an absorption barrier and available for absorption (although not necessarily having yet crossed the outer boundary of the organism). The absorbed dose is the amount crossing a specific absorption barrier (e.g., the exchange boundaries of skin, lung, and digestive tract) through uptake processes. Internal dose is a more general term denoting the amount absorbed without respect to specific absorption barriers or exchange boundaries. The amount of a chemical available for interaction by any particular organ or cell is termed the delivered dose for that organ or cell.

Dose-response relationship - The resulting biological responses in an organ or organism expressed as a function of a series of doses.

Dry weight intake rates - Intake rates that are based on the weight of the food consumed after the moisture content has been removed.

Employer tenure - The length of time a worker has been with the same employer.

Exposed foods - Those foods that are grown above ground and are likely to be contaminated by pollutants deposited on surfaces that are eaten.

Exposure duration - Total time an individual is exposed to the chemical being evaluated.

Exposure Assessment - The determination or estimation (qualitative or quantitative) of the magnitude, frequency, or duration, and route or exposure.

Exposure concentration - The concentration of a chemical in its transport or carrier medium at the point of contact.

Exposure pathway - The physical course a chemical takes from the source to the organism exposed.

Exposure route - The way a chemical pollutant enters an organism after contact, e.g., by ingestion, inhalation, or dermal absorption.

Exposure scenario - A set of facts, assumptions, and interferences about how exposure takes place that aids the exposure assessor in evaluating estimating, or quantifying exposures.

Exposure - Contact of a chemical, physical, or biological agent with the outer boundary of an organism. Exposure is quantified as the concentration of the agent in the medium in contact integrated over the time duration of the contact.

Exposure duration - Length of time over which contact with the contaminant lasts.

General population - The total of individuals inhabiting an area or making up a whole group.

Geometric mean - The nth root of the product of n values.

Homegrown/home produced foods - Fruits and vegetables produced by home gardeners, meat and dairy products derived form consumer-raised livestock, game meat, and home caught fish.

Inhaled dose - The amount of an inhaled substance that is available for interaction with metabolic processes or biologically significant receptors after crossing the outer boundary of an organism.

Insensible water loss - Evaporative water losses that occur during breastfeeding. Corrections are made to account for insensible water loss when estimating breast milk intake using the test weighing method.

Intake - The process by which a substance crosses the outer boundary of an organism without passing an absorption barrier (e.g., through ingestion or inhalation).

Intake rate - Rate of inhalation, ingestion, and dermal contact depending on the route of exposure. For ingestion, the intake rate is simply the amount of food containing the contaminant of interest that an individual ingests during some specific time period (units of mass/time). For inhalation, the intake rate is the rate at which contaminated air is inhaled. Factors that affect dermal exposure are the amount of material that comes into contact with the skin, and the rate at which the contaminant is absorbed.

Internal dose - The amount of a substance penetrating across absorption barriers (the exchange boundaries) of an organism, via either physical or biological processes (synonymous with absorbed dose).

Interzonal airflows - Transport of air through doorways, ductwork, and service chaseways that interconnect rooms or zones within a building.

Lifetime average daily dose - Dose rate averaged over a lifetime. The LADD is used for compounds with carcinogenic or chronic effects. The LADD is usually expressed in terms of mg/kg-day or other mass/mass-time units.

Limiting Tracer Method (LTM) - Method for evaluating soil ingestion that assumes that the maximum amount of soil ingested corresponds with the lowest estimate from various tracer elements.

Local circulation - Convective and adjective air circulation and mixing within a room or within a zone.

Mass-balance/tracer techniques - Method for evaluating soil intake that accounts for both inputs and outputs of tracer elements. Tracers in soil, food, medicine and other ingested items as well as in feces and urine are accounted for.

Median value - The value in a measurement data set such that half the measured values are greater and half are less.

Moisture content - The portion of foods made up by water. The percent water is needed for converting food intake rates and residue concentrations between whole weight and dry weight values.

Monte Carlo technique - A repeated random sampling from the distribution of values for each of the parameters in a generic (exposure or dose) equation to derive an estimate of the distribution of (exposures or doses in) the population.

Occupational mobility - An indicator of the frequency at which workers change from one occupation to another.

Occupational tenure - The cumulative number of years a person worked in his or her current occupation, regardless of number of employers, interruptions in employment, or time spent in other occupations.

Pathway - The physical course a chemical or pollutant takes from the source to the organism exposed.

Per capita intake rate - The average quantity of food consumed per person in a population composed of both individuals who ate the food during a specified time period and those that did not.

Pica - Deliberate ingestion of non-nutritive substances such as soil.

Population mobility - An indicator of the frequency at which individuals move from one residential location to another.

Potential dose - The amount of a chemical contained in material ingested, air breathed, or bulk material applied to the skin.

Precision - A measure of the reproducibility of a measured value under a given set of circumstances.

Preparation losses - Net cooking losses, which include dripping and volatile losses, post cooking losses, which involve losses from cutting, bones, excess fat, scraps and juices, and other preparation losses which include losses from paring or coring.

Probabilistic uncertainty analysis - Technique that assigns a probability density function to each input parameter, then randomly selects values from each of the distributions and inserts them into the exposure equation. Repeated calculations produce a distribution of predicted values, reflecting the combined impact of variability in each input to the calculation. Monte Carlo is a common type of probabilistic Uncertainty analysis.

Protected foods - Those foods that have outer protective coatings that are typically removed before consumption.

Random samples - Samples selected from a statistical population such that each sample has an equal probability of being selected.

Range - The difference between the largest and smallest values in a measurement data set.

Recreational/sport fishermen - Individuals who catch fish as part of a sporting or recreational activity and not for the purpose of providing a primary source of food for themselves or for their families.

Representativeness - The degree to which a sample is, or samples are, characteristic of the whole medium, exposure, or dose for which the samples are being used to make inferences.

Residential volume - The volume (m^3) of the structure in which an individual resides and may be exposed to airborne contaminants.

Residential occupancy period - The time (years) between a person moving into a residence and the time the person moves out or dies.

Retail weight equivalent - Weight of food as sold through retail foodstores; therefore, conversion factors are used to correct carcass weight to retail weight to account for trimming, shrinkage, or loss of meat and chicken at retail outlets.

Route - The way a chemical or pollutant enters an organism after contact, e.g., by ingestion, inhalation, or dermal absorption.

Sample - A small part of something designed to show the nature or quality of the whole. Exposure-related measurements are usually samples of environmental or ambient media, exposures of a small subset of a population for a short time, or biological samples, all for the purpose of inferring the nature and quality of parameters important to evaluating exposure.

Screening-level assessments - Typically examine exposures that would fall on or beyond the high end of the expected exposure distribution.

Sensitivity analysis - Process of changing one variable while leaving the others constant to determine its effect on the output. This procedure fixes each uncertain quantity at its credible lower and upper bounds (holding all others at their nominal values, such as medians) and computes the results of each combination of values. The results help to identify the variables that have the greatest effect on exposure estimates and help focus further information-gathering efforts.

Serving sizes - The quantities of individual foods consumed per eating occasion. These estimates may be useful for assessing acute exposures.

Soil adherence - The quantity of soil that adheres to the skin and from which chemical contaminants are available for uptake at the skin surface.

Subsistence fishermen - Individuals who consume fresh caught fish as a major source of food.

Test weighing - A method for estimating breast milk intake over a 24-hour period in which the infant is weighed before and after each feeding without changing its clothing. The sum of the difference between the measured weights over the 24-hour period is assumed to be equivalent to the amount of breast milk consumed daily.

Total tapwater - Water consumed directly from the tap as a beverage or used in the preparation of foods and beverages (i.e., coffee, tea, frozen juices, soups, etc.).

Total fluid intake - Consumption of all types of fluids including tapwater, milk, soft drinks, alcoholic beverages, and water intrinsic to purchased foods.

Tracer-element studies - Soil ingestion studies that use trace elements found in soil and poorly metabolized in the human gut as indicators of soil intake.

Uncertainty - Uncertainty represents a lack of knowledge about factors affecting exposure or risk and can lead to inaccurate or biased estimates of exposure. The types of uncertainty include: scenario, parameter, and model.

Upper percentile - Values at the upper end of the distribution of values for a particular set of data.

Uptake - The process by which a substance crosses an absorption barrier and is absorbed into the body.

Variability - Variability arises from true heterogeneity across people, places or time and can affect the precision of exposure estimates and the degree to which they can be generalized. The types of variability include: spatial, temporal, and inter-individual.

Ventilation rate (VR) - Alternative term for inhalation rate or breathing rate. Usually measured as minute volume, i.e. volume (liters) of air exhaled per minute.

Volume of exhaled air (V_E) - Product of the number of respiratory cycles in a minute and the volume of air respired during each respiratory cycle (tidal volume, V_T).