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Child-Specific Exposure Factors Handbook

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CHILD-SPECIFIC EXPOSURE FACTORS HANDBOOK

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DISCLAIMER

ABSTRACT

Children are often more heavily exposed to environmental toxicants than adults. They consume more food and water and have higher inhalation rates per pound of body weight than adults. Young children play close to the ground and come into contact with contaminated soil outdoors and with contaminated dust on surfaces and carpets indoors. As another example, exposure to chemicals in breast milk affects infants and young children.

Although NCEA has published the Exposure Factors Handbook in 1997 (EPA/600/P-95/002Fa-c), that include exposure factors and related data on both adults and children, the EPA Program Offices identified the need to consolidate all children exposure data into one document. The goal of the Child-Specific Exposure Factors Handbook is to fulfill this need. The document provides a summary of the available and up-to-date statistical data on various factors assessing children exposures. These factors include drinking water consumption, soil ingestion, inhalation rates, dermal factors including skin area and soil adherence factors, consumption of fruits and vegetables, fish, meats, dairy products, homegrown foods, breast milk, activity patterns, body weight, consumer products and life expectancy.

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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.

Exposure Factors Handbook was first published in 1989 to provide statistical data on the various factors used in assessing exposure for the general population; it was revised and published again in 1997. *Child-Specific Exposure Factors Handbook* is being prepared to focus on various factors used in assessing exposure, specifically for children ages 0–19 years. The recommended values are based solely on our interpretation of the available data. In many situations, the use of different values may be appropriate in consideration of policy, precedent, or other factors. This handbook contains numerous tables where data are presented using two and sometimes three significant figures. The use of significant figures implies that these values are known with some degree of certainty. However, in many cases, the data do not allow for this degree of precision and the user should understand this limitation and apply rounding rules as necessary to obtain a more appropriate value.

PREFACE

The National Center for Environmental Assessment (NCEA) of EPA's Office of Research and Development prepared this handbook to address factors commonly used in exposure assessments for children. Children are often more heavily exposed than adults to environmental toxicants. They consume more food and water and have higher inhalation rates per pound of body weight than do adults. Young children play close to the ground and come into contact with contaminated soil outdoors and with contaminated dust on surfaces and carpets indoors. Furthermore, exposure to chemicals in breast milk affects infants and young children.

NCEA published the latest version of *Exposure Factors Handbook* in 1997. It includes exposure factors and related data on children as well as adults. However, the EPA program offices have identified the need to prepare a document specifically for children's exposure factors. The goal of *Child-Specific Exposure Factors Handbook* is to fulfill this need.

This handbook will be continuously updated as new data become available. For example, the Agency is currently developing guidance on the use of a standard set of age groups that are needed to assess exposures in children. This guidance is expected to be completed by Fall 2002. The handbook will be revised to ensure consistency with new Agency guidance. In an effort to keep the handbook up-to-date, NCEA will incorporate new data as they become available in the published literature. Please submit comments, recommendations, suggested revisions, and corrections to moya.jacqueline@epa.gov.

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1. INTRODUCTION

1.1. BACKGROUND

Because of differences in physiology and behaviors, exposures among children are expected to be different than exposures among adults. Children may be more exposed to environmental toxicants because they consume more food and water per unit of body, they have higher inhalation rates per unit of body weight, and they have higher surface area to volume than adults.

Recent studies have shown that young children can be exposed to pesticides during normal oral exploration of their environment and by touching floors, surfaces, and objects such as toys (Eskenazi et al., 1999; Gurunathan et al., 1998; Lewis et al., 1999; Nishioka et al., 1999). Dust and tracked-in soil accumulates most effectively in carpets, where young children spend a significant amount of time (Lewis et al., 1999). Children living in agricultural areas may experience higher exposures to pesticides than do other children. Pesticides may be tracked into their homes by family members. In addition, children living in agricultural areas may also play in nearby fields or be exposed via consumption of contaminated breast milk from their farmworker mother (Eskenazi et al., 1999).

In terms of risk, children may also be more vulnerable to environmental pollutants because of differences in absorption, excretion, and metabolism (U.S. EPA, 1997a). The cellular immaturity of children and the ongoing growth processes account for elevated risk (AAP, 1997). Toxic chemicals in the environment can cause neurodevelopmental disabilities. The developing brain can be particularly sensitive to environmental contaminants. For example, elevated blood lead levels and prenatal exposures to even relatively low levels of lead result in reductions of intellectual function and behavior disorders. Exposure to high levels of methylmercury can result in developmental disabilities (Myers and Davidson, 2000). Other authors have described the importance of exposure timing (i.e., preconceptional, prenatal, and postnatal) and how it affects the outcomes observed (Selevan et al., 2000).

On April 21, 1997, President Clinton signed Executive Order 13045: Protection of Children From Environmental Health Risks and Safety Risks. The order requires all federal agencies to address health and safety risks to children, to coordinate research priorities on children's health, and to ensure that their standards take into account special risks to children. To implement the order, the U.S. Environmental Protection Agency (the EPA Agency) established the Office of Children's Health Protection (OCHP), and offices within EPA increased their efforts to provide a safe and healthy environment for children by ensuring that all regulations, standards, policies, and risk assessments take into account risks to children. Recent legislation such as the Food Quality Protection Act and the Safe Drinking Water Act amendments has made children's health issues more explicit, and research on children's health issues is continually expanding. As a result of the emphasis on children's risk, the EPA Office of Research and Development's (ORD's) National Center for Environmental Assessment (NCEA) issued a Children's Risk Policy, which emphasizes the need to evaluate exposures and risks among this population (U.S. EPA, 1997a; 1999a). ORD also developed a Strategy for Research on Risks to Children (Children's Research Strategy). The goal of the Children's Research Strategy is to improve risk assessments for children. This *Child-Specific Exposure Factors Handbook* is intended to support EPA/ORD/NCEA's efforts to improve exposure and risk assessments for children.

In 1997, EPA/ORD/NCEA published *Exposure Factors Handbook* (U.S. EPA, 1997b). The handbook includes exposure factors and related data on both adults and children. OCHP recently issued its child-related risk assessment policy and methodology guidance document survey (U.S. EPA, 1999b), which highlighted *Exposure Factors Handbook* as a source of information on exposure factors for children. EPA's *Children's Environmental Health Yearbook* (U.S. EPA, 1998) also lists *Exposure Factors Handbook* as a source of exposure information for children. However, the EPA Program Offices identified the need to consolidate all children exposure data into one document. The goal of this *Child-Specific Exposure Factors Handbook* is to fulfill this need. This handbook provides nonchemical-specific data on exposure factors that can be used to assess doses from dietary and nondietary ingestion exposure, dermal exposure, and inhalation exposure among children. Data are provided in the following areas:

- breast milk ingestion;
- food ingestion, including homegrown foods and other dietary-related areas;
- drinking water ingestion;
- soil ingestion;
- rates of hand-to-mouth and object-to-mouth activity;
- dermal exposure factors such as surface areas and soil adherence;
- inhalation rates;
- duration and frequency in different locations and various microenvironments;
- duration and frequency of consumer product use;
- body weight data; and
- duration of lifetime.

This handbook is a compilation of available data from a variety of sources. Most of these data have been presented in detail in EPA's *Exposure Factors Handbook* (U.S. EPA, 1997b), but data that have been published subsequent to the release of *Exposure Factors Handbook* are also included here. With very few exceptions, the data are the result of analyses by the individual study authors. Because the studies included in this handbook vary 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 age ranges to describe data for children. 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. 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.

Because of their large number, the tables in this handbook are presented at the end of the appropriate chapter, before the appendices, if any, and the references for the chapter.

1.2. PURPOSE

The dual purpose of *Child-Specific Exposure Factors Handbook* is to: (1) summarize key data on human behaviors and characteristics that affect children's 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 that Program Offices or individual exposure assessors can consider and modify as needed. Most of the factors are best quantified on a site- or situation-specific basis. The data presented in this handbook have been compiled from various sources, which include EPA's *Exposure Factor Handbook* (U.S. EPA, 1997b), government reports, and information presented in the scientific literature. The handbook has strived to include discussions of issues that assessors should consider in assessing exposure among children, and it may be used in conjunction with the EPA document entitled, *Sociodemographic Data Used for Identifying Potentially Highly Exposed Subpopulations of Children*, which is currently being drafted and provides population data for children.

This handbook is intended to be a continuously evolving document. Updates will be posted in the NCEA home page as new data become available.

1.3. INTENDED AUDIENCE

Child-Specific Exposure Factors Handbook may be used by exposure assessors inside as well as outside the Agency who need to obtain data on standard factors needed to calculate childhood exposure to toxic chemicals.

1.4. SELECTION OF STUDIES FOR THE HANDBOOK

The information in this handbook has been summarized from studies documented in the scientific literature and from other available sources. Studies were chosen that were seen as useful and appropriate for estimating exposure factors. The handbook contains summaries of selected studies published through June 2000.

1.4.1. General Considerations

Many scientific studies were reviewed for possible inclusion in this handbook. Generally, studies identified in *Exposure Factors Handbook* (U.S. EPA, 1997b) as key studies are included, as are new studies that became available after its publication. Key studies from *Exposure Factors Handbook* were generally defined as the most useful for deriving exposure factors. The recommended values for most exposure factors are based on the results of these studies. As in *Exposure Factors Handbook,* the key studies were selected on the basis of 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 contain sufficient information so that methods can be reproduced or at least so the details of the author's work can be accessed and evaluated.

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

- *Pertinence of data to the U.S.*: Studies were selected that address the U.S. population. Data from populations outside the U.S. were sometimes included if U.S. data were limited for a specific exposure factor. Studies similar in methodology are also used to support or enhance the U.S. data.

- *Use of primary data*: Studies were deemed preferable if they are based on primary data, but studies based on secondary sources are also included when they offer an original analysis. For example, the handbook cites studies of food consumption that are based on original data collected by the U.S. Department of Agriculture (USDA) National Food Consumption Survey.

- *Currency of information*: Studies were chosen only if they are sufficiently recent to represent current exposure conditions. This is an important consideration for those factors that change with time. In some instances, recent data were very limited. Therefore, the data provided in these instances are the only available data. Limitations as to the age of the data are noted.

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

- *Validity of approach*: Studies that used 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 that used direct measurement were not available, studies were selected that relied on validated indirect measurement methods, such as surrogate measures (e.g., heart rate for inhalation rate) and 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 a subpopulation were selected if they were appropriately representative of that population. Studies with limitations in areas where little data exist were included and are noted as such.

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

- *Minimal (or defined) bias in study design*: Studies were sought that were designed with minimal bias, or if biases were suspected to be present, the direction of the bias (i.e., an overestimate or underestimate of the parameter) is either stated or apparent from the study design.

- *Minimal (or defined) uncertainty in the data*: Studies were sought that have 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 document quality assurance/quality control measures were preferable.

1.5. APPROACH USED TO DEVELOP RECOMMENDATIONS FOR EXPOSURE FACTORS

As discussed above, EPA first reviewed all the literature pertaining to a factor and determined key studies. These 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 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 the studies are described in section 1.4.

2. If only one study was classified as key for a particular factor, the mean value from that study was selected as the recommended central value for that population. If multiple key studies with reasonably equal quality, relevance, and study design information were 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 is 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 was of interest, the midpoint of the range was usually 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 was described as either a series of percentiles or a distribution.

4. Uncertainties were discussed in terms of data limitations, the range of circumstances over which the estimates were (or were 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 were used to derive the recommended value.

5. Finally, EPA assigned a confidence rating of low, medium, or high to each recommended value. This rating is not intended to represent an uncertainty analysis, rather it represents EPA's judgment on the quality of the underlying data used to derive the recommendation. This judgment was made using the guidelines shown in Table 1-1. Table 1-1 is an adaptation of the General Considerations discussed in section 1.4. 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 that apply to children.

It is important to note that the study elements listed in Table 1-1 do not have the same weight when arriving at the overall confidence rating for the various exposure factors. The relative weight of each of these elements depends on the exposure factor of interest. Also, the relative weights given to the elements for the various factors were subjective and based on the professional judgement of the authors of this handbook. In general, most studies would rank high with regard to "level of peer review," "accessibility," "focus on exposure factor of interest," and "data pertinent to the U.S."

These elements are important considerations for inclusion of a study in this handbook. However, a high score on these elements does not necessarily translate into a high overall score. Other elements in Table 1-1 were also examined to determine the overall score. For example, the adequacy of the data collection period may be more important when determining usual intake of foods in a population; on the other hand, it is not as important for factors where long-term variability may be small, such as tapwater intake. In the case of tapwater intake, the currency of the data was a critical element in determining the final rating. In addition, some exposure factors are more easily measured than others. For example, soil ingestion by children is estimated by measuring the levels in the feces of certain elements found in soil. Body weight, however, can be measured directly, and it is, therefore, a more reliable measurement. The fact that soil ingestion is more difficult to measure than body weight is reflected in the confidence rating given to both of these factors. In general, the better the methodology used to measure the exposure factor, the higher the confidence in the value.

1.6. CHARACTERIZING VARIABILITY

This handbook attempts to characterize the variability of each of the factors. Variability is characterized in one or more of three ways: (1) as a table with various percentiles or ranges of values, (2) as an analytical distribution 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 they have been reproduced as 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 in which variability has been characterized throughout this handbook (i.e., average, median, upper percentiles, multiple percentiles, fitted distribution) are presented in Table 1-3. The term "upper percentile" is used throughout this handbook, and it is intended to represent values in the upper tail (i.e., between the 90th and the 99.9th percentile) of the distribution of values for a particular exposure factor. A detailed presentation on variability and uncertainty for exposure factors and algorithms used in estimating exposure is presented in Appendix A of this chapter.

In the recommendations, an attempt was made to present percentile values that are consistent with the exposure estimators defined in *Guidelines for Exposure Assessment* (U.S. EPA, 1992a) (i.e., mean, 50th, 90th, 95th, 98th, and 99.9th percentile). However, this was not always possible, because either the data available were limited for some factors or the authors of the study did not provide such information. It is important to note, however, that these percentiles were discussed in the guidelines within the context of risk descriptors and not individual exposure factors. For example, the guidelines state that the assessor may derive a high-end estimate of exposure by using maximum or near maximum values for one or more sensitive exposure factors, leaving others at their mean value.

The use of Monte Carlo or other probabilistic analysis requires a selection of distributions or histograms for the input parameters. Although this handbook is not intended to provide 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 whether 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. The assessor needs to evaluate the site-specific data, when available, to assess their quality and applicability. Distributions derived from national data may not represent local conditions. An assessor should use distributions or frequency histograms derived from local surveys to assess risks locally if they are determined to be of adequate quality and representative of the site conditions. The assessor may decide to use distributional data drawn from the national or other surrogate population. In this case, 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 technique 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 that 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 (e.g., Gilbert, 1987, among others). Off-the-shelf computer software such as Best-Fit by Palisade Corporation can be used to 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.
  - 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 are very limited for a key parameter;
    - data were collected over a short time period and may not represent long-term trends (the respondent usual behavior), for example, 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 was therefore not representative of the area of interest, for example, 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, for example, soil ingestion by children.

1.7. USING THE HANDBOOK IN AN EXPOSURE ASSESSMENT

Some of the steps for performing an exposure assessment are determining the pathways of exposure; identifying the environmental media that transports the contaminant; determining the contaminant concentration; determining the exposure time, frequency, and duration; and 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 Combustor Emissions* (U.S. EPA, 1990)
- *Risk Assessment Guidance for Superfund* (U.S. EPA, 1989)
- *Estimating Exposures to Dioxin-Like Compounds* (U.S. EPA, 1994a)
- *Superfund Exposure Assessment Manual* (U.S. EPA, 1988a)
- *Selection Criteria for Mathematical Models Used in Exposure Assessments: Groundwater Models* (U.S. EPA, 1988b)
- *Selection Criteria for Mathematical Models Used in Exposure Assessments: Surface Water Models* (U.S. EPA, 1987)
- *Standard Scenarios for Estimating Exposure to Chemical Substances During Use of Consumer Products* (U.S. EPA, 1986a)
- Pesticide assessment guidelines, subdivision K (U.S. EPA, 1984) and U (U.S. EPA, 1986b)
- *Methods for Assessing Exposure to Chemical Substances, volumes 1-13* (U.S. EPA, 1983-1989)
- *Guiding Principles for Monte Carlo Analysis* (U.S. EPA, 1997c)
- "Policy for Use of Probabilistic Analysis in Risk Assessment at the U.S." Environmental Protection Agency, May 15, 1997, available at http://www.epa.gov/ncea/mcpolicy.htm
- "Guiding Principles for Monte Carlo Assessments" (EPA/600/R-97/001), available at http://www.epa.gov/ncea/monteabs.htm
- Options for Developing Parametric Probability Distributions for Exposure Factors (U.S. EPA, 2000a)
- *Identifying Potentially Highly Exposed Children's Populations* (U.S. EPA, 2001)
- *Proposed Cancer Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 1999c)

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.

Most of the data presented in this handbook are derived from studies that target (1) the general population (e.g., USDA food consumption surveys), and (2) a sample population from a specific area or group (e.g., the Calabrese et al. (1989) soil ingestion study which uses children from the Amherst, MA, area). It is necessary for risk or exposure assessors who are characterizing a diverse population to identify and enumerate certain groups within the general population who are at risk for greater contaminant exposures or who exhibit a heightened sensitivity to particular chemicals. For further guidance on addressing susceptible populations, the reader is referred to *Socio-demographic Data Used for Identifying Potentially Highly Exposed Subpopulations* (U.S. EPA, 2001).

EPA is also developing guidance on the use of exposure factors data in exposure assessments. For further information on the status of this guidance, consult the NCEA's home page, www.epa.gov/ncea.

1.8. GENERAL EQUATION FOR CALCULATING DOSE

The definition of exposure, as used in *Guidelines for Exposure Assessment* (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 (the dose) is the amount of agent available at human exchange boundaries (skin, lungs, gut) where absorption takes place during some specified time. An example of exposure and dose for the oral route, as presented in the guidelines, is shown in Figure 1-1. Starting with a general integral equation for exposure, 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.

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

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 ADDs (LADDs). The LADD takes the form of eq. 1-1, with lifetime replacing averaging time. The LADD is a very common term used in carcinogen risk assessment where linear nonthreshold models are employed.

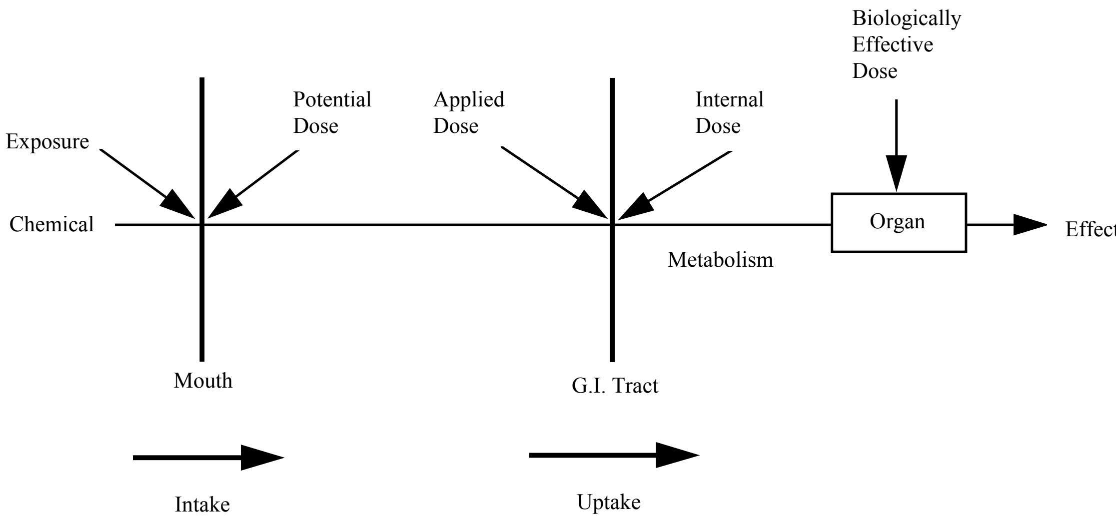

Figure 1-1. Schematic of dose and exposure: oral route

Source: U.S. EPA, 1992a

The total exposure can be expressed as follows:

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

Where:

C = Contaminant Concentration

IR = Intake Rate

ED = Exposure Duration

Contaminant concentration is the concentration of the contaminant in the medium (air, food, soil, etc.) contacting the body; it 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 of contaminant contact. The time a person lives in an area, frequency of bathing, time spent indoors versus outdoors, etc., all affect the exposure duration. Chapter 9, Activity Factors, gives some examples of population behavior/activity patterns that may be useful for estimating exposure durations.

When the parameter values IR and ED 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, exposure duration is the length of time exposure occurs at the concentration and at the intake rate specified by the other parameters in the equation.

Dose can be expressed as a total amount (with units of mass, e.g., mg) or as a dose 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 where 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 eq. 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 70 years has been considered a reasonable approximation. For exposure estimates that are 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 such a way that it can be combined with the dose-response relationship to calculate risk.

The body weight to be used in the exposure eq. 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 g/day/kgr body weight. In this case, the body weight has already been included in the "intake rate" term in eq. 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 and breast milk and the inhalation of air are not normalized to body weight. In this case, the exposure assessor needs to use (in eq. 1-1) the average weight of the exposed population during the time when the exposure actually occurs. If the body weight of the individuals in the population whose risk is being evaluated is nonstandard in some way (e.g., children 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 *Exposure Factors Handbook* (U.S. EPA, 1997b). Some of the parameters (primarily concentrations) used in estimating exposure are exclusively site specific, and therefore default recommendations could not be used. It should be noted that body weight is correlated with food consumption rates and inhalation rates.

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 (e.g., serving size per event). 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.

1.9. ADJUSTMENT OF DOSE FROM ADULTS TO CHILDREN

Section 1.8 discusses the general equation to calculate dose. To assess risk, dose estimates are combined with slope factors for chemicals that have a carcinogenic effect and with reference doses (RfDs) for those that have noncancer effects. For assessing risk via the inhalation route, the exposure concentration is compared with unit risk estimates for cancer effects and with reference concentrations (RfCs) for noncancer effects.

Slope factors and unit risk estimates for lifetime exposure incorporate exposure factors that are based on adults (specifically, body weight, breathing rate, and drinking water ingestion rate). When slope factors and unit risks are used to assess risks from less-than-lifetime exposures that occur during childhood, adjustments to toxicity values to account for differences between adults and children may be appropriate (U.S. EPA, 1999c). The reader is referred to the EPA's proposed cancer guidelines (U.S. EPA, 1999c) for further guidance on how to make these adjustments for slope factors and unit risks.

As it is the case with slope factors, RfCs are developed using default exposure values based on adults. The RfC methodology, which is described in *Methods for Derivation of Inhalation Reference Concentrations and Applications of Inhalation Dosimetry* (U.S. EPA, 1994b), allows the user to incorporate population-specific assumptions into the models. The reader is referred to EPA guidance (U.S. EPA, 1994b) on how to make these adjustments. It is important to note, however, that the EPA's Risk Assessment Forum is currently considering this existing guidance on animal-to-human cross-species extrapolation procedures described in U.S. EPA (1994b) and is recommending the development of procedures for inhalation adjustments to incorporate the most current scientific thought and data to address, as needed, issues of variability due to life stage and other intrinsic factors.

There are no specific exposure factor assumptions in the derivation of RfDs. The assessment of the potential for adverse health effects in infants and children is part of the overall hazard and dose-response assessment for a chemical. Available data pertinent to children's health risks are evaluated along with data on adults and the no-observed-adverse-effect-level (NOAEL) or benchmark dose (BMD) for the most sensitive critical effect(s), based on consideration of all health effects. By doing this, protection of the health of children will be considered along with that of other sensitive populations. In some cases, it is appropriate to evaluate the potential hazard to children separately from the assessment for the general population or other population subgroups. However, the Food Quality Protection Act (FQPA) of 1996 states that for threshold effects,

> an additional tenfold margin of safety for the chemical residue and other sources of exposure shall be applied for infants and children to take into account potential pre- and post-natal toxicity and completeness of data with respect to exposure and toxicity to infants and children. Notwithstanding such requirement for an

additional margin of safety, the Administrator may use a different margin of safety for the pesticide chemical residue only if, on the basis of reliable data, such margin of safety will be safe for infants and children.

In addition, FQPA lists several factors that must be considered when assessing risks to children, such as available information concerning the special susceptibility of children to pesticide chemical residues, neurological differences between children and adults, and effects of in utero exposure. In response to FQPA requirements, EPA's Office of Pesticide Programs is developing guidance on the use of this tenfold safety factor.

1.10. AGE GROUPING

Currently, there is no consistent EPA-wide approach for grouping children by age when assessing exposure to environmental contaminants. Existing approaches vary from case to case and among Program Offices within EPA. Often, the age groups depend on the availability of data and are based on professional judgment. This handbook presents data from a variety of studies in a manner that preserves, to the extent possible, the format followed by the study authors. Therefore, the childhood age groupings presented in the handbook may not be consistent across all studies. These age groupings typically reflect the expert judgment of the study authors and will vary with respect to how well they reflect behavioral and physiological changes during the childhood lifestage.

The development of standardized age groupings (or bins) was the subject of discussion in a recent workshop sponsored by EPA's Risk Assessment Forum. The workshop was titled "The Technical Workshop on Issues Associated with Considering Developmental Changes in Behavior and Anatomy When Assessing Exposure to Children." The purpose of this workshop was to gain insight and input into factors that need to be considered when developing standardized age groups and to identify future research necessary to accomplish these goals. During the workshop, participants were divided into two groups. One of the groups focused its discussions on defining and characterizing the important facets of behavioral development during childhood; the other group focused its discussions on defining and characterizing aspects of physiological development. EPA is using the input obtained during the workshop to develop guidance on the age groupings for children. This guidance is expected to be finalized by Fall 2002.

During the workshop, participants concluded that, ideally, exposure assessment would predict chemical exposures as a continuous function over a lifetime. However, given the paucity of existing data, this is not likely to be accomplished in the near future, and assessors will need to classify individuals into age groups in order to simplify the exposure model. The reader is referred to the workshop report in the Risk Assessment Forum home page (http://www.epa.gov/ncea/raf/rafpub.html) for more detailed information about the workshop results. Summarized below are some of the key findings and recommendations made by the workshop participants. These recommendations are currently under consideration by EPA as the guidance development process continues.

- Panelists agreed that child development is a series of discrete events, but these events occur along a continuum.

- Age grouping/bins are a useful tool for approximating the underlying exposure/dose distributions. Ideally, sufficient data should be generated to develop a continuous multivariate model that best reflects actual exposure/dose.

- Adequacy of existing exposure data is highly variable.

- A considerable amount of additional information already exists, but it is dispersed in the literature. It was recommended that EPA consult with experts in developmental biology, physiology, pharmacology, and toxicology and conduct an in-depth review of the literature.

- Long-term research should include the development of integrated data sets that combine information about the exposure factors with biomarkers of exposure and effects.

- The definition of age groups/bins for childhood exposure assessment is inextricably linked to toxicokinetic and toxicodynamic issues.

- The two break-out groups (i.e., behavioral and physiological) offered the following preliminary ideas for age groupings:

Age grouping based on behavioral characteristics

- 0 to < 3 months
- 3 to < 6 months
- 6 to < 12 months
- 1 to < 2 years
- 2 to < 6 years
- 6 to < 11 years
- 11 to < 16 years
- 16 to < 21 years

Age grouping based on physiological characteristics

- 0 to < 1 month
- 1 to < 3 months
- 3 to < 6 months
- 6 to < 12 months
- 1 to < 3 years
- 3 to < 8 (female) or 9 (male) years
- 8/9 to < 16 (female) or 18 (male) years

One can observe that there was fairly good agreement between the two groups with regard to the age groupings that are important for infants and toddlers. However, there was some disagreement with regard to the older children. Appropriate age groupings depend on not only behavioral and physiological characteristics, but also on the specific scenario being studied and the chemical of concern.

On the basis of the recommendations made by the workshop participants, the Risk Assessment Forum workgroup on childhood exposure has proposed a recommended set of age groups to be considered in risk assessments for children (Table1-4). The age groups and guidance on how to use them are currently under development and will be subjected to peer review. It is important to note that EPA will be directing efforts to revise this handbook to conform with the age grouping guidance as soon as guidance is finalized. A revised handbook is expected in Fall 2003.

1.11. CUMULATIVE RISK

EPA recognizes that children may be exposed to mixtures of chemicals both indoors and outdoors. Exposure may also occur through more than one pathway. New directions in risk assessments in EPA put more emphasis on total exposures via multiple pathways (U.S. EPA, 2000). However, methods and approaches to assess cumulative risks are not well developed. EPA has initiated the development of guidelines for assessing cumulative risks. An external peer review draft framework is expected in Spring 2002.

1.12. FUTURE OR ONGOING WORK

This section provides a summary of several ongoing activities in and outside of the Agency to address various aspects of children's exposures. Results from these activities, which are listed below, will be included in future updates to this handbook.

- EPA is developing guidance on the use of exposure data. For future information on the status of this guidance, consult NCEA's homepage (www.epa.gov/ncea).

- EPA is summarizing the information in *Sociodemographic Data Used for Identifying Potentially Highly Exposed Children's Populations*. An external review draft of this document was completed in April 2001.
- EPA is currently analyzing arsenic data in urine to backcalculate soil intake rates in a community living near a smelter. Results of this study are expected to be available in the Fall 2002.

- EPA is currently developing guidance on the age groupings that are more appropriate for characterizing children exposures. Guidance is expected to be finalized in September 2002.

- EPA, the National Institute of Environmental Health Sciences, and the Centers for Disease Control and Prevention (CDC) have established eight Centers of Excellence in Children's Environmental Health and Disease Prevention Research. These Centers are conducting basic and applied research in combination with community-based prevention efforts. Their aim is to better understand the causes of environmentally induced diseases among children and to eventually decrease their prevalence. More information about these centers is available at http://es.epa.gov/ncerqa/centers/cecehdpr.html.

- The Consumer Product Safety Commission (CPSC) is directing a study to collect frequency and duration of mouthing behavior from 200 children of ages ranging from 3 months through 36 months. A report is expected to be issued in May 2002. This report will be posted in the CPSC web page at www.cpsc.gov/library/library.htm.

- The President's Task Force on Environmental Health Risks and Safety Risks to Children is planning to conduct a national longitudinal cohort study to identify and quantify the effects of environmental factors on the health and development of children. This study is called the National Children's Study, and more information can be found at www.hichd.nih.gov/about/despr/cohort/.

- EPA's National Exposure Research Lab is directing research to study the transfer efficiency of pesticides to foods. This research emphasizes accurate measurement of pesticides transferred to foods from various surfaces, quantifying activities of children through videotape analysis, and analyzing field study data from three home environments to evaluate the dietary intake model. For more information, the reader is referred to http://www.epa.gov/nerl/research/2000/pdf_conversions/G3-2.pdf.

- The U.S. Department of Housing and Urban Development, in collaboration with EPA's National Exposure Research Laboratory and CPSC, conducted the first national survey of licensed child care centers to evaluate the levels of lead, pesticides, and allergens within and around these centers. Data will be available in 2003.

- The Duval County Health Department (Jacksonville, FL), in collaboration with CDC and EPA's National Exposure Research Laboratory, conducted a survey to evaluate organophosphate and pyrethroid pesticide metabolite levels in urine from young children, pesticide use practices, and a total aggregate exposure assessment in the greater Jacksonville area. Data will be available in 2003.

- EPA's National Exposure Research Laboratory, in collaboration with the Environmental and Occupational Health Sciences Institute at Rutgers University, conducted a research study to reduce the uncertainties associated with dermal exposures following a residential pesticide application.

1.13. RESEARCH NEEDS

The data for several exposure factors for children are limited. The following list is a compilation of areas for future research related to childhood exposure factors:

- More recent information is needed on breast milk consumption and the incidence and duration of breastfeeding.

- Information on children's food handling practices that might exacerbate exposure is needed to better characterize exposures among children.

- Further research on fish consumption rates among children, particularly recreational and subsistence populations, is needed.

- Further research is needed on consumption of ethnic foods by children.

- Research is needed to better estimate soil intake rates, particularly, how to extrapolate short-term data to chronic exposures. Research is also needed to refine the methods for calculating soil intake rates (inconsistencies among tracers and input/output misalignment errors indicate a fundamental problem with the methods). In particular, additional information on soil ingestion among children that provides better estimates of upper percentile rates is needed. Research is also needed to provide a better understanding of the relative contribution of soil versus dust ingestion.

- Further research is needed on nondietary ingestion exposure factors, such as the microenvironments in which children spend time and the types of materials that they contact. More information is needed on the rate at which they contact contaminated surfaces, the fraction of the contaminants that are transferred to skin and object surfaces, and the amount of the object/skin entering the mouth.

- Additional data on dermal exposure factors, such as the microenvironments in which children spend time and the types of materials that they contact, as well as information on the rate at which they contact contaminated surfaces and the fraction of the contaminants that are transferred to skin and object surfaces are needed.

- Further research is needed to obtain better soil adherence rates for additional activities involving children.

- Further data are needed on the frequency and duration of use and kinds of consumer products used by children.

- Additional information on derivation of new surface area based on newer body weight data is needed.

- New surface areas based on newer body weight data need to be derived.

- Additional data on inhalation rates that are specific to children's activities and overall 24-hour breathing rates are needed.

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

- Further research is needed to estimate food consumption rates by children based on the CSFII supplemental survey on children.

1.14. ORGANIZATION

The handbook is organized as follows:

Chapter 1 provides the overall introduction to the handbook.

Chapter 2 provides factors for estimating exposure through ingestion of breast milk.

Chapter 3 provides factors for estimating human exposure through the ingestion of foods, including fish.

Chapter 4 provides factors for estimating exposure through the ingestion of drinking water.

Chapter 5 provides factors for estimating exposure as a result of ingestion of soil.

Chapter 6 presents factors for estimating exposure to environmental contaminants from other nondietary ingestion, such as hand-to-mouth and object-to-mouth activity.

Chapter 7 provides factors for estimating exposure as a result of inhalation of vapors and particulates.

Chapter 8 provides factors for estimating dermal exposure to environmental contaminants that come in contact with the skin.

Chapter 9 presents data on activity factors (activity patterns, population mobility, and occupational mobility).

Chapter 10 presents data on consumer product use.

Chapter 11 presents data on body weight.

Chapter 12 presents data on life expectancy.

Table 1-1. Considerations used to rate confidence in recommended values

Considerations	High Confidence	Low Confidence
Study Elements		
Level of peer review	The studies received a high level of peer review (e.g., they appeared in peer review journals).	The studies received limited peer review.
Accessibility	The studies are widely available to the public.	The studies are difficult to obtain (e.g., draft reports, unpublished data).
Reproducibility	The results can be reproduced or the methodology can be followed and evaluated.	The results cannot be reproduced, the methodology is hard to follow, and the author(s) cannot be located.
Focus on factor of interest	The studies focus on the exposure factor of interest.	The purpose of the studies was to characterize a related factor.
Data pertinent to U.S.	The studies focused on the U.S. population.	The studies focus on populations outside the U.S.
Primary data	The studies analyzed primary data.	The studies are based on secondary sources.
Currency	The data were published after 1990.	The data were published before 1990.
Adequacy of data collection period	The study design captures the measurement of interest (e.g., usual consumption patterns of a population).	The study design does not very accurately capture the measurement of interest.
Validity of approach	The studies used the best methodology available to capture the measurement of interest.	There are serious limitations with the approach used.
Study sizes[a]	The sample size is greater than 100 samples.	The sample size is less than 20 samples.
Representativeness of the population	The study population is the same as the population of interest.	The study population is very different from the population of interest.[b]
Variability in the population	The studies characterize variability in the population studied.	The 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 the study design.	The study design introduces biases in the results.
Response rates:		
In-person interviews	The response rate is greater than 80 percent.	The response rate is less than 40 percent.
Telephone interviews	The response rate is greater than 80 percent.	The response rate is less than 40 percent.
Mail surveys	The response rate is greater than 70 percent.	The response rate is less than 40 percent.
Measurement error	The study design minimizes measurement errors.	Uncertainties with the data exist due to measurement error.
Other Elements		
Number of studies	The number of studies is greater than 3.	The number of studies is 1.
Agreement between researchers	The results of studies from different researchers are in agreement.	The results of studies from different researchers are in disagreement.

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

Table 1-2. Summary of exposure factor recommendations and confidence ratings

Exposure Factor	Recommendation[a]	Confidence Rating
Breast milk intake rate (1–6 months)	742 mL/day (average) 1033 mL/day (upper percentile)	Medium Medium
Drinking water intake rate	See Table 4-15 L/day (average) See Table 4-15 L/day (90th percentile)	High High
Total fruit intake rate	See Table 3-2 (per capita average) See Table 3-2 (per capita 95th percentile)	High Low
Total vegetable intake rate	See Table 3-2 (per capita average) See Table 3-2 (per capita 95th percentile)	High Low
Total meat intake rate	See Table 3-2 (per capita average) See Table 3-2 (per capita 95th percentile)	High Low
Total dairy intake rate	See Table 3-2 (per capita average) See Table 3-2 (per capita 95th percentile)	High Low
Total grain intake	See Table 3-2 (per capita average) See Table 3-2 (per capita 95th percentile)	High Low
Fat Intake	See Table 3-17	--
Fish intake rate	General Population See Table 3-6 (total fish) See Table 3-6 (marine) See Table 3-6 (freshwater/estuarine) Recreational fish intake 1–5 years, 370 mg/kg/day (average) 6–10 years, 280 mg/kg/day (average) Native American Subsistence Population < 5 years, 11 g/day (average)	 High (average) Low (upper percentile) Low Low Low
Home-produced food intake	See Table 3-28	Low (for means and short-term distributions) Low (for long-term distributions)
Soil ingestion rate	Children 100 mg/day (average) 400 mg/day (upper percentile) Pica child 10 g/day	 Medium Low

Table 1-2. Summary of exposure factor recommendations and confidence ratings (continued)

Exposure Factor	Recommendation[a]	Confidence Rating
Mouthing behavior	3–60 months 46 min/day (average) 24–72 months Hand-to-mouth, 9 contacts/hour (average) Hand-to-mouth, 20 contact/hour (90th percentile) Object-to-mouth, 16.3 contact/hour (average) 10–72 months Total mouthing, 49 contacts/hour (average)	Low Low Low Low Low
Inhalation rate	Children (< 1 year) 4.5 m^3/day (average) Children (1–12 years) 8.7 m^3/day (average)	Medium Medium
Surface area	Water contact (bathing and swimming) Use total body surface area for children in Tables 8-1 through 8-2; Soil contact (outdoor activities) Use body part area based on Table 8-3	Medium Medium
Soil adherence	Use values presented in Table 8-13 depending on activity and body part (central estimates only)	Medium
Life expectancy	70 years	High
Body weights for children	Use values presented in Tables 11-2 and 11-3 (percentiles); Tables 11-6 and 11-7 (mean)	High
Body weights for infants (birth to 6 months)	Use values presented in Table 11-1 (percentiles); Tables 11-6 and 11-7 (mean)	High
Showering/bathing	Showering time 10 min/day (average) 1 shower event/day 45 min (95th percentile)	Medium
Swimming	Frequency 1 event/month Duration 60 min/event (median)	Medium Medium

Table 1-2. Summary of exposure factor recommendations and confidence ratings (continued)

Exposure Factor	Recommendation[a]	Confidence Rating
Time indoors	At Residence:	
	Ages 1–17 years	Medium
	18 hrs/day (average)	
	24 hrs/day (95th percentile)	
	Ages 1–4, 5–11, and 12–17 years (use values in Table 9-41 for distribution data)	Medium
	Total Time Indoors	
	Ages 3–17 years	Medium
	19 hrs/day (total average)	
	Ages 3–5, 6–8, 9–11, 12–14, and 15–17 years (use Table 9-3 for mean values spent indoors weekend and weekday)	Medium
Time outdoors	At Residence	
	Ages 1–17 years	Medium
	3 hrs/day (average value)	
	8 hrs/day (95th percentile)	
	Ages 1–4, 5–11, and 12–17 years (use values in Table 9-43 for distribution data)	Medium
	Total Time Outdoors	
	Ages 3–17 years	Medium
	2 hrs/day (total average)	

[a] For drinking water and food intake, the reader is referred to the specific table within Chapters 3 and 4 to select the appropriate value, based on the age grouping and percentile of choice.

Table 1-3. Characterization of variability in exposure factors

Exposure Factors	Average	Median	Upper percentile	Multiple Percentiles	Fitted Distributions
Breast milk intake rate	✓		✓		
Total intake rate for major food groups	✓	✓	✓ Qualitative discussion for long-term	✓	
Individual food intake rate	✓				
Drinking water intake rate	✓		✓	✓	✓
Fish intake rate for general population, recreational marine, recreational freshwater, and Native American	✓	✓	✓	✓	
Serving size for foods	✓		✓		
Home-produced food intake rates	✓	✓	✓	✓	
Soil intake rate	✓	✓	✓ Qualitative discussion for long-term		
Inhalation rate	✓		✓	✓	
Surface area Soil adherence	✓ ✓		✓	✓	
Body weight	✓	✓	✓	✓	
Time indoors Time outdoors Showering time Occupational tenure Population mobility	✓ ✓ ✓ ✓ ✓	 ✓	 ✓ ✓	 ✓ ✓	

Table 1-4. Proposed set of childhood age groups for agency exposure assessments

Age groups < 1 year	Age groups ≥ 1 year
Birth to < 1 month	1 to < 2 years
1 to < 3 months	2 to < 3 years
3 to < 6 months	3 to < 6 years
6 to < 12 months	6 to < 11 years
	11 to < 16 years
	16 to < 18 years
	18 to < 21 years[a]

[a] To be considered on a case-by-case basis.

Appendix A for Chapter 1: Variability and Uncertainty

The sections that follow 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 review the general equation for potential average daily dose (ADD_{pot}):

$$ADD_{pot} = \frac{\text{Contaminant Concentration x Intake Rate x Exposure Duration}}{\text{Body Weight x Averaging Time}} \qquad (1A\text{-}1)$$

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). Although the topics of variability and uncertainty apply equally to contaminant concentrations and the rest of the exposure factors in eq. 1A-1, the focus of this appendix is on variability and uncertainty as they relate to exposure factors. Consequently, examples provided in this appendix relate primarily to exposure factors, although contaminant concentrations may be used when they better illustrate the point under discussion.

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

- Distinction between variability and uncertainty;
- Types of variability;
- Methods of confronting variability;
- Types of uncertainty and reducing uncertainty;
- Analysis of variability and uncertainty; and
- Presenting results of variability/uncertainty analysis.

Fairly extensive treatises on the topic of uncertainty have been provided by, for example, Morgan and Henrion (1990), the National Research Council (NRC) (NRC, 1994) and, to a lesser extent, the EPA (U.S. EPA, 1992a, 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 the risk-assessment process, the general concepts apply equally to the exposure-assessment component.

1A.1. VARIABILITY VERSUS UNCERTAINTY

Although some authors have treated variability as a specific type or component of uncertainty, the EPA (U.S. EPA, 1995) has advised the risk assessor (and, by analogy, the exposure assessor) to distinguish between variability and uncertainty. 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. Most of the data presented in this handbook concern variability.

Variability and uncertainty can complement or confound one another. An instructive analogy has been drawn by the NRC (1994), 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; or

- 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 or the contaminant concentration in water.

It is impractical to measure the individual's dose every day. For this reason, the exposure assessor may estimate the ADD on the basis of 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 on the basis of 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 NRC (1994), the realms of variability and uncertainty have fundamentally different ramifications for science and judgment. For example, uncertainty may force decisionmakers 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.

1A.2. 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); and

- Variability among individuals (inter-individual variability).

Spatial variability can occur at both the regional (macroscale) and the local (microscale) level. 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 a source 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. Variability arising from independent factors that combine multiplicatively generally will lead to an approximately lognormal distribution across the population or across spatial/temporal dimensions.

1A.3. CONFRONTING VARIABILITY

According to NRC (1994), variability can be confronted in four basic ways (Table 1A-1) when dealing with science-policy questions surrounding issues such as exposure or risk assessment. The first way 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. In this case, the variability is characterized by the range between the extreme values and a measure of central tendency. 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). As noted by EPA (U.S. EPA, 1992a), when an exposure assessor develops estimates of high-end individual exposure and dose, care must be taken not to set all factors to values that maximize exposure or dose; such an approach will almost always lead to an overestimate.

1A.4. CONCERN ABOUT UNCERTAINTY

Why should the exposure assessor be concerned with uncertainty? As noted by EPA (U.S. EPA, 1992a), exposure assessment can involve 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.

Table 1A-1. Four strategies for confronting variability

Strategy	Example	Comment
Ignore variability	Assume that all adults weigh 70 kg	Works best when variability is small
Disaggregate the variability	Develop distributions of body weight for age/gender groups	Variability will be smaller in each group
Use the average value	Use average body weight for adults	Can the average be estimated reliably given what is known about the variability?
Use a maximum or minimum value	Use a lower-end value from the weight distribution	Conservative approach—can lead to unrealistically high exposure estimate if taken for all factors

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, 1992a; 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, and

- 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.

1A.5. TYPES OF UNCERTAINTY AND REDUCING 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 EPA (U.S. EPA, 1992a) 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 1A-2.

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.

1A.6. ANALYZING VARIABILITY AND UNCERTAINTY

Exposure assessments often are developed in a phased approach. The initial phase usually screens out the exposure scenarios or pathways 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 usually are 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 variability or uncertainty.

According to EPA (U.S. 1992a), 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 decisionmakers 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 variability and uncertainty was made in section 1A.1. Although the quantitative process mentioned above applies more directly to variability and the qualitative approach more to uncertainty, there is some degree of overlap. In general, either method provides the assessor or decisionmaker with insights to better evaluate the assessment in the context of available data and assumptions. The following paragraphs describe some of the more common procedures for analyzing variability and uncertainty in exposure assessments. Principles that pertain to presenting the results of variability/uncertainty analysis are discussed in the next section.

Table 1A-2. 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

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 10L 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., 1.4L per day) determined by available data or professional judgement.

When sensitivity analysis 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 variability and uncertainty 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, 1992a). The four approaches are summarized in Table 1A-3.

1A.7. PRESENTING RESULTS OF VARIABILITY AND 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 appendix, 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.

Not all approaches historically used to construct measures or estimates of exposure have attempted to distinguish between variability and uncertainty. The assessor is advised to use a variety of exposure descriptors—and where possible, the full population distribution—when presenting the results. This information will provide risk managers with a better understanding of how exposures are distributed over the population and how variability in population activities influences this distribution.

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 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 *Guidelines for Exposure Assessment* (U.S. EPA, 1992a) 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.

Table 1A-3. 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

The data presented in the *Exposure Factors Handbook* (U.S. EPA, 1997b) is one of the tools available to exposure assessors to construct the various risk descriptors.

However, it is not sufficient to merely present the results using different exposure descriptors. Risk managers should also be presented with an analysis of the uncertainties surrounding these descriptors. Uncertainty may be presented using simple or very sophisticated techniques, depending on the requirements of the assessment and the amount of data available. It is beyond the scope of this handbook to discuss the mechanics of uncertainty analysis in detail. At a minimum, the assessor should address uncertainty qualitatively by answering questions such as:

- What is the basis or rationale for selecting these assumptions/parameters—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(s) supporting the selection of the chosen values?

Any exposure estimate developed by an assessor will have associated assumptions about the setting, the chemical, and 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.

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

Table 1A-2 summarizes the three types of uncertainty, associated sources, and examples. Table 1A-3 summarizes four approaches to analyzing uncertainty quantitatively. These are described further in the *Exposure Guidelines* (U.S. EPA, 1992a).

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2. BREAST MILK INTAKE

2.1. INTRODUCTION

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 milk intake rate (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 weighing 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 weighing data were corrected for insensible water loss, they were not significantly different from bottle weight data. 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 1200 g/day (437 to 1165 mL/day) (NAS, 1991). Similar intakes have also been reported for developing countries (NAS, 1991). Infant birth weight has 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.

Key studies on breast milk intake are summarized in the following sections. Recommended intake rates are based on the results of these key studies, as described in *Exposure Factors Handbook* (U.S. EPA, 1997). Relevant data on lipid content and fat intake, breast-feeding duration, and the estimated percentage of the U.S. population that breast-feeds are also presented.

2.2. STUDIES ON BREAST MILK INTAKE

2.2.1. Pao et al., 1980

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 the infants were from white middle-class families in southwestern Ohio. The goal of the study was to enroll infants as close to 1 month of age as possible and to obtain records near 1, 3, 6, and 9 months of age. However, not all mother/infant pairs participated at each time interval.

Data were collected for the 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. Reported mean daily breast milk intake rates for the infants surveyed at each time interval are presented in Table 2-1. 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. The investigations also noted that intake rates for boys in both groups were slightly higher than those for girls.

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. In addition, this study did not account for insensible water loss, which may underestimate the amount of breast milk ingested.

2.2.2. Dewey and Lönnerdal, 1983

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 the investigations, the mothers were all well educated and recruited through Lamaze childbirth classes in the Davis area of California. Breast milk intake volume was estimated on the basis of two 24-hour test weighings per month. Breast milk intake rates for the various age groups are presented in Table 2-2. Breast milk intake averaged 673, 782, and 896 mL/day at 1, 3, and 6 months of age, respectively.

The advantage of this study is that it evaluated breast-fed infants for a period of 6 months, 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.

2.2.3. Butte et al., 1984

Breast milk intake was studied in exclusively breast-fed infants during the first 4 months of life (Butte et al., 1984). Breast-feeding 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. 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 2-3). Intakes were also calculated on the basis of body weight (Table 2-3). 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%.

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.

2.2.4. Neville et al., 1988

Neville et al. (1988) studied breast milk intake among 13 infants during their first year of life. The mothers were all multiparous, nonsmoking, Caucasian women of middle to upper socioeconomic status living in Denver, CO. All the women in the study practiced exclusive breast-feeding for at least 5 months. Solid foods were introduced at a 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 2-4. 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.

Compared with the previously described studies, data were collected in this study 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 2-4 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.

2.2.5. Dewey et al., 1991a, b

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, b). Seventy-three infants aged 3 months were included in the study. At subsequent time intervals, the number of infants 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 they did not consume solid foods until after the first 4 months of age. The mothers were from the Davis area of California and were highly educated and of "relatively high socioeconomic status."

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 declined over the first 12 months of life. This decline was associated with the intake of solid food. 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 2-5). Based on the estimated intakes at 3 months of age, variability between individuals (coefficient of variation ([CV] = 16.3%) was higher than individual day-to-day variability ([CV] = 5.4%) for the infants in the study (Dewey et al., 1991a).

The advantages of this study are that data were collected over a relatively long time period (4 days) at each test interval, which would account for some day-to-day infant variability, and corrections for insensible water loss were made.

2.3. 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. The lipid content of breast milk varies according to the length of time that an infant nurses, and it increases from the beginning to the end of a single nursing session (NAS, 1991). The lipid portion accounts for approximately 4% 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.

2.3.1. Butte et al., 1984

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 2-6. The overall lipid content for the 4-month study period was 34.3 ± 6.9 mg/g (3.4%). The investigators 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.

2.3.2. Maxwell and Burmaster, 1993

Maxwell and Burmaster (1993) used a hypothetical population of 5000 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 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%). A model was used to simulate intake among 1113 of the 5000 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 (minimum intake was 1 g/day, maximum intake was 51.5 g/day). 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), the investigators estimated the lipid content of breast milk to be 36.7 g/L at 3 months (35.6 mg/g or 3.6%) and 40.2 g/L (39.0 mg/g or 3.9%) at 12 months.

The advantage of this study is that it provides a “snapshot” of daily lipid intake from breast milk for breast-fed infants. However, these results are 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. However, the study did not generate “new” data. A reanalysis of previously reported data on breast milk intake and breast milk lipid intake were provided.

2.4. OTHER FACTORS

Other factors associated with breast milk intake include 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.

2.4.1. Population of Nursing Infants

According to the National Academy of Sciences (NAS), the percentage of breast-feeding women has changed dramatically over the years (NAS, 1991). The Ross Products Division of Abbott Laboratories conducted a large national mail survey in 1995 to determine patterns of breast feeding during the first 6 months of life. The Ross Laboratory Mothers's Survey was first developed in 1955 and has since been expanded to include many more infants. Before 1991, the survey was conducted on a quarterly basis, and approximately 40,000 to 50,000 questionnaires were mailed each quarter (Ryan, 1997). Beginning 1991, the survey was conducted monthly; 35,000 were mailed each month. Over time, the response rate has been consistently in the range of 50 ± 5%. In 1989 and 1995, 196,000 and 720,000 questionnaires were mailed, respectively. Ryan (1997) reported rates of breast-feeding through 1995 and compared them with rates in 1989.

The survey demonstrates recent increases in both the initiation of breast-feeding and continued breast-feeding at 6 months of age. Table 2-7 presents the proportion of breast-feeding in hospitals and at 6 months of age by selected demographic characteristics. In 1995, the incidence of breast-feeding at birth and at 6 months for all infants was approximately 60% and 22%, respectively. The largest increases in the initiation of breast-feeding between 1989 and 1995 occurred among women who (1) were Black, were < 25 years of age, were in the < $10,000 income level, had no more than grade school education, and were living in the South Atlantic region of the U.S.; (2) had infants of low birth weight; (3) were employed full time outside the home at the time they received the survey; and (4) participated in the Women, Infants, and Children (WIC) program. In 1995, as in 1989, the initiation of breast-feeding was highest among women who were > 35 years of age, in the > $25,000 income group, and college educated; women who did not participate in the WIC program; and women who were living in the Mountain and Pacific regions of the U.S.

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% of infants under 1 year of age are breast-fed. This estimate is based on a reanalysis of the survey data in Ryan et al. (1991) collected by Ross Laboratories (Maxwell and Burmaster, 1993).

2.4.2. Intake Rates Based on Nutritional Status

Information on differences in the quality and quantity of breast milk consumed on the basis of 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. Similar data were observed for well-nourished Swedish mothers. 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, b) 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.

2.5. RECOMMENDATIONS

The 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 used in the studies to estimate intake, the mean and standard deviation estimates reported in these studies are relatively consistent. There are, however, limitations with the data. Data are not available for infants under 1 month of age. This subpopulation may be of particular concern, because a larger number of newborns are totally breast-fed. In addition, with the exception of Butte (1984), data were not presented on a body weight basis. This is particularly important because intake rates may be higher on a body-weight basis for younger infants. Also, the data used to derive the recommendations are more than 10 years old, and the sample sizes of the studies were small. Other subpopulations of concern, such as mothers highly committed to breast-feeding—sometimes for periods longer than 1 year—may not be captured by the studies presented in this chapter. Further research is needed to identify these subgroups and to get better estimates of breast milk intake rates. Table 2-8 presents the confidence rating for breast milk intake recommendations.

2.5.1. Breast Milk Intake

The breast milk intake rates for nursing infants that have been reported in the studies described in this section are summarized in Table 2-9. Based on the combined results of these studies, 742 mL/day is recommended to represent an average breast milk intake rate, and 1033 mL/day represents an upper-percentile intake rate (based on the middle range of the mean plus 2 standard deviations) for infants between the ages of 1 and 6 months of age. The average value is the mean of the average intakes at 1, 3, and 6 months from the key studies listed in Table 2-9. 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 427 mL/day for 12-month-olds (Neville et al. 1988; Dewey et al. 1991a, b). 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 2-10 summarizes these recommended intake rates.

2.5.2. 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) in infants between 1 and 4 months of age. These intake rates are consistent with those reported by Maxwell and Burmaster (1993) of 26.8 ± 7.4 g/day (26.0 ± 7.2 mL/day) for infants under 1 year of age. 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% based on data from NAS (1991), Butte et al. (1984), and Maxwell and Burmaster (1993).

Table 2-1. Daily intakes of breast milk

Age	Number of infants	Mean ± SD (mL/day)[a]	Intake Range (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

Table 2-2. Breast milk intake for infants aged 1 to 6 months

Age (months)	Number of Infants	Intake	
		Mean ± SD (mL/day)	Range (mL/day)
1	16	673 ± 192	341–1003
2	19	756 ± 170	449–1055
3	16	782 ± 172	492–1053
4	13	810 ± 142	593–1045
5	11	805 ± 117	554–1045
6	11	896 ± 122	675–1096

Source: Dewey and Lönnerdal, 1983

Table 2-3. Breast milk intake among exclusively breast-fed infants during the first 4 months of life

Age (months)	Number of Infants	Intake (g/day)	Intake (g/kg-day)	Body Weight[a] (kg)
		Mean ± SD	Mean ± SD	
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] Calculated by dividing breast milk intake (g/day) by breast milk intake (g/kg-day).

Source: Butte et al., 1984

Table 2-4. Breast milk intake during a 24-hour period

Age (days)	Number of Infants	Intake (g/day)	
		Mean ± SD	Range
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

Table 2-5. Breast milk intake estimated by the Darling Study

Age (months)	Number of Infants	Intake
		Mean ± SD
3	73	812 ± 133
9	60	769 ± 171
9	50	646 ± 217
12	42	448 ± 251

Source: Dewey et al., 1991b

Table 2-6. Lipid content of human milk and estimated lipid intake among exclusively breast-fed infants

Age (months)	Number of Observations	Lipid Content (mg/g)	Lipid Content % [a]	Lipid Intake (g/day) Mean ± SD	Lipid Intake (g/kg-day) Mean ± SD
		Mean ± SD			
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] Percents calculated from lipid content reported in mg/g.

Source: Butte et al., 1984

Table 2-7. 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]

Characteristic	Percentage of mothers breast-feeding					
	In hospital			At 6 months		
	1989	1995	Change	1989	1995	Change
All Infants	52.2	59.7	14.4	18.1	21.6	19.3
White	58.5	64.3	9.9	21.0	24.1	14.8
Black	23.0	37.0	60.9	6.4	11.2	75.0
Hispanic	48.4	61.0	26.0	13.9	19.6	41.0
Maternal age (years)						
< 20	30.2	42.8	41.7	5.6	9.1	62.5
20–24	4.2	52.6	16.4	11.5	14.6	27.0
25–29	58.8	63.1	7.3	21.1	22.9	8.5
30–34	65.5	68.1	4.0	29.3	29.0	(1.0)[b]
35+	66.5	70.0	5.3	34.0	33.8	(0.6)[b]
Total family income						
< $10,000	31.8	41.8	31.4	8.2	11.4	39.0
$10,000 – $14,999	47.1	51.7	9.8	13.9	15.4	10.8
$15,000 – $24,999	54.7	58.8	7.5	18.9	19.8	4.8
≥ $25,000	66.3	70.7	6.6	25.5	28.5	11.8
Maternal education						
Grade school	31.7	43.8	38.2	11.5	17.1	48.7
High school	42.5	49.7	16.9	12.4	15.0	21.0
College	70.7	74.4	5.2	28.8	31.2	8.3
Maternal employment						
Employed full time	50.8	60.7	19.5	8.9	14.3	60.7
Employed part time	59.4	63.5	6.9	21.1	23.4	10.9
Not employed	51.0	58.0	13.7	21.6	25.0	15.7
Birth weight						
Low (≤2,500 g)	36.2	47.7	31.8	9.8	12.6	28.6
Normal	53.5	60.5	13.1	18.8	22.3	18.6
Parity						
Primiparous	52.6	61.6	17.1	15.1	19.5	29.1
Multiparous	51.7	57.8	11.8	21.1	23.6	11.8
WIC participation						
Participant	34.2	46.6	36.3	8.4	12.7	51.2
Nonparticipant	62.9	71.0	12.9	23.8	29.2	22.7

Table 2-7. 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] (continued)

	Percentage of mothers breast-feeding					
	In hospital			At 6 months		
Characteristic	1989	1995	Change	1989	1995	Change
U.S. census region						
New England	52.2	61.2	17.2	18.6	22.2	19.4
Middle Atlantic	47.4	53.8	13.5	16.8	19.6	16.7
East North Central	47.6	54.6	14.7	16.7	18.9	13.2
West North Central	55.9	61.9	10.7	18.4	21.4	16.3
South Atlantic	43.8	54.8	25.1	13.7	18.6	35.8
East South Central	37.9	44.1	16.4	11.5	13.0	13.0
West South Central	46.0	54.4	18.3	13.6	17.0	25.0
Mountain	70.2	75.1	7.0	28.3	30.3	7.1
Pacific	70.3	75.1	6.8	26.6	30.9	16.2

[a] The percent change was calculated using the following formula: % breast fed in 1984 – % breast fed in 1989 / % breast fed in 1984.
[b] Figures in parentheses indicate a decrease in the rate of breast-feeding from 1989 to 1995.

WIC = Women, Infants, and Children supplemental food program.

Source: Ryan, 1997

Table 2-8. Confidence in breast milk intake recommendations

Considerations	Rationale	Rating
Study Elements		
Level of peer review	All key studies are from peer-reviewed 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 1980–1997.	Medium-High
Adequacy of data collection period	Infants were not studied long enough to fully characterize day-to-day variability. With the exception of Neville et al. (1988), the measurements were made for frequency (e.g., once a month) and the data may not represent the potential first year of lactation (both for less than 1 month of age and for longitudinal measurements of more than 6 months).	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 five studies corrected data for insensible water loss.	Low
Study size	The sample sizes used in the key studies were fairly small (range 13–73).	Low
Representativeness of the population	Population are representative of the general mother-infant pair population.	High
Characterization of variability	Not very well characterized. Infants under 1 month not captured, mothers committed to breast-feeding over 1 year not captured.	Low

Table 2-8. Confidence in breast milk intake recommendations (continued)

Considerations	Rationale	Rating
Lack of bias in study design (high rating is desirable)	Bias in the studies was not characterized. Two out of five studies corrected for insensible water loss.	Low
Measurement error	All mothers were well-educated and trained in the use of the scale, which helped minimize measurement error. 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).	Medium
Other Elements		
Number of studies	There are five key studies.	Medium
Agreement between researchers	There is good agreement among researchers.	High
Overall Rating	Studies were well-designed. Results were consistent. Sample size was fairly low. Variability cannot be characterized due to limitations in data collection period.	**Medium**

Table 2-9. Breast milk intake rates derived from key studies

Age (months)	Mean intake (mL/day)	Number of Children	Upper Percentile (mL/day)[a]	Reference
1	600	11	918	Pao et al., 1980
	729	37	981	Butte et al., 1984
	747	13	1095	Neville et al., 1988
	673	16	1057	Dewey and Lönnerdal, 1983
	weighted avg = 702		1007[b]	
3	833	2	—	Pao et al., 1980
	702	37	923	Butte et al., 1984
	712	12	934	Neville et al., 1988
	782	16	1126	Dewey and Lönnerdal, 1983
	788	73	1046	Dewey et al., 1991b
	weighted avg = 759		1025[b]	
6	682	1	—	Pao et al., 1980
	744	13	978	Neville et al., 1988
	896	11	1140	Dewey and Lönnerdal, 1983
	747	60	1079	Dewey et al., 1991b
	weighted avg = 765		1059[b]	
9	600	12	1027	Neville et al., 1988
	627	50	1049	Dewey et al., 1991b
	avg = 622		1038	
12	391	9	877	Neville et al., 1988
	435	42	923	Dewey et al., 1991a, b
	weighted avg = 427		900	
12-month time weighted average 688			Range 900–1059 (middle of the range 980)	

[a] Upper percentile is reported (mean plus 2 standard deviations), except as noted.
[b] Middle of the range.

Table 2-10. Summary of recommended breast milk and lipid intake rates

Age	Mean intake (mL/day)	Upper percentile (mL/day)
Breast Milk		
1–6 months	742	1033.0
12-month-average	688	980.0
Lipids[a]		
< 1 Year	26	40.4

[a] The recommended value for the lipid content of breastmilk is 4%.

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3. FOOD INTAKE

3.1. INTRODUCTION

Ingestion of contaminated foods is a potential pathway of exposure to toxic chemicals among children. Fruits, vegetables, and grains 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. Meat, poultry, and dairy products can become contaminated if animals are exposed to contaminated media (i.e., soil, water, or feed crops). Contaminated finfish and shellfish are also 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. Intake rates for home-produced food products are needed to assess exposure to local contaminants present in homegrown or home-caught foods.

Children's exposure from food ingestion may differ from that of adults because of differences in the type and amounts of food eaten. Also, for many foods, the intake per unit body weight is greater for children than for adults. The most common foods eaten by children include nonfat milk solids, apple juice, fresh apples, orange juice, fresh pears, milk fat and solids, fresh peaches, carrots, lean beef, milk sugar (lactose), fresh bananas, milled rice, succulent garden peas, succulent garden beans, oats, soybean oil, coconut oil, and wheat flour (Goldman, 1995).

The primary sources of recent information on consumption rates of foods among children are USDA's Nationwide Food Consumption Survey (NFCS) and the USDA Continuing Survey of Food Intakes by Individuals (CSFII). Data from the 1989–1991 and 1994–1996 CSFIIs have been used in various studies to generate children's per capita intake rates for both individual foods and the major food groups. Earlier studies have used the NFCS from 1977–1978 or 1987–1988. Because data from the 1989–1991 and 1994–1996 CSFIIs are available, data from the older surveys are not reported here, except in the case of data on homegrown foods, which are based on the 1987–1988 NFCS, and serving size information, which is based on the 1977–1978 NFCS. Older USDA data analyses can be found *Exposure Factors Handbook* (U.S. EPA 1997).

It should be noted that a variety of terms may be used to define intake (e.g., consumer-only intake, per capita intake, as-consumed intake, dry-weight intake. These terms are defined below to assist the reader in interpreting and using the intake rates that are appropriate for the exposure scenario being assessed.

Consumer-only intake is defined as the quantity of foods consumed only by children 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 children (i.e., both users and nonusers). In general, per capita intake rates are appropriate for use in exposure assessment for which average dose estimates for children are of interest, because they represent children who ate the foods during the survey period, as well as children who may eat the food items at some time but did not consume them during the survey period. Intake rates for the major food categories include all forms of that food type. For example, 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.

Intake rates may be presented on an “as consumed” (e.g., cooked) basis or on the basis of an uncooked weight. As-consumed intake rates (g/day) are based on the weight of the food in the form in which it is consumed and should be used in assessments where the basis for the contaminant concentrations in foods is whole weight. When data are based on as-consumed form, corrections to account for changes in portion sizes from cooking losses are generally not required. When dry-weight contaminant concentrations in foods are available, dry-weight intake rates must be used. Dry-weight intake rates are based on the weight of the food consumed after the moisture content has been removed.

The food ingestion rate values provided in this handbook are generally expressed as “as consumed” since this is the fashion in which data are reported by survey respondents. This is important because concentration data to be used in the dose equation are generally measured in uncooked food samples. In most situations, the only practical choice is to use the as-consumed ingestion rate and the uncooked concentration. However, it should be recognized that cooking generally results in some reductions in weight (e.g., loss of moisture) and that if the mass of the contaminant in the food remains constant, then the concentration of the contaminant in the cooked food item will increase. Therefore, if the as-consumed ingestion rate and the uncooked concentration are used in the dose equation, the dose may be underestimated. On the other hand, cooking may cause a reduction in mass of contaminant and other ingredients, such that the overall concentration of contaminant does not change significantly. In this case, combining cooked ingestion rates and uncooked concentration will provide an appropriate estimate of dose. Ideally, food concentration data should be adjusted to account for changes after cooking; then the as-consumed intake rates are appropriate. In the absence of data, it is reasonable to assume that no change in contaminant concentration occurs after cooking. Except for general population fish consumption and home-produced foods, uncooked intake rate data were not available for presentation in this handbook. Data on the general population fish consumption are presented in this handbook on both an as-consumed and an uncooked basis (Chapter 3). It is important for the assessor to be aware of these issues and to choose intake rate data that best match the concentration data that are being used.

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 (e.g., those having protective coverings that are removed before eating would be considered protected) or the amount grown beneath the soil (e.g., most root crops such as carrots). 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 foods, the major food groups, and total foods among children, including homegrown foods; (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.

3.2. INTAKE RATE DISTRIBUTIONS FOR VARIOUS FOOD TYPES

3.2.1. USDA, 1999

The Supplemental Children's Survey to the 1994–1996 Continuing Survey of Food Intakes by Individuals (CSFII 1998) was conducted in response to the Food Quality Protection Act of 1996, which required the USDA to provide data from a larger sample of children for use by the EPA in estimating exposure to pesticide residues in the diets of children. The 1998 survey adds intake data from 5559 children from birth through 9 years of age to the intake data collected from 4253 children of the same age who participated in the CSFII 1994–1996. The

1994–1996 survey included the collection of data from persons of all ages. Both surveys are nationally representative samples of persons living in U.S. households.

The CSFII 1998 was designed to be combined with the CSFII 1994–1996; thus, the approaches to sample selection, data collection, data file preparation, and weighting were consistent. The design, methodology, and operation of the CSFII 1994–1996 are detailed in a separate report (Tippett and Cypel, 1997). The CSFII 1998 was conducted between December 1997 and December 1998 by USDA's Agricultural Research Service.

The results presented in Tables 3-1 through 3-14 include national probability estimates based on all 4 years of the CSFII (1994–1996 and 1998) for children ages 9 years and under and on CSFII 1994–1996 only for individuals ages 10 years and over. The results are weighted to adjust for differential rates of sample selection and nonresponse, to calibrate the sample to match population characteristics that are correlated with eating behavior, and to equalize intakes over the four quarters of the year and the 7 days of the week. Users should note that some weights calculated for the purpose of combining data from 1994–1996 with those from 1998 yield estimates for individuals 12 through 19 years of age that may be slightly different from estimates issued earlier from the CSFII 1994–1996.

The sample sizes on which estimates are based are provided in the tables; readers using data for young children should note that 503 breast-fed children were excluded from the estimates. Fasters (individuals reporting no food or beverage consumed for the day) were included in the calculations. In general, the sample sizes for each sex-age group provide a sufficient level of precision to ensure statistical reliability of the estimates. For CSFII 1998, the overall day 1(the first day surveyed) response rate was 85.6% and the overall 2-day response rate was 81.7%. The CSFII 1994–1996 day 1 response rate was 80%, and the 2-day response rate was 76.1%.

Tables that present data on mean intakes or mean percentages are based on respondents' day 1 intakes so that readers can track trends over time from surveys with different numbers of days of dietary information. Tables that present percentages of individuals meeting recommendations are based on respondents' 2-day average intakes. The data for food intakes from this analysis are presented in Tables 3-1 through 3-14. Data are presented for mean quantities in grams of food products/groups consumed per individual for 1 day and the percent consuming. The foods presented include grain products; vegetables; fruits; milk and milk products; meat, poultry, and fish; and beverages. Data are also provided for eggs, legumes, nuts and seeds, fats and oils, and sugars and sweets.

3.2.2. U.S. EPA, 2000

EPA's National Center for Environmental Assessment (NCEA) analyzed 3 years of data from USDA's CSFII to generate distributions of intake rates for various food items/groups. USDA conducts CSFII annually 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, 1995). 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. Using a stratified sampling technique, individuals of all ages living in selected households in the 50 states and Washington, DC, were surveyed. Individuals provided data for 2 nonconsecutive days, based on 24-hour recall. The 2-day response rate for the 1994–1996 CSFII was approximately 76%. Data from the 1994, 1995, and 1996 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 3 survey years (USDA, 1998).

The food groups selected for this analysis include the major food groups: total fruits, total vegetables, total grains, total meats, and total dairy. Individual foods include fruit and vegetable items such as apples, bananas, 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). Individual meats include beef, eggs, game, pork, and poultry; individual grain items include breads, breadfast foods, cereals, pasta, rice, snacks, and sweets. Intake rates of total vegetables, tomatoes, and white potatoes, total meats, fish, beef, pork, poultry, dairy, eggs, and total grains were adjusted to account for the amount of these food items eaten as meat and grain mixtures as described in Appendix 3A. Food items/groups were identified in the CSFII database according to USDA-defined food codes. Appendix 3B presents the codes and definitions used to determine the various food groups used in the analysis. 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, age, body weight, weighting factor, and number of days that data were reported. Distributions of intake were determined for children who provided data for 2 days of the survey. Individuals who did not provide information on body weight or for whom identifying information was unavailable were excluded from the analysis. Two-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 reported body weight to generate intake rates in units of grams per kilogram of body weight per day (g/kg-day). The data were also weighted according to the 2-day weights provided in the 1994–1996 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 nonusers 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. Intake data from the 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 generally required. 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, 1st, 5th, 10th, 25th, 50th, 75th, 90th, 95th, 99th, and 100th percentile or maximum observed in the survey). Data were provided for the total population using the food item being evaluated and for several age groups of children, including < 1, 1–2, 3-5, 6–11, and 12–19 years. The total numbers of individuals in the data set, by age group are presented in Table 3-15. The food analysis was accomplished using the SAS statistical programming system (SAS, 1990).

The results of this analysis are presented in Table 3-16 for total fruits, total vegetables, total grains, total meats, total fish, and total dairy products. Table 3-17 provides data for individual foods, and Table 3-18 for the various USDA categories. The data for exposed/protected and root food items are presented in Table 3-19. Because the results are presented in units of g/kg-day, 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 reported body weights of the survey respondents. However, if there is a need to compare the intake data presented here to intake data in units of g/day, a body weight for the age group of interest, as presented in Chapter 10 of this handbook, may be used.

The *distribution* of average daily intake rates generated using short-term data (e.g., 2-day) does 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 individual's intakes are constant from day to day.

Day-to-day variation in intake among individuals will be great for foods that are highly seasonal and for foods that are eaten year-round 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) that 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. Distributions are shown only for the major food groups and broad categories of foods. For individual foods, only the mean standard deviation and percent consuming are provided. 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.

The advantages of using the 1949–1996 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. The data set is the most recent of a series of publicly available USDA data sets, and should reflect recent eating patterns in the U.S. The data set includes 3 years of intake data combined and is based on a 2-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 Table 3A-1 in Appendix A in the proportions specified in that table. This may under- or overestimate intake of certain foods among some individuals.

3.3. FISH INTAKE RATES

3.3.1. General Population Studies

3.3.1.1. *U.S. EPA, 1996*

EPA's Office of Water used the 1989, 1990, and 1991 CSFII data 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 used 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 3 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 specific 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 bodyweight of the individual was used to convert consumption in g/day to consumption in g/kg-day.

A total of 11,912 respondents in the combined data set who had three-day dietary intake data. Survey weights were assigned to this data set to make it representative of the U.S. population with respect to various demographic characteristics related to food intake.

U.S. EPA (1996) reported means, medians, upper percentiles, and 90% interval estimates for the 90th, 95th, and 99th percentiles. The 90% interval estimates are nonparametric estimates from bootstrap techniques. The bootstrap estimates result from the percentile method, which estimates the lower and upper bounds for the interval estimate by the 100α percentile and 100 (1-α) percentile estimates from the nonparametric distribution of the given point estimate. Analyses of fish intake were performed on an as-eaten as well as on an uncooked equivalent basis and on a g/day and g/kg-day basis.

Table 3-20 presents data for daily average per capita fish consumption by age and gender in g/day and in mg/kg/day, as consumed. Table 3-21 provides consumer-only data in units of g/day and mg/kg/day, as consumed. Tables 3-22 and 3-23 provide similar data on an uncooked basis. These data are presented by selected age groupings (14 years and under and 15–44 years) and gender.

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 NFCSs that reported per capita fish intake rates (e.g., Pao et al., 1982; USDA, 1992) excluded certain fish-containing foods (e.g., fish mixtures, frozen plate meals) in their calculations.

The Office of Water is currently in the process of analyzing data from the 1994, 1995, and 1996 CSFIIs. Total fish intake was estimated from the 1994–1996 CSFII by NCEA (see section 3.2). The data will be included in this handbook when they are available.

3.3.1.2. *Tsang and Klepeis, 1996*

EPA's National Human Activity Pattern Survey (NHAPS) 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. More than 9000 individuals from the 48 contiguous states participated in NHAPS. Approximately 4700 participants also provided information on seafood consumption. More than 900 of these participants were children between the ages of 1 and 17 years. The survey was conducted between October 1992 and September 1994. Data were collected on (1) the number of people who 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 the 900 children who participated in the survey, approximately 43% reported eating seafood (including shellfish, eels, or squid) in the last month. 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 3-24). The highest number of respondents for all ages of children had one to two servings per month. Most of the respondents purchased the seafood they ate (Table 3-24).

Intake data were not provided in the survey. However, intake of fish can be estimated using the information from this study on the number of servings of fish eaten and serving size data for each age group from other studies (e.g., Pao et al., 1982) (see section 3.7). Using this mean value for serving size and the assumption that the average child eats one to two servings per month (Table 3-24), the age-specific amount of seafood eaten per month can be estimated.

The advantages of the 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 is comparable to that observed in the EPA CSFII analysis. It should be noted that an all-inclusive description for seafood was not presented in Tsang and Klepeis (1996). It is not known whether processed or canned seafood and seafood mixtures are included in the seafood category.

3.3.2. Freshwater Recreational Study

The Michigan Sport Anglers Fish Consumption Survey gathered data from a stratified random sample of Michigan residents who had fishing licenses. 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 that recorded respondents' fish intake over a 7-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 7 days. The source of the fish for each meal was requested (i.e., 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 "about the same size," "less," or "more." 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 came from recreational sources. A sample of 2600 individuals was selected from state records to receive survey questionnaires. A total of 2334 survey questionnaires were deliverable, and 1104 were completed and returned, giving a response rate of 47.3%.

In an 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 cannot 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 who had 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 than, about the same as, 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 NFCS 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% 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. respectively, for fish meals described as less than, about the same as, and more than the 8 oz. picture. 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 3-25 displays the mean number of total and recreational fish meals for each household member between age 1 and 20 years, based on the 7-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 g/day and g/kg-day basis. This analysis was restricted to individuals who ate fish and who resided in households reporting some recreational fish consumption during the previous year. About 75% of survey respondents (i.e., licensed anglers) and about 84% of respondents who fished in the prior year reported some household recreational fish consumption.

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 response rate of this survey, 47%, was relatively low. This study was conducted in the winter and spring months, a period that 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.

3.3.3. Native American Subsistence Studies

3.3.3.1. *Columbia River Inter-Tribal Fish Commission (CRITFC), 1994*

CRITFC conducted a fish consumption survey among four Columbia River Basin Native American 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 for 204 children 5 years old and less was provided by the participating adult respondent. The overall response rate was 69%.

Information requested included annual and seasonal numbers of fish meals, average serving size per fish meal, species and part(s) of fish consumed, and preparation methods, based on 24-hour dietary recall. Foam sponge food models approximating 4, 8, and 12 oz. 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, because the population sizes of the tribes were highly unequal, it was necessary to weight the data (in proportion to tribal population size) so that the survey results were representative of 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.

A total of 49% of respondents of the total survey population 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% reported that they obtained fish from either self-harvesting, family or friends, at tribal ceremonies, or from tribal distributions. Of all fish consumed, 41% came from self-harvesting or family harvesting, 11% from the harvest of friends, 35% from tribal ceremonies or distribution, 9% from stores and 4% from other sources.

The analysis of seasonal intake showed that May and June tended to be high-consumption months and December and January low-consumption months. Table 3-26 shows the fish intake distribution for children under 5 years of age. The mean intake rate was 19.6 g/day, and the 95th percentile was approximately 70 g/day, which includes consumers and nonconsumers.

The authors noted that some nonresponse bias may have occurred in the survey because respondents were more likely to live near the reservation and were more likely to be female than were nonrespondents. In addition, they hypothesized that nonfish consumers may have been more likely than fish consumers to be nonrespondents, because nonconsumers may have thought their contribution to the survey would be meaningless; if this was the case, this study would overestimate 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, so the reliability of some of its data is questioned.

Although the authors have noted its 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.

3.3.3.2. *Toy et al., 1996*

Toy et al. (1996) conducted a study to determine fish and shellfish consumption rates of the Tulalip and Squaxin Island tribes living in the Puget Sound region. These two tribes were selected nonrandomly to represent the expected range of fishing and fish consumption activities of tribes in the Puget Sound region.

A survey was conducted to describe fish consumption for Puget Sound tribal members over the age of 18 and their dependents ages 5 and under in terms of their consumption rate of anadromous, pelagic and bottom fish and shellfish in g/kg-day. Data were also collected on fish parts consumed, preparation methods, patterns of acquisition for all fish and shellfish consumption, and children's consumption rates. Interviews were conducted between February 25 and May 15, 1994. A total of 190 tribal members ages 18 years old and older and 69 children 5 years and younger were included in the survey on consumption of 52 fish species. The response rate was 77% for the Squaxin Island Tribe and 76% for the Tulalip Tribes.

The mean and median consumption rate for children 5 years and younger was 0.53 and 0.17 g/kg-day, respectively, which was significantly lower than that of adults, even when the consumption rate was adjusted for body weight (Table 3-27). Squaxin island children tended to consume more fish (mean 0.825 g/kg-day vs. 0.239 g/kg-day).

The advantage of this study is that the data can be used to improve the manner in which exposure assessments are conducted for high-consumer populations and to identify cultural characteristics that place tribal members at disproportionate risk to chemical contamination. The survey of Tulalip and Squaxin Island tribes showed considerable higher consumption rates for both adults and children than the 0.09 g/kg-day reported for the general population by SRI international (Toy et al., 1996). The median total fish consumption rate for women of both tribes was four to five times higher than the rate (6.5 g/day) recommended as a national default value by EPA. For males of both tribes, the median consumption rate was 8 to 10 times higher than the recommended national default value.

One limitation associated with this study is that although data from the Tulalip and Squaxin Island tribes may be representative of consumption rates of these specific tribes, fish consumption rates, habits, and patterns can vary among tribes and other subpopulations. The authors noted that the total fish consumption rates were similar for both tribes; however, consumption pattern by fish species and other factors differed. In some instances, these differences were statistically significant. Another limitation noted by the authors is that the distribution presented in this study is skewed toward higher rates, and it might be more appropriate to use the 90th or 95th percentiles rather than means or medians for analysis of risk (Toy et al., 1996). There might also be a possible bias due to the time the survey was conducted; many species in the survey are seasonal. For example, because of the timing of the survey, respondents may have overestimated the annual consumption of shellfish (Toy et al., 1996).

3.3.3.3. *The Suquamish Tribe, 2000*

The Suquamish Tribal Council conducted a study of the Suquamish tribal members living on and near the Port Madison Indian Reservation in the Puget Sound region. The study was funded by the Agency for Toxic Substances and Disease Registry through a grant to the Washington State Department of Health. The purpose of the study was to determine seafood consumption rates, patterns, and habits of the members of the Suquamish Tribe. The second objective was to identify cultural practices and attributes that affect consumption rates, patterns, and habits of members of the Suquamish Tribe.

A systematic random sample of adults ages 16 and older was selected from a sorted tribal enrollment roster. The study had a participation rate of 64.8%, which was calculated on the basis of 92 respondents out of a total of 142 potentially eligible adults on the list of those selected into the sample. Consumption data for children under 6 years of age were gathered through adult respondents who had children under 6 years of age living in the household at the time of the survey since birth or for at least 1 year.

A survey questionnaire was administered by personal interview. The survey included four parts: (1) a 24-hour dietary recall; (2) identification, portions, frequency of consumption, preparation, harvest location of fish; (3) shellfish consumption, preparation, harvest location; and (4) changes in consumption over time and cultural, physical, and socioeconomic information.

A display booklet was developed to assist respondents in providing consumption data and identifying harvest locations of seafood consumed. Physical models of finfish and shellfish were constructed to assist respondents in determining typical food portions. Finfish and shellfish were grouped into categories on the basis of similarities in life history as well as practices of tribal members who fish for subsistence, ceremonial, and commercial purposes.

Interviewers collected data from 92 adults and for 31 children under 6 years of age. Table 3-28 provides the consumption rate for children in terms of g/kg-day. Table 3-29 provides consumption rates for consumers only. Because all the children involved in the study consumed some form of fish, the consumption distribution of all fish is the same in both tables. The mean, median, and 95th percentile consumption of all fish were 1.5, 0.72, and 7.3 g/kg-day, respectively.

An important attribute of this survey is that it provides consumption rates by individual type of fish and shellfish. It is important to note that the report indicates that increased levels of development as well as pollutants from residential, industrial, and commercial uses have resulted in degraded habitats and harvesting restrictions. There were 11 Superfund sites within the immediate area of the Port Madison Indian Reservation at the time the fish consumption survey was conducted. Despite degraded water quality and habitat, tribal members continue to rely on fish and shellfish as a significant part of their diet.

3.4. FAT INTAKE

Cresanta et al. (1988), Nicklas et al. (1993), and Frank et al. (1986) analyzed dietary fat intake data as part of the Bogalusa heart study. The Bogalusa study, an epidemiologic investigation of cardiovascular risk-factor variables and environmental determinants, has collected dietary data on subjects residing in Bogalusa, LA, since 1973. Among other things, the study collected fat intake data for children, adolescents, and young adults. Researchers have examined various cohorts of subjects, including (1) six cohorts of 10-year olds, (2) two cohorts of 13-year olds, (3) one cohort of subjects from 6 months to 4 years of age, and (4) one cohort of subjects from 10 to 17 years of age (Nicklas, 1995). In order to collect the data, interviewers used the 24-hour dietary recall method. According to Nicklas (1995), "the diets of children in the Bogalusa study are similar to those reported in national studies of children." Thus, these data are useful in evaluating the variability of fat intake among the general population for the purposes of evaluating variability in exposure for dioxin-like compounds among this group. Data for 6-month-old to 17-year-old individuals collected from 1973 to 1982 are presented in Tables 3-30 and 3-31 (Frank et al., 1986). Data are presented for total fats, animal fats, vegetable fats, and fish fats in units of g/day (Table 3-30) and g/kg-day (Table 3-31).

Total fat intake and intake of individual fat products were also estimated by NCEA using data from the 1994/1996 CSFII. It should be noted that the fat intake rates presented here include all forms of fats (i.e., added fats such as butter and vegetable oil as well as fats consumed in meats and fish).

The Centers for Disease Control and Prevention (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 older, of which 14,001 respondents (73% 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).

The authors 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 2095 kcal for the total population, and 34% (or 82 g) of the TFEI was from total dietary fat. Based on this information, the mean daily fat intake was calculated for the various age groups and genders (see Appendix 3D for detailed calculation). Table 3-32 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, based on this calculation.

3.5. TOTAL DIETARY INTAKE AND CONTRIBUTIONS TO DIETARY INTAKE

3.5.1. U.S. EPA, 2000

Using data from the 1994–1996 CSFII, EPA evaluated total dietary intake (U.S. EPA, 2000). Total dietary intake was defined as intake of the sum of all foods in the following major food groups using the same foods codes as those described in Appendix 3B and the same method for allocation of mixtures as described in Appendix 3B: dairy, eggs, meats, fish, fats, grains, vegetables, and fruits. Beverages, sugar, candy, sweets, and nuts and nut products were not included. Distributions of total dietary intake were generated, as described previously, for various age groups. Means, standard errors, and percentiles of total dietary intake were estimated in units of g/kg-day as well as g/day.

To evaluate variability in the contributions of the major food groups to total dietary intake, individuals were ranked from lowest to highest, based on total dietary intake. Three subsets of individuals were defined, as follows: a group at the low end of the distribution of total intake (i.e., below the 10^{th} percentile of total intake), a central group (i.e., the 45^{th} to 55^{th} percentile of total intake), and a group at the high end of the distribution of total intake (i.e., above the 90th percentile of total intake). Mean total dietary intake (in g/day and g/kg-day), mean intake of each of the major food groups (in g/day and g/kg-day), and the percent of total dietary intake that each of these food groups represents was calculated for each of the three populations (i.e., individuals with low-end, central, and high-end total dietary intake). A similar analysis was conducted to estimate the contribution of the major food groups to total dietary intake for individuals at the low end, central, and high end of the distribution of total meat intake, total dairy intake, total meat and dairy intake, total fish intake, and fruit and vegetable intake. For example, to evaluate the variability in the diets of individuals at the low end, central range, and high-end of the distribution of total meat intake, surveyed individuals were ranked according to their reported total meat intake. Three subsets of individuals were formed as described above. Mean total dietary intake, intake of the major food groups, and the percent of total dietary intake represented by each of the major food groups were tabulated. This analysis was conducted for the following age groups of the population: < 1 year, 1–2 years, 3–5 years, 6–11 years, and 12–19 years. The data were tabulated in units of g/kg-day and g/day.

Distributions of total dietary intake are presented in Table 3-33. Tables 3-34, and 3-35 compare total dietary intake to intake of the various major food groups for the various age groups in units of g/day and g/kg/day, respectively. Tables 3-36 through 3-41 present the contributions of the major food groups to total dietary intake for individuals (in the various age groups) at the low end, central range, and high end of the distribution of total dietary intake, total meat intake, total meat and dairy intake, total fish intake, total fruit and vegetable intake, and total dairy intake in units of g/day and g/kg-day, respectively.

3.6. INTAKE OF HOME-PRODUCED FOODS

In EPA's analysis of the 1987–1988 NFCS to estimate homegrown intake rates (U.S. EPA, 1997). 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 (USDA, 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 7-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 3-day period (USDA, 1993). The sample size for the 1987-88 survey was approximately 4300 households (more than 10,000 individuals). This is a decrease over the previous survey conducted in 1977–1978 which sampled approximately 15,000 households (more than 36,000 individuals) (USDA, 1994). The sample size was lower in the 1987–1988 survey as a result of budgetary constraints and low response rate (i.e., 38% for the household survey and 31% for the individual survey) (USDA, 1993). However, NFCS data from 1987–1988 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, such as total fruits, total vegetables, total meats, total dairy, total fish and shellfish. Individual food items for which fewer than 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 (e.g., dark green vegetables, citrus fruits) were also evaluated for the general population (U.S. EPA, 1997). However, age-specific data for children are not presented here because of the small number of observations for children eating individual homegrown foods in the data set. Food items/groups were identified in the NFCS database according to

NFCS-defined food codes. Appendix 3D presents the codes and definitions 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 group 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 that incorporated data from both the household and the 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 by 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 were used to generate average sex- and age-specific serving sizes for each food item. The age categories used in the analysis were 1–2, 3–5, 6–11, and 12–19 years (intake rates were not calculated for children younger than 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 SAS programming in which the following general equation was used:

$$w_i = w_f \left[\frac{m_i q_i}{\sum_{i=1}^{n} m_i q_i} \right] \qquad (3\text{-}1)$$

where:

w_i = homegrown amount of food item/group attributed to member "i" during the week (g/wk);

w_f = total quantity of homegrown food item/group used by the family members (g/wk);

m_i = number of meals of household food consumed by member "i" during the week (meals/wk); 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 7. 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 1 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.

For the major food groups (fruits, vegetables, meats, dairy, and fish) consumed by at least 30 households, distributions of home-produced intake among consumers were generated by age group. Consumers were defined as members of survey households who reported consumption of the food item/group of interest during the 1-week survey period. Finally, the percentages of total intake of the food items/groups consumed within survey households that could 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 discussed previously, percentiles of average daily intake derived from short time intervals (e.g., 7 days) will not, in general, be reflective of long-term patterns.

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 IR_p is the homegrown intake rate of food item/group at the p^{th} percentile, N_c is the weighted number of individuals consuming the homegrown food item, and N_T is the weighted total number of individuals surveyed, then $N_T–N_c$ is the weighted number of individuals who reported zero consumption of the food item. In addition, there are ($p/100 \times N_c$) individuals below the p^{th} percentile. Therefore, the percentile that corresponds to a particular intake rate (IR_p) for the overall distribution of homegrown food consumption (including consumers and nonconsumers) can be obtained by:

$$P_{overall}^{th} = 100 \text{ x } \frac{\left[\frac{P}{100} \text{ x } N_c + \left(N_T - N_c \right) \right]}{N_T} \tag{3-2}$$

Table 3-42 displays the weighted numbers (N_T) 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 3-42 (9852) is somewhat lower than the number of observations reported by USDA because this study used only observations for family members for whom age and body weight were specified.

Table 3-43 present homegrown intake rates for fruits, vegetables, meats, and fish. 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, that is, 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 spoilage, by being discarded (e.g., inedible parts), through cooking processes, etc.

USDA (1975) estimated preparation losses for various foods. 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. Mean values for all meats and fish are provided in Table 3-44. For individual fruits and vegetables, USDA (1975) also gave cooking and post-cooking losses. These data, averaged across all types of fruits and vegetables to give mean net cooking and post cooking losses, are also provided in Table 3-44.

The following formula can be used to convert the homegrown intake rates tabulated here to rates reflecting actual consumption:

$$I_A = I \times \left(1 - L_1\right) \times \left(1 - L_2\right) \tag{3-3}$$

where:

I_A = the adjusted intake rate, I is the tabulated intake rate;

L_1 = the cooking or preparation loss; and

L_2 = the post-cooking loss.

For fruits, corrections based on post-cooking losses only apply to fruits that are eaten in cooked forms. 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 from draining of liquids from canned or frozen forms.

In calculating ingestion exposure, assessors should use consistent forms in combining intake rates with contaminant concentrations, as previously discussed.

3.7. SERVING SIZE STUDY BASED ON THE USDA NFCS

Using data gathered in the 1977–1978 USDA NFCS, Pao et al. (1982) calculated distributions for the quantities of individual fruit and vegetables consumed per eating occasion (i.e., serving sizes) by members of the U.S. population 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/eating occasion) basis in Table 3-45 for various age groups of the population. Only the mean and standard deviation serving size data and percent of the population consuming the food during the 3-day survey period are presented in this handbook. Percentiles of serving sizes of the foods consumed by these age groups of the U.S. population 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 sizes for a number of commonly eaten foods, 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 foods consumed per eating occasion. Although these estimates are based on USDA NFCS 1977–1978 data, serving size data have been collected but not published for the more recent USDA surveys. 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. However, it should be noted that serving sizes may have changed since the data were collected in 1977–1978.

Serving sizes can also be calculated directly from the USDA CSFII data sets that are available on CD-ROM from NTIS. Default serving sizes which were assumed by USDA when the respondents did not know how much they ate, are also on the CD-ROM.

3.8. 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 per 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 3-46 and Table 3-47 and the following equation:

$$IR_{dw} = IR_{ac} * [(100-W)/100] \qquad (3\text{-}4)$$

"Dry weight" intake rates may be converted to "as consumed" rates as follows:

$$IR_{ac} = IR_{dw} / [(100-W)/100] \qquad (3\text{-}5)$$

where:

IR_{dw} = dry weight intake rate;
IR_{ac} = as consumed intake rate; and
W = percent water content.

3.9. 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. This may be particularly true for lipophilic compounds. 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:

$$\frac{\text{residue level}}{\text{g-product}} = \frac{\text{residue level}}{\text{g-fat}} \times \frac{\text{g-fat}}{\text{g-product}} \tag{3-6}$$

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, 1979–1986) 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 3-48 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* to estimate total fat content in grams, based on a 3-oz. (85.05 g) cooked serving size, and the corresponding percent fat content values for several categories of meats (Table 3-49). The authors also reported that 0.17 g of fat are consumed per gram of meat (i.e., beef, pork, lamb, veal, game, processed meats, and variety meats) (17%) and 0.08 grams of fat are consumed per gram of poultry (8%).

3.10. RECOMMENDATIONS

The 1994–1996 CSFII data described in this section were used in selecting recommended intake rates for most food groups for children in the general population. For fish intake among these children, the 1989–1991 CSFII analyses were used to recommend intake rates. For children, the data for recreational fish intake, the data for children are limited. The studies that address these populations should be used in exposure assessments where these populations are of interest (see Table 3-11). Table 3-50 presents a summary of the recommended values for food intake and Table 3-51 presents the confidence ratings for the food intake (including fish) recommendations for general population children. Table 3-52 presents the confidence ratings for fish intake recommendations for the freshwater recreational population.

Fish consumption data for Native American children are limited. Three Native American fish consumption studies were identified (CRITFC, 1994; Toy et al., 1996; The Suquamish Tribe, 2000). The means of these studies ranged from 11 to 25 g/day. The consumers-only weighted mean based on those three studies is 21 g/day for children younger than 6 years of age. CRITFC (1994) and Toy et al. (1996) did not present the distributions for consumersonly. EPA calculated the consumers-only distributions on the basis of the total number of the population surveyed and the reported percentage of nonconsumers. Toy et al. (1996), however, presented only the mean, 50th, 75th, and 90th percentile values of intake rates for the population of consumers and nonconsumers. When those percentiles are converted to consumers only, they result in the 32nd, 66th, and 86th percentiles, respectively. Therefore, the 95th percentile cannot be estimated without the raw data. Based on CRITFC (1994) and The Suquamish Tribe (2000), the weighted 90th and 95th percentiles for children younger than 6 years of age are 60 g/day and 78 g/day, respectively. Table 3-53 presents the summary of intake rates for Native American children and Table 3-54 provides the confidence ratings.

Per capita intake rates for specific food items, on a g/kg-day basis, may be obtained from Table 3-3. Percentiles of the per capita intake rate distributions for the major food groups in the general population are presented in Table 3-2. It is important to note that these distributions are based on data collected over a 2-day period and may not necessarily reflect the long-term distribution of average daily intake rates. However, for these broad categories of food, 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.

Table 3-1. Grain products: mean quantities consumed per individual, by sex and age, 1 day, 1994–1996/1998[a, b]

Gender	Age (Years)	Sample size	Mean quantity consumed (g) per individual									
			Total grams	Yeast breads and rolls	Cereals and pasta				Quick breads, pancakes, French toast	Cakes, cookies, pastries, pies	Crackers, popcorn, pretzels, corn chips	Mixtures, mainly grain
					Total	Ready-to-eat cereals	Rice	Pasta				
Males and Females												
	< 1	1,126	56	2	29	1	2	1[c]	1	3	1	20
	1	1,016	192	16	57	11	9	9	9	16	7	87
	2	1,102	219	26	62	16	15	12	12	22	9	87
	1–2	2,118	206	21	59	13	12	11	11	19	8	87
	3	1,831	242	30	64	19	13	12	16	23	11	98
	4	1,859	264	36	67	22	15	11	17	30	13	102
	5	884	284	41	76	24	17	11	15	33	13	107
	3–5	4,574	264	36	69	22	15	11	16	29	12	102
	≤ 5	7,818	219	27	61	16	13	10	12	22	9	87
Males												
	6–9	787	310	45	77	28	18	15	23	39	16	109
	6–11	1,031	318	46	80	31	16	18	23	40	15	115
	12–19	737	406	54	82	29	27	17	26	49	19	175
Females												
	6–9	704	284	43	61	21	12	15	18	42	13	107
	6–11	969	280	43	62	20	14	15	19	42	14	101
	12–19	732	306	40	67	17	19	22	15	37	15	132
All individuals												
	≤ 9	9,309	250	34	64	20	14	12	16	30	12	96
	≤ 19	11,287	298	40	69	22	17	15	18	36	14	120

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.

[c] Appendix E, Statistical Notes.

Source: USDA, 1998

Table 3-2. Grain products: percentages of individuals consuming, by sex and age, 1 day, 1994–1996/1998 [a, b]

Gender	Age (Years)	Sample size	Percentage of individuals consuming									
					Cereals and pasta							
			Total grams	Yeast breads and rolls	Total	Ready-to-eat cereals	Rice	Pasta	Quick breads, pancakes, French toast	Cakes, cookies, pastries, pies	Crackers, popcorn, pretzels, corn chips	Mixtures, mainly grain
Males and Females												
	< 1	1,126	90.6	10.9	62.8	9.1	3.4	2.1	4.4	16.5	10.3	20
	1	1,016	98.2[c]	48.4	70.6	45.3	11.3	9.4	23.0	47.0	39.0	87
	2	1,102	99.0[c]	58.7	71.1	51.9	14.4	9.4	27.5	46.6	37.9	87
	1–2	2,118	98.7	53.7	70.9	48.7	12.9	9.4	25.3	46.8	38.4	87
	3	1,831	99.4[c]	64.1	69.7	53.3	11.1	8.6	28.8	46.1	38.5	98
	4	1,859	99.5[c]	67.0	69.1	54.8	11.4	7.1	28.6	52.3	39.4	102
	5	884	99.9[c]	69.2	70.4	54.9	11.4	6.8	25.2	52.4	32.1	107
	3–5	4,574	99.6[c]	66.8	69.7	54.3	11.3	7.5	27.5	50.3	36.7	102
	≤ 5	7,818	95.8	55.5	69.3	46.9	10.9	7.5	24.0	45.0	34.1	87
Males												
	6–9	787	98.9[c]	69.8	62.6	50.8	10.5	7.4	28.1	52.5	36.0	109
	6–11	1,031	99.0[c]	69.1	64.0	52.4	9.7	8.1	27.1	52.3	33.8	115
	12–19	737	98.2[c]	62.7	44.6	33.2	10.0	5.9	24.4	41.3	27.2	175
Females												
	6–9	704	99.7[c]	71.5	61.2	47.6	9.0	7.9	26.3	57.1	38.3	107
	6–11	969	99.3[c]	71.0	59.3	45.6	9.4	7.1	27.1	55.0	37.1	101
	12–19	732	97.6[c]	60.9	45.9	30.3	8.6	9.3	19.8	40.6	30.9	132
All individuals												
	≤ 9	9,309	97.2	61.6	66.4	47.9	10.5	7.6	25.3	48.9	35.3	96
	≤ 19	11,287	97.6	62.4	57.6	41.7	9.9	7.6	24.2	46.1	32.5	120

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.

Source: USDA, 1998

Table 3-3. Vegetables: mean quantities consumed per individual, by sex and age, 1 day, 1994–1996/1998[a, b]

Gender	Age (Years)	Sample size	Mean quantity consumed per individual (g)									
			Total grams	White potatoes		Dark-green vegetables	Deep-yellow vegetables	Tomatoes	Lettuce, lettuce-based salads	Green beans	Corn, green peas, lima beans	Other vegetables
				Total	Fried							
Males and Females												
	< 1	1,126	57	9	1	2	19	1[c]	–[c, d]	6	5	16
	1	1,016	79	26	11	5	9	7	1	8	9	16
	2	1,102	87	32	17	4	5	11	2	7	10	17
	1–2	2,118	83	29	14	5	7	9	1	7	9	17
	3	1,831	91	34	17	5	5	13	2	5	11	16
	4	1,859	97	37	19	6	5	11	3	5	12	18
	5	884	103	44	22	4	6	12	3	6	12	17
	3–5	4,574	97	38	20	5	5	12	3	5	11	17
	≤ 5	7,818	88	31	16	4	7	10	2	6	10	17
Males												
	6–9	787	110	47	26	4	5	15	5	5	11	16
	6–11	1,031	115	50	27	5	5	16	5	5	11	18
	12–19	737	176	85	44	6	6	28	12	3[c]	10	25
Females												
	6–9	704	110	42	22	5	4	14	6	5	13	21
	6–11	969	116	46	25	5	4	15	7	5	12	22
	12–19	732	145	61	31	9	4	18	12	4	8	28
All individuals												
	≤ 9	9,309	97	37	19	4	6	12	3	6	11	18
	≤ 19	11,287	125	53	27	6	6	17	7	5	10	22

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.
[d] Value less than 0.5, but greater than 0.

Source: USDA, 1998

Table 3-4. Vegetables: mean quantities consumed per individual, by sex and age, 1 day, 1994–1996/1998[a, b]

			Percentage of individuals consuming									
				White potatoes								
Gender	Age (Years)	Sample size	Total grams	Total	Fried	Dark-green vegetables	Deep-yellow vegetables	Tomatoes	Lettuce, lettuce-based salads	Green beans	Corn, green peas, lima beans	Other vegetables
Males and Females												
	< 1	1,126	47.2	12.3	4.3	2.3	20.5	1.8	0.2[c]	7.8	8.5	14.8
	1	1,016	73.3	40.4	25.2	6.4	13.3	18.0	3.9	13.7	17.6	19.4
	2	1,102	78.4	46.7	34.5	7.6	10.5	30.8	7.5	11.5	15.0	22.3
	1–2	2,118	75.9	43.6	29.9	7.0	11.8	24.6	5.7	12.6	16.2	20.9
	3	1,831	80.5	46.7	34.7	7.0	10.7	34.1	8.3	10.1	14.6	24.7
	4	1,859	80.7	47.3	34.8	7.2	12.0	33.0	10.0	9.0	16.4	26.5
	5	884	83.0	50.7	38.3	4.6	13.3	36.5	13.4	10.4	16.1	28.8
	3–5	4,574	81.4	48.2	35.9	6.3	12.0	34.5	10.6	9.9	15.7	26.7
	≤ 5	7,818	75.4	42.3	30.1	6.1	13.0	27.2	7.6	10.5	15.0	23.3
Males												
	6–9	787	78.8	47.9	38.0	6.3	12.5	38.2	13.1	7.8	15.0	29.7
	6–11	1,031	79.3	48.7	38.4	6.1	12.4	38.7	13.9	6.7	13.8	30.8
	12–19	737	78.2	49.5	38.6	3.6	8.0	43.0	23.8	3.5	7.4	33.2
Females												
	6–9	704	80.5	48.2	36.3	5.9	11.9	33.8	15.8	8.4	15.9	26.6
	6–11	969	81.7	50.8	38.9	5.4	11.4	33.5	17.1	7.8	15.1	29.2
	12–19	732	79.5	46.4	34.6	7.0	10.6	35.3	25.1	4.4	7.4	34.5
All individuals												
	≤ 9	9,309	77.1	44.6	32.9	6.1	12.7	30.7	10.3	9.6	15.2	25.2
	≤ 19	11,287	78.3	46.8	35.3	5.6	11.2	34.6	16.6	7.0	11.9	29.4

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.

Source: USDA, 1998

Table 3-5. Fruits: mean quantities consumed per individual, by sex and age, 1 day, 1994–1996/1998[a, b]

Gender	Age (Years)	Sample size	Mean quantity consumed (g)									
			Total grams	Citrus fruits		Dried Fruits	Other fruits, mixtures, and juices					
				Total	Juices		Total	Apples	Bananas	Melons and berries	Other fruits and mixtures mainly fruits	Noncitrus juices and nectars
Males and Females												
	< 1	1,126	131	4	4	–[c, d]	126	14	10	1[c]	39	61
	1	1,016	267	47	42	2	216	22	23	8	29	134
	2	1,102	276	65	56	2	207	27	20	10	20	130
	1–2	2,118	271	56	49	2	212	24	22	9	24	132
	3	1,831	256	61	51	1	191	27	18	13	24	110
	4	1,859	243	62	52	1	177	31	17	14	22	92
	5	884	218	55	44	–[c, d]	160	31	14	13	24	78
	3–5	4,574	239	59	49	1	176	30	16	13	23	93
	≤ 5	7,818	237	52	44	1	182	26	17	10	26	103
Males												
	6–9	787	194	58	51	–[c, d]	133	32	11	21	20	50
	6–11	1,031	183	67	60	–[c, d]	113	28	11	16	19	40
	12–19	737	174	102	94	1[c]	70	13	8	11[c]	10	29
Females												
	6–9	704	180	63	54	1[c]	113	23	10	10	25	46
	6–11	969	169	64	54	–[c, d]	103	21	8	8	23	42
	12–19	732	157	72	67	–[c, d]	83	13	5	15	14	35
All individuals												
	≤ 9	9,309	217	55	47	1	159	27	15	12	24	81
	≤ 19	11,287	191	70	62	1	118	21	11	12	19	56

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.
[d] Value less than 0.5, but greater than 0.

Source: USDA, 1998

Table 3-6. Fruits: percentages of individuals consuming, by sex and age, 1 day, 1994–1996/1998[a, b]

Gender	Age (Years)	Sample size	Percentages of individuals consuming									
			Total grams	Citrus fruits		Dried Fruits	Other fruits, mixtures, and juices					
				Total	Juices		Total	Apples	Bananas	Melons and berries	Other fruits and mixtures mainly fruits	Noncitrus juices and nectars
Males and Females												
	< 1	1,126	59.7	3.6	2.7	0.4[c]	59.0	15.7	13.3	1.8	29.9	33.0
	1	1,016	81.0	23.6	19.0	5.9	73.0	23.4	25.1	6.9	26.5	43.2
	2	1,102	76.6	30.6	23.4	5.3	64.7	24.0	20.2	8.5	19.4	37.0
	1–2	2,118	78.8	27.2	21.3	5.6	68.8	23.7	22.6	7.7	22.9	40.0
	3	1,831	74.5	27.9	21.4	4.1	64.2	22.4	17.5	7.8	20.1	33.3
	4	1,859	72.6	28.0	21.8	3.0	62.1	23.7	15.7	7.6	20.0	30.8
	5	884	67.6	26.9	19.5	1.3[c]	56.9	21.9	12.6	7.4	19.0	24.5
	3–5	4,574	71.6	27.6	20.9	2.8	61.0	22.7	15.3	7.6	19.7	29.5
	≤ 5	7,818	72.6	24.6	18.8	3.5	63.5	22.2	17.6	6.9	22.0	33.5
Males												
	6–9	787	59.0	24.8	20.5	0.8[c]	49.1	20.3	8.7	7.3	16.8	15.5
	6–11	1,031	56.5	25.2	21.6	1.1[c]	44.2	18.2	8.0	6.6	15.4	12.7
	12–19	737	44.5	24.7	21.7	1.0[c]	27.1	8.2	6.0	4.1	7.1	8.2
Females												
	6–9	704	180	63	54	1.5[c]	50.4	17.3	8.8	7.4	20.4	17.3
	6–11	969	169	64	54	1.1[c]	47.2	16.2	7.3	7.4	19.0	14.9
	12–19	732	157	72	67	1.1[c]	30.2	8.2	4.4	6.0	11.3	9.7
All individuals												
	≤ 9	9,309	217	55	47	2.5	58.0	20.9	14.0	7.1	20.6	26.7
	≤ 19	11,287	191	70	62	1.8	44.4	15.2	9.7	6.2	15.5	17.9

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.

Source: USDA, 1998

Table 3-7. Milk and milk products: mean quantities consumed per individual, by sex and age, 1 day, 1994–1996/1998[a, b]

Gender	Age (Years)	Sample Size	Mean quantity consumed per individual (g)								
			Total grams	Milk, milk drinks, yogurt						Milk desserts	Cheese
				Total	Fluid milk				Yogurt		
					Total	Whole	Lowfat	Skim			
Males and Females											
	< 1	1,126	762	757	61	49	11	–[c, d]	4	3	1
	1	1,016	546	526	475	347	115	5[c]	14	11	9
	2	1,102	405	377	344	181	141	17	10	16	11
	1–2	2,118	474	450	408	262	128	11	12	14	10
	3	1,831	419	384	347	166	150	26	10	22	12
	4	1,859	407	369	328	147	149	27	10	23	14
	5	884	417	376	330	137	159	25	9	25	14
	3–5	4,574	414	376	335	150	153	26	10	23	13
	≤ 5	7,818	477	447	327	177	127	18	10	18	11
Males											
	6–9	787	450	405	343	127	176	29	6	31	13
	6–11	1,031	450	402	335	121	172	33	6	35	12
	12–19	737	409	358	303	99	158	40	3[c]	29	19
Females											
	6–9	704	380	337	288	105	146	26	4	29	13
	6–11	969	382	336	283	108	136	29	4	30	14
	12–19	732	269	220	190	66	92	30	4[c]	29	14
All individuals											
	≤ 9	9,309	55	47	1	159	27	15	8	23	12
	≤ 19	11,287	70	62	1	118	21	11	6	27	14

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.
[d] Value less than 0.5, but greater than 0.

Source: USDA, 1998

Table 3-8. Milk and milk products: percentages of individuals consuming, by sex and age, 1 day, 1994–1996/1998[a, b]

			Percentages of individuals consuming								
				Milk, milk drinks, yogurt							
					Fluid milk						
Gender	Age (Years)	Sample Size	Total grams	Total	Total	Whole	Lowfat	Skim	Yogurt	Milk desserts	Cheese
Males and Females											
	< 1	1,126	85.4	84.6	11.1	8.3	11	2.4	0.2[c]	4.5	6.0
	1	1,016	95.3	92.7	87.7	61.7	115	26.5	1.5[c]	13.9	29.7
	2	1,102	91.6	87.3	84.3	44.8	141	36.3	5.2	17.5	32.6
	1–2	2,118	93.4	90.0	86.0	53.0	128	31.5	3.4	15.8	31.2
	3	1,831	94.3	88.3	84.6	42.5	150	39.5	6.8	21.4	37.0
	4	1,859	93.2	87.8	85.0	41.3	149	40.4	7.7	21.7	36.9
	5	884	93.1	86.4	81.2	38.1	159	41.7	6.5	21.4	34.9
	3–5	4,574	93.5	87.5	83.6	40.6	153	40.6	7.0	21.5	36.3
	≤ 5	7,818	92.5	88.0	75.7	41.0	127	32.9	4.9	17.5	30.9
Males											
	6–9	787	93.2	85.5	80.7	32.4	176	44.3	8.6	24.0	34.6
	6–11	1,031	92.3	84.6	79.0	30.8	172	43.1	9.5	25.0	32.3
	12–19	737	81.3	65.8	59.6	22.6	158	30.7	7.0	13.6	37.1
Females											
	6–9	704	90.2	82.5	77.5	31.5	146	40.8	8.1	24.1	30.9
	6–11	969	90.2	81.5	76.0	33.2	136	37.8	8.4	22.4	31.9
	12–19	732	75.4	54.0	49.7	17.5	92	23.9	9.5	17.1	36.1
All individuals											
	≤ 9	9,309	92.2	86.4	77.1	37.4	27	36.8	6.3	20.1	31.7
	≤ 19	11,287	86.7	75.6	68.1	30.1	21	33.1	7.5	18.6	33.5

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.

Source: USDA, 1998

Table 3-9. Meat, poultry, and fish: mean quantities consumed per individual, by sex and age, 1 day, 1994–1996/1998[a, b]

Gender	Age (Years)	Sample size	Mean quantity consumed per individual (g)									
			Total grams	Beef	Pork	Lamb, veal, game	Organ meats	Frank-furters, sausages, luncheon meats	Poultry		Fish and shellfish	Mixtures mainly meat poultry, fish
									Total	Chicken		
Males and Females												
	< 1	1,126	24	1[c]	–[c, d]	–[c, d]	–[c, d]	2	3	2	–[c, d]	16
	1	1,016	80	5	2	–[c, d]	–[c, d]	13	12	12	3	43
	2	1,102	94	7	6	–[c, d]	–[c, d]	18	17	16	4	41
	1–2	2,118	87	6	4	–[c, d]	–[c, d]	15	15	14	3	42
	3	1,831	101	8	6	–[c, d]	–[c, d]	19	19	18	4	43
	4	1,859	115	10	6	–[c, d]	–[c, d]	22	20	19	5	49
	5	884	121	14	6	–[c, d]	–[c, d]	22	22	19	5	51
	3–5	4,574	112	11	6	–[d]	–[c, d]	21	21	19	5	47
	≤ 5	7,818	93	8	5	–[d]	–[c, d]	17	16	15	4	42
Males												
	6–9	787	151	18	51	–[c, d]	–[c, d]	24	23	21	7	71
	6–11	1,031	154	19	60	–[c, d]	–[c, d]	24	22	20	6	72
	12–19	737	250	30	94	1[c]	0	28	31	26	8	134
Females												
	6–9	704	121	17	54	–[c, d]	–[c, d]	18	19	16	5	55
	6–11	969	130	18	54	–[c, d]	–[c, d]	19	20	17	5	60
	12–19	732	158	21	67	–[c, d]	–[c, d]	15	21	19	6	85
All individuals												
	≤ 9	9,309	110	12	47	–[d]	–[d]	19	18	17	5	50
	≤ 19	11,287	152	18	62	–[c, d]	–[c, d]	20	22	19	6	76

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.
[d] Value less than 0.5, but greater than 0.

Source: USDA, 1998

Table 3-10. Meat, poultry, and fish: percentages of individuals consuming, by sex and age, 1 day, 1994–1996/1998[a, b]

			Percentages of individuals consuming									
								Frank-furters, sausages, luncheon meats	Poultry			Mixtures mainly meat poultry, fish
Gender	Age (Years)	Sample size	Total grams	Beef	Pork	Lamb, veal, game	Organ meats		Total	Chicken	Fish and shellfish	
Males and Females												
	< 1	1,126	26.0	2.1	1.1[c]	0.2[c]	0.2[c]	6.1	6.3	5.0	1.0[c]	13.7
	1	1,016	77.4	11.9	7.3	0.8[c]	0.2[c]	26.3	24.0	23.1	5.4	32.2
	2	1,102	85.2	16.2	14.9	0.8[c]	0.2[c]	33.2	27.6	25.6	6.1	31.4
	1–2	2,118	81.4	14.1	11.2	0.8[c]	0.2[c]	29.9	25.8	24.4	5.8	31.8
	3	1,831	86.2	13.8	13.3	0.5[c]	–[c, d]	36.4	28.3	26.0	6.4	29.2
	4	1,859	86.2	16.1	13.8	0.5[c]	0.2[c]	37.0	27.4	25.1	6.4	30.5
	5	884	87.1	18.2	13.2	0.6[c]	0.2[c]	35.1	27.7	24.8	6.2	30.8
	3–5	4,574	86.5	16.0	13.4	0.5	0.2[c]	36.1	27.8	25.3	6.3	30.2
	≤ 5	7,818	77.5	13.7	11.2	0.6	0.2[c]	30.4	24.5	22.6	5.5	28.8
Males												
	6–9	787	87.4	20.1	11.9	0.4[c]	0.1[c]	37.4	24.8	22.3	5.1	36.2
	6–11	1,031	87.8	22.0	12.2	0.4[c]	0.2[c]	36.2	22.9	20.5	5.4	35.7
	12–19	737	86.8	24.2	15.8	0.6[c]	0.0	31.8	20.6	17.6	5.0	38.3
Females												
	6–9	704	84.6	19.4	9.2	0.4[c]	0.2[c]	33.5	23.1	20.2	6.4	32.4
	6–11	969	86.5	20.2	10.0	0.4[c]	0.1[c]	33.1	22.9	19.8	6.1	32.8
	12–19	732	80.1	22.0	11.2	0.1[c]	0.1[c]	24.6	21.6	18.9	5.8	34.0
All individuals												
	≤ 9	9,309	80.9	16.1	10.9	0.5	0.2[c]	32.4	24.3	22.0	5.6	31.0
	≤ 19	11,287	82.8	19.6	12.1	0.4	0.1[c]	30.9	22.7	20.1	5.5	33.3

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.

Source: USDA, 1998

Table 3-11. Eggs, legumes, nuts and seeds, fats and oils, sugars and sweets: mean quantities consumed per individual, by sex and age, 1 day, 1994–1996/1998[a, b]

Gender	Age (Years)	Sample size	Mean quantity consumed per individual (g)								
			Eggs	Legumes	Nuts and seeds	Fats and oils			Sugars and sweets		
						Total	Table fats	Salad dressings	Total	Sugars	Candy
Males and Females											
	< 1	1,126	3	151	–[c, d]	–[d]	–[d]	–[c, d]	2	–[d]	–[c, d]
	1	1,016	13	26	2	2	1	1	13	–[d]	3
	2	1,102	18	12	4	3	2	1	22	–[d]	5
	1–2	2,118	16	19	3	3	2	1	18	–[d]	4
	3	1,831	13	13	5	4	2	2	31	1	7
	4	1,859	13	15	5	5	2	2	33	1	8
	5	884	13	12	6	5	2	3	33	1	9
	3–5	4,574	13	13	5	5	2	2	32	1	8
	≤ 5	7,818	13	32	4	4	2	2	23	1	6
Males											
	6–9	787	11	11	5	8	3	4	46	1	13
	6–11	1,031	12	13	5	7	3	4	42	1	12
	12–19	737	22	17	5	12	3	9	35	2	13
Females											
	6–9	704	10	14	5	7	3	3	41	1	11
	6–11	969	11	12	5	7	3	4	41	1	12
	12–19	732	13	14	3	10	2	7	31	2	12
All individuals											
	≤ 9	9,309	12	24	4	5	2	3	32	1	8
	≤ 19	11,287	14	20	4	8	2	5	33	1	10

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.
[d] Value less than 0.5, but greater than 0.

Source: USDA, 1998

Table 3-12. Eggs, legumes, nuts and seeds, fats and oils, sugars and sweets: percentages of individuals consuming, by sex and age, 1 day, 1994–1996/1998[a, b]

Gender	Age (Years)	Sample size	Percentages of individuals consuming								
						Fats and oils			Sugars and sweets		
			Eggs	Legumes	Nuts and seeds	Total	Table fats	Salad dressings	Total	Sugars	Candy
Males and Females											
	< 1	1,126	6.7	18.7	1.1[c]	6.0	5.3	0.7[c]	6.9	1.9	0.5[c]
	1	1,016	22.8	12.7	12.4	31.5	25.6	7.5	39.3	7.9	12.1
	2	1,102	27.3	10.9	16.8	41.1	30.9	14.0	50.2	8.2	21.0
	1–2	2,118	25.1	11.8	14.7	36.4	28.3	10.8	44.9	8.1	16.7
	3	1,831	19.8	11.1	20.5	42.1	30.2	15.6	57.5	10.4	24.1
	4	1,859	16.9	12.5	20.4	44.3	30.3	18.1	58.4	11.3	24.6
	5	884	16.4	11.2	21.1	44.7	29.0	20.1	57.3	11.7	25.7
	3–5	4,574	17.7	11.6	20.7	43.7	29.8	17.9	57.7	11.1	24.8
	≤ 5	7,818	18.9	12.5	16.3	36.6	26.4	13.4	47.2	9.0	19.1
Males											
	6–9	787	15.1	9.3	17.0	48.1	30.8	24.0	61.3	11.9	31.2
	6–11	1,031	15.6	9.8	15.7	46.9	29.0	24.6	59.6	12.2	29.3
	12–19	737	17.0	10.9	8.7	43.1	20.8	27.7	46.7	13.3	21.0
Females											
	6–9	704	13.4	12.7	18.7	52.3	33.3	23.0	61.0	12.2	28.5
	6–11	969	13.4	11.0	17.2	49.3	31.0	23.4	60.3	12.9	28.9
	12–19	732	15.0	10.7	7.8	45.6	23.9	28.6	46.3	11.9	23.9
All individuals											
	≤ 9	9,309	17.1	11.9	16.9	42.0	28.6	17.5	52.8	10.2	23.4
	≤ 19	11,287	16.4	11.2	13.2	43.2	25.9	22.4	50.8	11.5	23.5

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.

[b] Excludes breast-fed children.

[c] Appendix E, Statistical Notes.

Source: USDA, 1998

Table 3-13. Beverages: mean quantities consumed per individuals, by sex and age, 1 day, 1994–1996/1998[a, b]

Gender	Age (Years)	Sample Size	Mean quantity consumed per individual (g)												
			Total grams	Alcoholic			Nonalcoholic								
				Total	Wine	Beer and ale	Total	Coffee	Tea	Fruit drinks and ades			Carbonated soft drinks		
										Total	Regular	Low calorie	Total	Regular	Low calorie
Males and Females															
	< 1	1,126	19	0	0	0	19	0	2[c]	15	7	3[c]	1[c]	1[c]	–[c, d]
	1	1,016	120	0	0	0	120	–[c, d]	15	79	69	7	25	24	1[c]
	2	1,102	196	0	0	0	196	–[c, d]	21	113	100	11[c]	62	56	5
	1–2	2,118	159	0	0	0	159	–[c, d]	18	96	85	9	44	40	3
	3	1,831	240	–[c, d]	0	–[c, d]	240	1[c]	18	137	126	8	84	77	7
	4	1,859	268	–[c, d]	–[c, d]	0	268	–[c, d]	20	141	130	8	106	95	11
	5	884	299	0	0	0	299	1	28	149	140	6[c]	121	112	7
	3–5	4,574	269	–[c, d]	–[c, d]	–[c, d]	269	1	22	143	132	8	104	95	8
	≤ 5	7,818	201	–[c, d]	–[c, d]	–[c, d]	201	1	18	111	101	8	71	65	6
Males															
	6–9	787	385	–[c, d]	0	0	385	2[c]	39	163	145	17	181	159	21
	6–11	1,031	413	–[c, d]	0	0	413	2[c]	39	155	137	17	217	194	23
	12–19	737	995	44[c]	1[c]	40[c]	951	21	114	205	158	44	609	584	25
Females															
	6–9	704	322	–[c, d]	0	0	322	1[c]	32	135	126	7	154	143	11
	6–11	969	370	–[c, d]	0	0	370	2[c]	34	134	125	8[c]	200	181	19
	12–19	732	645	8[c]	1[c]	6[c]	637	14	93	134	113	20	395	349	43
All individuals															
	≤ 9	9,309	263	–[c, d]	–[c, d]	–[c, d]	263	1	25	127	115	9	110	99	10
	≤ 19	11,287	502	10	–[c, d]	9[c]	492	8	57	144	124	19	282	260	21

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.
[d] Value less than 0.5, but greater than 0.

Source: USDA, 1998

Table 3-14. Beverages: percentages of individuals consuming, by sex and age, 1 day, 1994–1996/1998[a, b]

Gender	Age (Years)	Sample Size	Percentages of individuals consuming												
			Total grams	Alcoholic			Nonalcoholic								
										Fruit drinks and ades			Carbonated soft drinks		
				Total	Wine	Beer and ale	Total	Coffee	Tea	Total	Regular	Low calorie	Total	Regular	Low calorie
Males and Females															
	< 1	1,126	8.4	0.0	0.0	0.0	8.4	0.0	1.4[c]	6.5	3.8	1.2[c]	1.2[c]	1.1[c]	0.2[c]
	1	1,016	40.8	0.0	0.0	0.0	40.8	0.1[c]	5.9	27.7	24.6	2.7	14.2	13.6	0.8[c]
	2	1,102	57.1	0.0	0.0	0.0	57.1	0.3[c]	7.4	34.0	31.2	3.0	27.5	24.7	3.0
	1–2	2,118	49.1	0.0	0.0	0.0	49.1	0.2[c]	6.6	30.9	28.0	2.8	21.0	19.3	1.9
	3	1,831	61.6	0.1[c]	0.0	0.1[c]	61.6	0.7[c]	6.5	38.9	36.6	2.5	31.7	29.1	2.9
	4	1,859	67.8	–[c, d]	–[c, d]	0.0	67.8	0.6[c]	7.4	41.2	38.4	2.6	36.9	32.8	4.5
	5	884	70.9	0.0	0.0	0.0	70.9	0.8[c]	9.1	38.8	37.3	2.2	39.0	36.1	2.9
	3–5	4,574	66.8	–[c, d]	–[c, d]	–[c, d]	66.8	0.7	7.7	39.6	37.4	2.4	35.9	32.7	3.4
	≤ 5	7,818	53.7	–[c, d]	–[c, d]	–[c, d]	53.7	0.5	6.6	32.6	30.1	2.4	26.6	24.3	2.5
Males															
	6–9	787	73.2	0.3[c]	0.0	0.0	73.2	0.9[c]	8.8	41.6	38.1	5.3	43.1	38.8	5.4
	6–11	1,031	74.2	0.2[c]	0.0	0.0	74.2	1.2[c]	8.9	39.0	35.4	4.8	47.1	43.2	5.5
	12–19	737	87.4	2.9	0.3[c]	2.3[c]	86.9	6.1	16.2	28.4	23.7	5.6	69.2	66.2	5.2
Females															
	6–9	704	69.4	0.2[c]	0.0	0.0	69.4	1.7[c]	10.4	37.9	35.6	1.9[c]	39.1	36.4	3.7
	6–11	969	72.8	0.1[c]	0.0	0.0	72.8	0.8[c]	10.7	36.2	33.9	2.1	44.8	40.9	5.8
	12–19	732	87.0	1.8[c]	0.4[c]	0.9[c]	86.7	3.7	19.2	27.2	23.9	4.0	62.2	56.1	8.5
All individuals															
	≤ 9	9,309	60.7	0.1[c]	–[c, d]	–[c, d]	60.7	0.6	7.8	35.5	32.8	2.9	32.4	29.6	3.3
	≤ 19	11,287	72.8	1.0	0.1[c]	0.6	72.7	2.4	11.9	32.3	29.1	3.7	47.8	44.1	5.2

[a] Estimates based on combined data from 1994–1996 and 1998 for individuals 9 years of age and under and on 1994–1996 data alone for age 10 years and over.
[b] Excludes breast-fed children.
[c] Appendix E, Statistical Notes.
[d] Value less than 0.5, but greater than 0.

Source: USDA, 1998

Table 3-15. Weighted and unweighted number of observations, 1994–1996 CSFII analysis

Population Group	Weighted Number of Observations	Unweighted Number of Observations
Total	261,897,260	15,303
Age group (years)		
< 01	3,772,296	359
01–02	8,270,523	1,356
03–05	12,376,836	1,435
06–11	23,408,882	1,432
12–19	29,657,098	1,398
20–39	81,672,622	2,992
40–69	81,480,145	4,921
70+	21,258,858	1,410
Season		
Fall	65,474,320	3,653
Spring	65,474,321	4,015
Summer	65,474,320	4,143
Winter	65,474,299	3,492
Urbanization		
Central City	83,904,160	4,600
Nonmetropolitan	55,263,514	3,778
Suburban	122,729,586	6,925
Race		
Asian	7,764,799	387
Black	33,466,094	1,963
Native American	1,669,637	115
Other/NA	14,321,336	972
White	204,675,394	11,866
Region		
Midwest	61,512,403	3,658
Northeast	51,416,379	2,737
South	91,294,341	5,474
West	57,674,137	3,434

Table 3-16. Per capita intake of the major food groups (g/kg-day as consumed)[a]

Population Group	Percent Consuming	Mean	SE	Percentile 1st	5th	10th	25th	50th	75th	90th	95th	99th	100th
Fruits													
Age (years)													
< 01	56.8	13.183	1.106	0	0.000	0.000	0.000	7.559	22.669	35.694	41.181	63.725	110.230
1–2	85.5	19.308	0.521	0	0.000	0.000	6.351	15.524	27.447	41.622	53.898	77.260	125.321
3–5	79.0	11.022	0.341	0	0.000	0.000	2.273	8.102	16.342	26.441	32.675	52.991	105.159
6–11	71.2	5.393	0.200	0	0.000	0.000	0.000	3.351	7.874	13.628	17.952	28.447	44.574
12–19	60.7	2.771	0.133	0	0.000	0.000	0.000	1.371	4.116	7.978	10.970	16.639	32.229
Vegetables													
Age (years)													
< 01	50.1	6.902	0.721	0	0.000	0.000	0.000	2.337	12.227	17.857	24.179	36.281	102.646
1–2	95.4	9.528	0.213	0	0.471	1.929	4.534	8.013	12.580	18.716	23.278	33.457	83.285
3–5	92.7	7.295	0.159	0	0.000	1.348	3.411	6.231	9.690	13.933	18.274	28.992	45.543
6–11	93.2	5.337	0.118	0	0.000	1.120	2.480	4.334	7.103	10.438	13.539	21.210	52.266
12–19	97.9	4.034	0.085	0	0.633	1.121	2.140	3.404	5.145	7.399	9.346	14.684	42.431
Grains													
Age (years)													
< 01	64.9	4.124	0.416	0	0.000	0.000	0.000	1.575	5.438	12.972	20.235	26.610	40.133
1–2	95.6	11.211	0.202	0	1.686	3.594	6.434	9.807	14.267	21.042	24.706	34.672	47.987
3–5	93.1	10.291	0.197	0	0.000	3.674	6.292	9.177	13.132	17.766	21.073	33.638	120.900
6–11	93.4	7.200	0.122	0	0.000	2.452	4.285	6.656	9.413	12.924	15.548	19.893	36.296
12–19	98.2	4.401	0.080	0	1.130	1.543	2.452	3.788	5.541	7.899	9.702	14.079	34.571
Meats													
Age (years)													
< 01	32.3	1.132	0.198	0	0.000	0.000	0.000	0.000	1.383	3.870	5.853	10.585	12.369
1–2	94.0	4.422	0.094	0	0.000	0.759	1.909	3.845	6.195	8.869	10.159	14.662	24.436
3–5	92.2	4.144	0.080	0	0.000	0.768	2.125	3.814	5.624	7.847	9.436	13.103	20.743
6–11	92.4	2.919	0.060	0	0.000	0.523	1.418	2.520	3.996	5.555	6.802	10.232	17.597
12–19	97.3	2.158	0.046	0	0.266	0.527	1.106	1.947	2.835	3.930	4.865	7.459	26.747
Fish													
Age (years)													
< 01	20.9	0.108	0.047	0	0.000	0.000	0.000	0.000	0.000	0.325	0.527	1.562	4.685
1–2	58.2	0.368	0.037	0	0.000	0.000	0.000	0.080	0.286	0.783	1.791	4.687	14.415
3–5	56.4	0.316	0.030	0	0.000	0.000	0.000	0.069	0.245	0.661	1.736	4.567	9.553
6–11	57.5	0.259	0.025	0	0.000	0.000	0.000	0.058	0.178	0.479	1.346	4.234	6.686
12–19	62.9	0.204	0.017	0	0.000	0.000	0.000	0.055	0.172	0.417	1.100	2.499	5.354
Dairy Products													
Age (years)													
< 01	83.6	111.360	4.855	0	0.000	2.522	63.886	102.208	158.574	197.773	235.341	318.289	576.345
1–2	95.7	37.478	0.779	0	0.412	6.677	17.754	31.756	51.441	73.894	90.146	132.802	182.812
3–5	92.9	20.914	0.402	0	0.000	3.473	10.177	18.727	29.155	41.241	48.750	66.157	89.717
6–11	93.3	13.918	0.276	0	0.000	2.167	6.438	12.348	19.249	27.337	33.463	43.426	80.780
12–19	96.9	6.110	0.160	0	0.168	0.413	1.832	4.467	8.803	13.488	17.789	27.837	38.005

[a] Food codes used and category definitions are provided in Appendix 3.

Source: Based on U.S. EPA, 2000

Table 3-17. Per capita intake of individual foods (g/kg-day as consumed)[a]

Population Group	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE
	Apples			**Asparagus**			**Bananas**			**Beets**			**Broccoli**		
Age (years)															
< 01	41.2	7.030	0.977	0.0	0.000	0.000	21.4	1.153	0.34	0.6	0.032	0.25	1.1	0.017	0.110
1–2	55.1	8.020	0.448	0.7	0.014	0.080	35.0	1.688	0.14	0.4	0.000	0	8.6	0.242	0.100
3–5	47.7	4.103	0.273	0.7	0.009	0.040	20.8	0.713	0.10	0.6	0.012	0.1	7.8	0.137	0.060
6–11	34.1	1.437	0.135	0.8	0.014	0.070	14.2	0.353	0.10	0.3	0.000	0	6.8	0.108	0.060
12–19	20.0	0.582	0.090	0.3	0.003	0.020	9.4	0.119	0.00	0.2	0.000	0	5.8	0.064	0.040
	Cabbage			**Carrots**			**Corn**			**Cucumbers**			**Lettuce**		
Age (years)															
< 01	0.6	0.023	0.209	12.3	0.678	0.348	2.2	0.164	0.36	0.3	0.000	0	0.0	0.000	0.000
1–2	3.8	0.071	0.070	14.5	0.343	0.177	18.5	0.462	0.10	6.9	0.089	0.1	11.0	0.109	0.040
3–5	5.7	0.099	0.060	15.1	0.182	0.040	19.2	0.426	0.10	11.2	0.130	0.1	18.9	0.166	0.030
6–11	6.7	0.074	0.040	17.8	0.153	0.030	21.0	0.316	0.00	14.7	0.123	0	24.7	0.184	0.030
12–19	5.8	0.039	0.020	13.1	0.057	0.020	12.8	0.144	0.00	15.2	0.094	0	35.6	0.177	0.020
	Lima Beans			**Okra**			**Onions**			**Other Berries**			**Peaches**		
Age (years)															
< 01	0.3	0.000	0.000	0.0	0.000	0.000	0.3	0.010	0.14	0.3	0.010	0.1	12.8	0.856	0.393
1–2	1.6	0.037	0.070	1.0	0.010	0.040	4.1	0.019	0.00	1.5	0.073	0.23	9.7	0.447	0.145
3–5	0.8	0.010	0.040	0.3	0.006	0.080	4.7	0.022	0.00	1.7	0.034	0.1	7.2	0.248	0.117
6–11	1.0	0.018	0.060	0.8	0.008	0.030	6.7	0.026	0.00	1.8	0.029	0.1	5.6	0.125	0.080
12–19	0.5	0.007	0.060	0.7	0.003	0.020	12.9	0.044	0.00	1.4	0.016	0	4.0	0.064	0.050
	Pears			**Peas**			**Peppers**			**Pumpkins**			**Snap Beans**		
Age (years)															
< 01	14.8	1.354	0.490	9.2	0.603	0.313	0.3	0.000	0.00	7.5	0.433	0.38	11.7	0.624	0.267
1–2	8.5	0.393	0.159	12.3	0.257	0.070	1.5	0.010	0.00	1.0	0.054	0.17	19.4	0.49	0.090
3–5	5.0	0.178	0.114	9.1	0.163	0.050	3.1	0.018	0.00	0.3	0.000	0	15.3	0.239	0.050
6–11	5.2	0.114	0.070	7.8	0.111	0.050	4.7	0.018	0.00	0.1	0.000	0	12.2	0.16	0.060
12–19	1.7	0.023	0.040	5.6	0.060	0.040	7.4	0.018	0.00	0.1	0.000	0	7.9	0.063	0.020
	Strawberries			**Tomatoes**			**White Potatoes**			**Breads**			**Breakfast Foods (Grains)**		
Age (years)															
< 01	0.6	0.007	0.090	28.7	0.518	0.119	27.6	0.537	0.15	15.0	0.256	0.11	1.7	0.048	0.162
1–2	4.4	0.116	0.090	88.8	2.139	0.080	77.4	2.245	0.10	76.9	1.950	0.1	19.5	0.429	0.070
3–5	4.4	0.096	0.080	87.7	1.741	0.060	77.6	2.027	0.10	85.6	2.289	0.1	21.5	0.391	0.060

Table 3-17. Per capita intake of individual foods (g/kg-day as consumed)[a] (continued)

Population Group	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE
	Strawberries			Tomatoes			White Potatoes			Breads			Breakfast Foods (Grains)		
6–11	4.5	0.064	0.050	89.4	1.217	0.040	79.0	1.510	0.060	87.0	1.698	0.040	21.9	0.370	0.050
12–19	3.8	0.032	0.030	94.8	1.010	0.030	84.3	1.243	0.050	86.4	1.068	0.030	12.7	0.130	0.030
	Cereals (Baby)			Cereals (Cooked)			Cereals (Ready-to-Eat)			Pasta			Rice		
Age (years)															
< 01	52.9	1.595	0.265	5.6	0.931	0.819	8.6	0.059	0.050	2.5	0.066	0.149	3.9	0.167	0.283
1–2	6.5	0.162	0.100	16.6	1.618	0.286	65.0	0.965	0.040	16.2	0.795	0.152	19.1	0.905	0.166
3–5	0.3	0.004	0.060	14.7	1.260	0.283	68.5	1.100	0.040	12.5	0.552	0.128	16.3	0.795	0.179
6–11	0.1	0.000	0.000	8.7	0.471	0.171	63.1	0.794	0.030	12.3	0.488	0.115	16.1	0.492	0.100
12–19	0.0	0.000	0.000	5.9	0.164	0.090	44.6	0.360	0.020	12.1	0.264	0.090	17.2	0.462	0.105
	Snacks (Grains)			Sweets (Grains)			Beef			Eggs			Game		
Age (years)															
< 01	13.9	0.135	0.060	10.6	0.158	0.100	29.0	0.508	0.111	29.0	0.405	0.142	0.0	0.000	0.000
1–2	57.5	0.738	0.040	53.9	1.155	0.070	88.9	1.389	0.050	88.8	1.174	0.060	0.5	0.010	0.070
3–5	54.5	0.701	0.040	62.1	1.342	0.060	86.1	1.311	0.040	84.5	0.650	0.040	0.6	0.010	0.050
6–11	51.0	0.461	0.030	63.4	1.151	0.060	87.7	1.073	0.040	85.3	0.400	0.030	1.0	0.013	0.050
12–19	45.6	0.287	0.020	54.6	0.621	0.030	92.9	0.917	0.030	91.0	0.286	0.020	0.8	0.010	0.030
	Pork			Poultry			Butter			Margarine			Dressing		
Age (years)															
< 01	29.0	0.092	0.030	30.4	0.350	0.100	1.1	0.002	0.000	2.2	0.004	0.010	0.8	0.000	0.020
1–2	86.7	0.400	0.030	89.7	1.408	0.050	12.9	0.034	0.010	30.1	0.073	0.000	11.7	0.062	0.020
3–5	84.5	0.375	0.020	88.1	1.307	0.050	13.7	0.040	0.010	31.6	0.085	0.000	18.3	0.084	0.020
6–11	85.0	0.265	0.020	87.8	0.829	0.030	14.9	0.030	0.000	31.4	0.062	0.000	23.1	0.094	0.010
12–19	90.2	0.209	0.010	93.3	0.619	0.020	11.6	0.015	0.000	24.0	0.034	0.000	24.2	0.080	0.010
	Mayonnaise			Sauce			Vegetable Oil								
Age (years)															
< 01	0.6	0.001	0.000	0.0	0.000	0.000	0.6	0.005	0.060						
1–2	9.1	0.024	0.010	0.4	0.004	0.030	0.4	0.001	0.010						
3–5	14.8	0.036	0.000	0.8	0.003	0.020	0.7	0.002	0.000						
6–11	16.4	0.028	0.000	0.7	0.003	0.010	0.4	0.001	0.000						
12–19	21.5	0.032	0.000	1.3	0.005	0.010	0.5	0.000	0.000						

[a] Food codes used and category definitions are provided in Appendix 3.

Source: Based on U.S. EPA, 2000

Table 3-18. Per capita intake of USDA categories of vegetables and fruits (g/kg-day as consumed)[a]

Population Group	Percent Consuming	Mean	SE	Percentile 1st	5th	10th	25th	50th	75th	90th	95th	99th	100th
Dark Green Vegetables													
Age (years)													
< 01	1.7	0.045	0.219	0	0	0	0.000	0.000	0.000	0.000	0.000	0.678	9.770
1–2	12.5	0.328	0.098	0	0	0	0.000	0.000	0.000	0.845	2.315	6.513	20.944
3–5	10.9	0.197	0.063	0	0	0	0.000	0.000	0.000	0.224	1.488	4.127	12.724
6–11	9.9	0.154	0.054	0	0	0	0.000	0.000	0.000	0.162	1.042	3.655	6.761
12–19	9.4	0.124	0.041	0	0	0	0.000	0.000	0.000	0.150	0.935	2.792	4.333
Deep Yellow Vegetables													
Age (years)													
< 01	4.5	0.162	0.217	0	0	0	0.000	0.000	0.000	0.000	0.372	5.708	7.862
1–2	15.2	0.276	0.065	0	0	0	0.000	0.000	0.000	0.728	2.131	4.235	11.719
3–5	16.9	0.243	0.051	0	0	0	0.000	0.000	0.000	0.716	1.729	4.299	8.268
6–11	19.3	0.180	0.035	0	0	0	0.000	0.000	0.000	0.658	1.180	2.450	10.844
12–19	14.3	0.071	0.021	0	0	0	0.000	0.000	0.000	0.152	0.506	1.387	4.850
Citrus Fruits													
Age (years)													
< 01	4.5	0.213	0.392	0	0	0	0.000	0.000	0.000	0.000	0.000	8.578	30.252
1–2	37.7	4.018	0.341	0	0	0	0.000	0.000	5.741	12.866	18.714	37.074	113.369
3–5	38.9	2.946	0.22	0	0	0	0.000	0.000	4.704	9.308	13.032	21.209	66.539
6–11	35.0	1.900	0.163	0	0	0	0.000	0.000	2.745	6.329	9.465	16.736	27.935
12–19	36.1	1.409	0.121	0	0	0	0.000	0.000	1.92	4.652	7.160	12.871	17.935
Other Fruits													
Age (years)													
< 01	55.4	12.929	1.110	0	0	0	0.000	7.266	22.669	35.384	41.181	63.419	110.230
1–2	79.6	15.266	0.496	0	0	0	2.817	10.692	23.001	35.155	48.171	70.309	105.506
3–5	71.4	8.071	0.311	0	0	0	0.000	4.92	11.758	20.53	27.381	44.078	84.574
6–11	62.0	3.493	0.163	0	0	0	0.000	1.901	5.102	9.341	12.808	22.222	38.467
12–19	43.1	1.362	0.104	0	0	0	0.000	0.000	1.833	4.153	6.261	12.706	32.229
Other Vegetables													
Age (years)													
< 01	10.9	0.466	0.293	0	0	0	0.000	0.000	0.000	0.565	2.853	11.069	14.759
1–2	62.4	2.161	0.125	0	0	0	0.000	0.75	2.961	6.35	8.871	16.072	53.611
3–5	64.5	1.726	0.091	0	0	0	0.000	0.706	2.239	4.693	7.206	13.350	21.713
6–11	66.3	1.328	0.067	0	0	0	0.000	0.62	1.836	3.639	4.858	9.762	28.579
12–19	68.8	0.804	0.042	0	0	0	0.000	0.33	1.127	2.086	2.961	6.270	12.563

[a] Food codes used and category definitions are provided in Appendix 3.

Source: U.S. EPA, 2000

Table 3-19. Per capita intake of exposed/protected fruit and vegetable categories (g/kg-day as consumed)[a]

Population Group	Percent Consuming	Mean	SE	Percentile 1st	5th	10th	25th	50th	75th	90th	95th	99th	100th
Exposed Fruits													
Age (years)													
< 01	49.9	10.017	0.995	0	0	0	0	4.449	16.534	30.093	38.775	58.459	69.610
1–2	68.6	10.902	0.469	0	0	0	0	5.695	15.681	29.372	38.988	65.811	101.307
3–5	60.7	5.637	0.277	0	0	0	0	2.717	8.096	15.837	22.178	34.985	77.078
6–11	49.3	2.197	0.136	0	0	0	0	0.000	3.075	6.338	8.777	17.549	32.203
12–19	31.9	0.872	0.087	0	0	0	0	0.000	1.070	2.857	4.85	8.787	14.911
Protected Fruits													
Age (years)													
< 01	27.0	1.719	0.392	0	0	0	0	0.000	1.957	6.013	8.344	16.608	30.252
1–2	62.1	6.449	0.309	0	0	0	0	3.590	9.186	17.836	24.183	39.032	113.369
3–5	54.5	4.356	0.223	0	0	0	0	2.062	6.721	12.142	17.155	27.900	66.539
6–11	49.0	2.702	0.165	0	0	0	0	0.165	3.817	8.074	11.436	19.811	31.710
12–19	46.4	1.809	0.124	0	0	0	0	0.000	2.612	5.417	8.402	15.427	27.022
Exposed Vegetables													
Age (years)													
< 01	18.1	1.189	0.371	0	0	0	0.000	0.000	0.000	4.991	7.353	14.654	19.040
1–2	63.4	1.996	0.114	0	0	0	0.000	0.591	2.678	5.753	8.551	14.869	45.031
3–5	68.2	1.630	0.083	0	0	0	0.000	0.674	2.241	4.442	6.378	12.787	25.072
6–11	70.6	1.235	0.058	0	0	0	0.000	0.601	1.580	3.417	4.836	8.102	19.600
12–19	76.4	0.966	0.041	0	0	0	0.055	0.530	1.338	2.530	3.610	5.767	13.022
Protected Vegetables													
Age (years)													
< 01	18.9	1.281	0.371	0	0	0	0.000	0.000	0.000	5.420	7.785	11.899	23.097
1–2	41.4	1.469	0.125	0	0	0	0.000	0.000	1.863	4.422	7.042	14.162	27.812
3–5	38.8	1.079	0.09	0	0	0	0.000	0.000	1.402	3.520	5.417	10.300	17.992
6–11	38.7	0.778	0.065	0	0	0	0.000	0.000	1.042	2.583	3.894	7.496	26.510
12–19	31.2	0.462	0.055	0	0	0	0.000	0.000	0.437	1.517	2.348	5.766	21.550
Root Vegetables													
Age (years)													
< 01	30.4	1.812	0.355	0	0	0	0.000	0.000	2.307	6.944	9.582	15.585	32.922
1–2	68.2	2.572	0.134	0	0	0	0.000	1.447	3.562	6.774	8.331	16.777	83.285
3–5	71.1	2.191	0.091	0	0	0	0.000	1.355	3.215	5.512	7.125	14.063	32.045
6–11	73.7	1.620	0.063	0	0	0	0.000	1.034	2.315	4.171	5.325	9.492	20.591
12–19	76.2	1.263	0.053	0	0	0	0.094	0.823	1.747	3.015	3.992	7.661	22.474

[a] Food codes used and category definitions are provided in Appendix 3.

Source: Based on U.S. EPA, 2000

Table 3-20. Per capita distribution of fish (finfish and shellfish) intake by age and gender, as consumed

Age (years)	Sample Size	Mean (g/day)	Percentile 90th (g/day)	Percentile 95th (g/day)	Percentile 99th (g/day)	Mean (mg/kg-day)	Percentile 90th (mg/kg-day)	Percentile 95th (mg/kg-day)	Percentile 99th (mg/kg-day)
Freshwater and Estuarine									
Females									
14 or under	1431	1.58	1.44	12.51	36.09	67.12	57.30	460.16	1356.54
15–44	2891	4.28	10.90	28.80	70.87	66.22	174.96	451.04	1188.16
Males									
14 or under	1546	2.17	0.99	14.94	48.72	73.93	28.10	723.93	1290.10
15–44	2151	6.14	18.19	48.61	96.32	75.35	230.13	577.84	1132.23
Both Sexes									
14 or under	2977	1.88	1.31	13.90	40.77	70.59	53.24	556.34	1347.67
15–44	5042	5.17	13.88	36.21	86.14	70.58	197.11	502.26	1167.57
Marine									
Females									
14 or under	1431	6.60	24.84	37.32	87.05	256.90	936.94	1545.15	3060.22
15–44	2891	9.97	36.83	55.53	105.32	159.79	573.49	873.73	1700.21
Males									
14 or under	1546	7.25	24.85	49.89	92.64	230.25	846.57	1504.37	2885.08
15–44	2151	13.33	52.73	71.49	116.51	165.92	626.85	933.05	1472.98
Both Sexes									
14 or under	2977	6.93	24.88	42.07	91.64	243.31	873.87	1522.52	3059.93
15–44	5042	11.58	44.24	62.18	110.07	162.72	602.58	893.82	1576.09
All Fish									
Females									
14 or under	1431	8.19	32.28	43.09	95.19	324.02	1091.52	1690.99	3982.60
15–44	2891	14.25	47.13	71.58	120.84	226.01	755.51	1126.02	2195.86
Males									
14 or under	1546	9.42	34.85	52.85	98.36	304.17	1172.17	1575.43	3393.84
15–44	2151	19.46	68.60	93.65	149.07	241.27	867.70	1208.43	1760.48
Both Sexes									
14 or under	2977	8.82	32.88	50.95	98.33	313.90	1128.26	1679.91	3419.49
15–44	5042	16.74	57.88	84.59	138.21	233.30	828.12	1155.30	2003.46

Source: U.S. EPA, 1996

Table 3-21. Consumers only distribution of fish (finfish and shellfish) intake by age and gender, as consumed

Age (years)	Sample Size	Mean (g/day)	Percentile 90th (g/day)	Percentile 95th (g/day)	Percentile 99th (g/day)	Mean (mg/kg-day)	Percentile 90th (mg/kg-day)	Percentile 95th (mg/kg-day)	Percentile 99th (mg/kg-day)
Freshwater and Estuarine									
Females									
14 or under	138	38.44	91.30	128.97	182.66	1639.20	3915.56	6271.09	10113.24
15–44	445	61.40	148.83	185.44	363.56	961.58	2578.81	3403.75	6167.24
Males									
14 or under	157	52.44	112.05	154.44	230.74	1798.24	3759.29	3952.99	7907.38
15–44	356	81.56	224.01	275.00	371.00	1004.96	2744.61	3348.86	4569.62
Both Sexes									
14 or under	295	45.73	108.36	136.24	214.62	1721.99	3760.67	4208.18	9789.49
15–44	801	71.44	180.67	230.95	371.52	983.19	2616.63	3360.85	5089.78
Marine									
Females									
14 or under	315	69.04	114.23	162.37	336.59	2591.57	5074.80	6504.67	9970.44
15–44	774	76.53	149.78	178.74	271.06	1227.41	2469.67	3007.98	4800.68
Males									
14 or under	348	78.44	160.97	190.68	336.98	2471.15	4852.33	5860.72	8495.57
15–44	565	104.57	191.29	227.56	316.69	1302.62	2390.20	2882.91	3887.23
Both Sexes									
14 or under	663	73.62	153.20	176.90	337.24	2532.95	5068.69	6376.47	8749.02
15–44	1339	89.93	171.88	209.17	308.06	1263.35	2464.80	2961.92	4251.47
All Fish									
Females									
14 or under	378	69.54	126.22	165.27	338.04	2683.51	5299.68	7160.73	12473.65
15–44	952	88.80	170.01	212.56	361.04	1414.54	2726.46	3740.83	6703.25
Males									
14 or under	429	79.72	161.62	190.00	308.59	2568.93	4714.97	5818.08	9350.89
15–44	702	124.78	230.77	296.66	397.70	1545.93	2854.49	3773.51	5254.04
Both Sexes									
14 or under	807	74.80	153.70	178.08	337.46	2624.35	5020.14	6904.83	10384.82
15–44	1654	106.06	203.33	271.66	372.77	1477.57	2798.37	3747.88	5386.43

Source: U.S. EPA, 1996

Table 3-22. Per capita distribution of fish (finfish and shellfish) intake by age and gender, uncooked fish weight

Age (years)	Sample Size	Percentile Mean (g/day)	90th (g/day)	95th (g/day)	99th (g/day)	Percentile Mean (mg/kg-day)	90th (mg/kg-day)	95th (mg/kg-day)	99th (mg/kg-day)
Freshwater and Estuarine									
Females									
14 or under	1431	1.99	1.81	15.88	46.82	84.78	70.75	599.06	1713.06
15–44	2891	5.50	13.62	36.68	94.93	85.15	202.83	584.79	1411.42
Males									
14 or under	1546	2.69	1.07	18.47	57.07	91.62	38.98	868.97	1642.60
15–44	2151	7.87	22.10	63.26	126.61	96.91	281.17	740.91	1589.97
Both Sexes									
14 or under	2977	2.35	1.72	17.46	50.14	88.26	66.00	717.37	1688.55
15–44	5042	6.64	18.30	47.31	109.66	90.77	250.26	631.31	1529.94
Marine									
Females									
14 or under	1431	8.61	31.23	49.75	104.26	333.99	1132.99	1959.91	3776.60
15–44	2891	12.84	46.66	72.16	133.69	206.03	762.54	1137.58	2174.21
Males									
14 or under	1546	9.40	31.32	65.37	118.42	296.99	1089.46	1907.65	3723.81
15–44	2151	17.11	66.06	93.32	155.16	212.88	800.79	1191.75	1890.42
Both Sexes									
14 or under	2977	9.02	31.52	56.35	117.75	315.12	1123.28	1909.37	3820.21
15–44	5042	14.88	55.99	80.70	138.23	209.30	780.16	1174.69	2019.59
All Fish									
Females									
14 or under	1431	10.60	41.10	56.16	130.78	418.76	1389.10	2341.90	4985.96
15–44	2891	18.35	62.21	93.13	155.75	291.18	993.92	1436.00	2726.50
Males									
14 or under	1546	12.09	45.59	68.18	127.20	388.61	1476.31	2038.58	4294.12
15–44	2151	24.98	87.15	122.29	197.15	309.78	1096.57	1566.39	2275.15
Both Sexes									
14 or under	2977	11.36	43.00	65.34	130.41	403.38	1442.72	2191.90	4425.27
15–44	5042	21.51	75.15	109.57	175.73	300.06	1040.98	1514.82	2481.23

Source: U.S. EPA, 1996

Table 3-23. Per capita distribution of fish (finfish and shellfish) intake by age and gender, uncooked fish weight

Age (years)	Sample Size	Percentile				Percentile			
		Mean (g/day)	90th (g/day)	95th (g/day)	99th (g/day)	Mean (mg/kg-day)	90th (mg/kg-day)	95th (mg/kg-day)	99th (mg/kg-day)
Freshwater and Estuarine									
Females									
14 or under	138	48.30	117.27	161.44	230.63	2070.41	4450.54	6915.31	13269.61
15–44	445	78.56	191.95	242.76	472.21	1229.97	3045.41	4191.25	7711.43
Males									
14 or under	157	64.91	141.35	193.79	287.28	2229.31	4638.34	5071.41	9622.15
15–44	356	104.86	269.96	343.66	494.38	1294.27	3318.89	4275.83	5974.96
Both Sexes									
14 or under	295	56.95	134.89	166.32	262.87	2153.11	4634.82	5756.93	12388.27
15–44	801	91.66	237.27	322.06	494.64	1261.99	3276.06	4246.63	6625.15
Marine									
Females									
14 or under	315	89.92	169.23	198.62	432.51	3359.10	6058.97	8573.62	13050.09
15–44	774	98.53	194.59	231.22	317.42	1582.77	3129.41	3854.14	5961.80
Males									
14 or under	348	101.50	205.49	242.28	408.68	3180.45	6434.20	8089.26	10764.01
15–44	565	133.86	244.46	297.67	393.14	1666.42	3102.24	3651.10	4998.14
Both Sexes									
14 or under	663	95.56	189.32	231.72	442.87	3272.13	6278.74	8424.77	11838.54
15–44	1339	115.41	223.99	263.76	383.16	1622.75	3120.60	3682.17	5517.95
All Fish									
Females									
14 or under	378	89.73	163.47	204.14	476.56	3448.73	7100.43	9012.18	15381.13
15–44	952	114.04	220.63	277.69	461.54	1818.32	3506.20	4661.96	8789.33
Males									
14 or under	429	102.01	205.25	244.46	386.47	3273.63	5734.46	7570.83	11891.85
15–44	702	160.06	305.61	379.38	495.51	1983.16	3720.05	4769.44	6121.56
Both Sexes									
14 or under	807	96.07	195.35	232.85	466.09	3358.33	6333.46	8611.73	12406.35
15–44	1654	136.12	262.15	343.86	488.90	1897.40	3674.88	4709.78	7276.18

Source: U.S. EPA, 1996

Table 3-24. Number of respondents reporting consumption of seafood, by number of servings and source

Age (years)	N	Number of servings in a month						Source		
		1–2	3–5	6–10	11–19	20+	Don't know	Mostly purchased	Mostly caught	Don't know
1–4	102	55	29	12	2	NA	4	94	8	NA
5–11	166	72	57	21	6	4	6	153	9	4
12–17	137	68	54	9	2	1	3	129	6	2

Source: Tsang and Klepeis, 1996

Table 3-25. Mean fish intake among individuals who eat fish and reside in households with recreational fish consumption

Age (years)	All fish (meals/week)	Recreational fish (meals/week)	N	Total fish (g/day)	Recreational fish (g/day)	Total fish (g/kg-day)	Recreational fish (g/kg-day)
1–5	0.463	0.223	121	11.4	5.63	0.737	0.369
6–10	0.490	0.278	151	13.6	7.94	0.481	0.276
11–20	0.407	0.229	349	12.3	7.27	0.219	0.123

Source: U.S. EPA analysis using data from West et al., 1989

Table 3-26. Fish consumption rates throughout year of 194 children ages 5 years and under

Number of grams/day	Unweighted Cumulative Percent = 19.6 grams/day
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	100.0

Unweighted SE = 1.94

Source: CRITFC, 1994

Table 3-27. Mean, 50th, and 90th percentiles of consumption rates for children ages birth to 5 years (g/kg-day)

Population	Mean (SE)	95% CI	Percentile	
			50th	90th
Tulalip Tribes (N = 21)				
Shellfish	0.125 (0.056)	(0.014, 0.236)	0.000	0.597
Total finfish	0.114 (0.030)	(0.056, 0.173)	0.060	0.290
Total, all fish	0.239 (0.077)	(0.088, 0.390)	0.078	0.738
Squaxin Island Tribe (N = 48)				
Shellfish	0.228 (0.053)	(0.126, 0.374)	0.045	0.574
Total finfish	0.250 (0.063)	(0.126, 0.374)	0.061	0.826
Total, all fish	0.825 (0.143)	(0.546, 1.105)	0.508	2.056
Both tribes combined (weighted)				
Shellfish	0.177 (0.039)	(0.101, 0.253)	0.012	0.574
Total finfish	0.182 (0.035)	(0.104, 0.251)	0.064	0.615
Total, all fish	0.532 (0.081)	(0.373, 0.691)	0.173	1.357

Source: Toy et al., 1996

Table 3-28. Children's consumption rate (g/kg-day): individual finfish and shellfish and fish groups [a, b]

	All children (including nonconsumers)										Consumers Only			
					Percentile									
Species/Group	Mean	SE	95% LCL	95% UCL	5th	75th	90th	95th	Median	Max.	N	%	GM	MSE
Manila/Littleneck clams	0.095	0.051	0.000	0.195	0.000	0.063	0.181	0.763	0.031	1.597	23	74	0.050	1.278
Horse clams	0.022	0.013	0.000	0.048	0.000	0.006	0.048	0.269	0.000	0.348	12	39	0.015	1.587
Butter clams	0.021	0.014	0.000	0.048	0.000	0.000	0.041	0.247	0.000	0.422	6	19	0.041	1.844
Geoduck	0.112	0.041	0.033	0.191	0.000	0.116	0.252	0.841	0.027	1.075	22	71	0.054	1.480
Cockles	0.117	0.079	0.000	0.271	0.000	0.054	0.240	1.217	0.000	2.433	10	32	0.123	1.545
Oysters	0.019	0.012	0.000	0.043	0.000	0.056	0.058	0.205	0.000	0.362	10	32	0.020	1.606
Mussels	0.001	0.001	0.000	0.002	0.000	0.000	0.000	0.011	0.000	0.026	1	3	0.026	1.000
Moon snails	0.000				0.000	0.000	0.000	0.000	0.000	0.000	0	0		
Shrimp	0.093	0.038	0.019	0.168	0.000	0.059	0.394	0.712	0.004	0.982	17	55	0.050	1.527
Dungeness crab	0.300	0.126	0.053	0.547	0.000	0.166	1.251	2.689	0.047	2.833	21	68	0.116	1.442
Red rock crab	0.007	0.003	0.001	0.014	0.000	0.000	0.046	0.064	0.000	0.082	5	16	0.040	1.308
Scallops	0.011	0.006	0.000	0.022	0.000	0.005	0.031	0.089	0.000	0.174	8	26	0.026	1.410
Squid	0.002	0.002	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.411	2	6	0.032	1.265
Sea urchin	0.000				0.000	0.000	0.000	0.000	0.000	0.000	0	0		
Sea cucumber	0.000				0.000	0.000	0.000	0.000	0.000	0.000	0	0		
Group A	0.271	0.117	0.043	0.499	0.000	0.216	0.532	2.064	0.663	3.559	28	90	0.100	1.312
Group B	0.004	0.002	0.000	0.008	0.000	0.000	0.015	0.038	0.000	0.069	5	16	0.014	1.618
Group C	0.131	0.040	0.052	0.210	0.000	0.205	0.339	0.838	0.036	1.014	25	81	0.069	1.309
Group D	0.030	0.011	0.008	0.053	0.000	0.037	0.081	0.191	0.010	0.342	17	55	0.033	1.262
Group F[c]	0.240	0.075	0.094	0.387	0.000	0.254	0.684	1.571	0.092	1.901	24	77	0.140	1.315
All Finfish	0.677	0.168	0.346	1.007	0.026	0.740	2.110	3.549	0.306	4.101	31	100	0.312	1.273
All Shellfish	0.801	0.274	0.265	1.337	0.000	0.799	2.319	4.994	0.287	7.948	28	90	0.314	1.360
All Seafood	1.477	0.346	0.799	2.155	0.042	1.983	3.374	7.272	0.724	9.063	31	100	0.729	1.268

[a] The minimum consumption for all species and groups was zero, except for "all finfish" and "all seafood." The minimum rate for "all finfish" was 0.023, and for "all seafood" was 0.035. GM = Geometric Mean MSE = Multiplicative Standard Error.

[b] N = 31, LCL = Lower Confidence Limit, UCL = Upper Confidence Limit.

[c] Group F includes tuna, other finfish, and all others not included in Groups A, B, C, and D.

Source: The Suquamish Tribe, 2000

Table 3-29. Children's consumption rate (g/kg-day) for consumers only: individual finfish and shellfish and fish groups

Group	Species	Consumers Only					
						Percentile	
		N	Mean	SE	Median	75%tile	90%tile
Group E	Manila/Littleneck	23	0.128	0.068	0.043	0.066	0.200
	clams	12	0.058	0.032	0.009	0.046	0.308
	Horse clams	6	0.106	0.066	0.032	0.203	—
	Butter clams	22	0.158	0.054	0.053	0.230	0.554
	Geoduck	10	0.361	0.233	0.078	0.291	2.230
	Cockles	10	0.060	0.035	0.015	0.074	0.336
	Oysters	1	0.026	—	—	—	—
	Mussels	0	—	—	—	—	—
	Moon snails	17	0.170	0.064	0.035	0.299	0.621
	Shrimp	21	0.443	0.179	0.082	0.305	2.348
	Dungeness crab	5	0.046	0.011	0.051	0.067	—
	Red rock crab	8	0.042	0.019	0.027	0.032	—
	Scallops	2	0.033	0.008	0.033	—	—
	Squid	0	—	—	—	—	—
	Sea urchin	0	—	—	—	—	—
	Sea cucumber						
Group A		28	0.300	0.128	0.112	0.246	0.599
Group B		5	0.023	0.012	0.017	0.043	—
Group C		25	0.163	0.048	0.048	0.236	0.493
Group D		17	0.055	0.019	0.033	0.064	0.140
Group F (tuna/other finfish)		24	0.311	0.092	0.177	0.336	1.035
All finfish		31	0.677	0.168	0.306	0.740	2.110
All shellfish		28	0.886	0.299	0.363	0.847	2.466
All seafood		31	1.477	0.346	0.724	1.983	3.374

Source: The Suquamish Tribe, 2000

Table 3-30. Fat intake among children based on data from the Bogalusa Heart Study, 1973–1982 (g/day)

				Percentile						
Age (years)	N	Mean	SD	10th	25th	50th	75th	90th	Minimum	Maximum
Total Fat Intake										
6 (months)	125	37.1	17.500	18.7	25.6	33.9	46.3	60.80	3.4	107.6
1	99	59.1	26.000	29.1	40.4	56.1	71.4	94.40	21.6	152.7
2	135	86.7	41.300	39.9	55.5	79.2	110.5	141.10	26.5	236.4
3	106	91.6	38.800	50.2	63.6	82.6	114.6	153.00	32.6	232.5
4	219	98.6	56.100	46.0	66.8	87.0	114.6	163.30	29.3	584.6
10	871	93.2	50.800	45.7	60.5	81.4	111.3	154.50	14.6	529.5
13	148	107.0	53.900	53.0	69.8	90.8	130.7	184.10	9.8	282.2
15	108	97.7	48.700	46.1	65.2	85.8	124.0	165.20	10.0	251.3
17	159	107.8	64.300	41.4	59.7	97.3	140.2	195.10	8.5	327.4
Total Animal Fat										
6 (months)	125	18.400	16.000	0.7	4.2	13.9	28.4	42.50	0.0	61.1
1	99	36.500	20.000	15.2	23.1	33.0	45.9	65.30	0.0	127.1
2	135	49.500	28.300	20.1	28.9	42.1	66.0	81.40	10.0	153.4
3	106	50.100	29.400	21.3	29.1	42.9	64.4	88.90	14.1	182.6
4	219	50.800	31.700	21.4	28.1	42.6	66.4	92.60	5.9	242.2
10	871	54.100	39.600	20.3	30.6	45.0	64.6	97.50	0.0	412.3
13	148	56.200	39.800	19.8	28.5	44.8	72.8	109.40	4.7	209.6
15	108	53.800	35.100	15.9	28.3	44.7	67.9	105.80	0.6	182.1
17	159	64.400	48.500	15.2	30.7	51.6	86.6	128.80	2.6	230.3
Total Vegetable Fat Intake										
6 (months)	125	9.200	12.800	0.6	1.2	2.8	11.6	29.40	0.0	53.2
1	99	15.400	14.300	3.7	6.1	11.3	18.1	38.00	0.2	70.2
2	135	19.300	16.300	3.8	7.9	14.8	26.6	42.90	0.7	96.6
3	106	21.100	15.500	3.9	8.6	18.7	26.6	45.20	1.0	70.4
4	219	24.500	18.600	5.7	10.4	21.8	33.3	48.50	0.9	109.0
10	871	23.700	21.600	4.3	9.5	18.3	30.6	49.00	0.6	203.7
13	148	34.300	27.400	8.4	17.9	31.2	44.6	57.50	0.0	238.3
15	108	27.300	22.800	5.1	11.9	22.6	38.1	54.40	0.7	132.2
17	159	25.700	21.300	4.2	11.7	20.8	32.9	47.60	0.0	141.5
Total Fish Fat Intake										
6 (months)	125	0.046	0.130	0.0	0.0	0.0	0.0	0.14	0.0	0.9
1	99	0.047	0.233	0.0	0.0	0.0	0.0	0.00	0.0	1.9
2	135	0.036	0.229	0.0	0.0	0.0	0.0	0.00	0.0	1.9
3	106	0.100	0.591	0.0	0.0	0.0	0.0	0.00	0.0	4.5
4	219	2.255	31.05	0.0	0.0	0.0	0.0	0.00	0.0	459.2
10	871	0.292	1.452	0.0	0.0	0.0	0.0	0.00	0.0	19.2
13	148	0.269	2.151	0.0	0.0	0.0	0.0	0.00	0.0	25.4
15	108	0.431	1.467	0.0	0.0	0.0	0.0	0.00	0.0	9.5
17	159	0.465	2.010	0.0	0.0	0.0	0.0	0.00	0.0	15.3

Source: Frank et al., 1986

Table 3-31. Fat intake among children based on data from the Bogalusa Heart Study, 1973–1982 (g/kg-day)

Age (years)	N	Mean	SD	Percentile 10th	25th	50th	75th	90th	Minimum	Maximum
Total Fat Intake										
6 (months)	125	4.940	2.320	2.410	3.280	4.670	6.190	7.970	0.390	13.160
1	99	6.120	2.750	3.030	4.110	5.660	7.470	9.530	2.270	16.380
2	132	6.980	3.340	3.370	4.450	6.150	8.560	11.940	2.140	18.690
3	106	6.400	2.670	3.610	4.560	5.500	8.160	9.930	2.180	16.730
4	218	6.050	3.660	2.880	3.960	5.240	6.970	9.980	2.030	38.210
10	861	2.700	1.520	1.230	1.680	2.350	3.320	4.540	0.330	13.860
13	147	2.280	1.300	1.030	1.470	1.990	2.800	3.810	0.210	10.190
15	105	1.730	0.840	0.840	1.180	1.540	2.140	3.130	0.150	4.730
17	149	1.770	1.020	0.690	0.920	1.620	2.240	3.100	0.160	6.230
Total Animal Fat										
6 (months)	125	2.430	2.130	0.080	0.600	2.030	3.740	5.470	0.000	8.990
1	99	3.780	2.120	1.700	2.370	3.390	4.900	6.480	0.000	13.640
2	132	3.990	2.310	1.730	2.290	3.360	5.220	6.690	0.670	13.400
3	106	3.500	2.010	1.560	2.070	3.130	4.180	6.050	0.900	13.140
4	218	3.120	2.050	1.260	1.730	2.640	4.040	5.380	0.390	15.430
10	861	1.560	1.160	0.550	0.840	1.280	1.920	2.830	0.000	10.790
13	147	1.190	0.860	0.400	0.590	0.940	1.590	2.280	0.080	5.190
15	105	0.950	0.620	0.320	0.540	0.810	1.250	1.900	0.010	3.070
17	149	1.040	0.770	0.260	0.510	0.830	1.380	1.970	0.050	4.150
Total Vegetable Fat Intake										
6 (months)	125	1.237	1.794	0.079	0.160	0.354	1.558	4.076	0.000	8.199
1	99	1.594	1.550	0.401	0.630	1.169	1.868	3.784	0.022	7.610
2	132	1.561	1.381	0.299	0.647	1.134	2.037	3.504	0.057	8.474
3	106	1.474	1.066	0.277	0.603	1.359	1.963	2.958	0.077	5.047
4	218	1.492	1.153	0.356	0.617	1.208	2.059	2.827	0.061	7.315
10	861	0.685	0.638	0.127	0.257	0.516	0.863	1.440	0.019	4.244
13	147	0.748	0.790	0.161	0.381	0.606	0.931	1.248	0.000	8.603
15	105	0.490	0.397	0.086	0.225	0.436	0.653	0.904	0.010	2.226
17	149	0.439	0.359	0.071	0.175	0.353	0.597	0.908	0.000	2.128
Total Fish Fat Intake										
6 (months)	125	0.006	0.018	0.000	0.000	0.000	0.000	0.021	0.000	0.127
1	99	0.005	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.219
2	132	0.003	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.160
3	106	0.007	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.341
4	218	0.148	2.034	0.000	0.000	0.000	0.000	0.000	0.000	30.03
10	861	0.009	0.047	0.000	0.000	0.000	0.000	0.000	0.000	0.625
13	147	0.005	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.405
15	105	0.008	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.189
17	149	0.008	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.234

Source: Frank et al., 1986

Table 3-32. Mean total daily dietary fat intake grouped by age and gender[a]

Age (years)	N	Total mean fat intake (g/day)	Males		Females	
			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	1231	49.96	601	51.74	630	48.33
3–5	1647	60.39	744	70.27	803	61.51
6–11	1745	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

[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 3-33. Per capita total dietary intake

Age (years)	Percent Consuming	Mean	Adjusted SE	Percentile 1st	5th	10th	25th	50th	75th	90th	95th	99th	100th
(g/day, as consumed)													
< 01	92.2	1.0E+03	2.6E+01	8.0E+00	1.3E+02	3.5E+02	8.4E+02	1.1E+03	1.3E+03	1.6E+03	1.8E+03	2.3E+03	2.5E+03
01–02	100.0	1.1E+03	1.1E+01	3.2E+02	5.1E+02	6.2E+02	8.1E+02	1.1E+03	1.3E+03	1.6E+03	1.8E+03	2.2E+03	2.8E+03
03–05	100.0	1.0E+03	9.9E+00	3.4E+02	5.0E+02	5.8E+02	7.6E+02	1.0E+03	1.2E+03	1.5E+03	1.7E+03	2.1E+03	2.6E+03
06–11	100.0	1.1E+03	1.1E+01	4.0E+02	5.7E+02	6.7E+02	8.3E+02	1.1E+03	1.3E+03	1.7E+03	1.9E+03	2.3E+03	3.6E+03
12–19	100.0	1.2E+03	1.7E+01	2.9E+02	4.2E+02	5.6E+02	7.8E+02	1.1E+03	1.5E+03	1.9E+03	2.3E+03	3.2E+03	9.0E+03
(g/kg/day, as consumed)													
< 01	88.0	1.4E+02	4.6E+00	0	6.9E+00	2.4E+01	1.0E+02	1.4E+02	1.8E+02	2.2E+02	2.4E+02	3.2E+02	5.8E+02
01–02	96.0	8.4E+01	1.1E+00	0	2.6E+01	3.9E+01	6.0E+01	8.1E+01	1.0E+02	1.3E+02	1.5E+02	1.9E+02	2.6E+02
03–05	93.2	5.5E+01	7.3E-01	0	0.0E+00	2.6E+01	3.8E+01	5.4E+01	7.0E+01	8.9E+01	1.0E+02	1.3E+02	1.9E+02
06–11	93.4	3.6E+01	5.1E-01	0	0.0E+00	1.5E+01	2.4E+01	3.4E+01	4.6E+01	6.0E+01	6.9E+01	8.9E+01	1.2E+02
12–19	98.2	2.0E+01	3.1E-01	0	6.2E+00	8.1E+00	1.2E+01	1.8E+01	2.6E+01	3.5E+01	4.0E+01	5.8E+01	1.2E+02

Source: Based on U.S. EPA, 2000

Table 3-34. Per capita total intake of major food groups (g/day, as consumed)

Food Group	Percent Consuming	MEAN	Adjusted SE	Percentile									
				1st	5th	10th	25th	50th	75th	90th	95th	99th	100th
Total							**Age < 1 Year**						
Dietary	92.2	1.0E+03	2.6E+01	8.0E+00	1.3E+02	3.5E+02	8.4E+02	1.1E+03	1.3E+03	1.6E+03	1.8E+03	2.3E+03	2.5E+03
Dairy	87.7	7.9E+02	2.4E+01	0.0E+00	3.1E+00	1.3E+02	6.1E+02	8.1E+02	9.9E+02	1.3E+03	1.5E+03	2.0E+03	2.1E+03
Meat	33.4	1.1E+01	1.9E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E+01	3.5E+01	5.7E+01	8.9E+01	1.2E+02
Egg	30.1	3.9E+00	1.3E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.3E-01	2.7E+00	3.8E+01	7.5E+01	8.9E+01
Fish	20.9	9.6E-01	4.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.5E+00	5.0E+00	1.3E+01	4.3E+01
Grain	67.4	3.7E+01	3.6E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E+01	4.7E+01	1.2E+02	1.8E+02	2.4E+02	3.6E+02
Vegetable	52.4	6.0E+01	5.7E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.8E+01	1.1E+02	1.6E+02	1.9E+02	3.0E+02	7.0E+02
Fruit	58.8	1.1E+02	9.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.4E+01	1.9E+02	2.9E+02	3.5E+02	5.6E+02	7.5E+02
Fat[a]	30.1	7.5E-01	1.5E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E+00	2.5E+00	3.3E+00	7.5E+00	1.1E+01
Total							**Ages 1–2 Years**						
Dietary	100.0	1.1E+03	1.1E+01	3.2E+02	5.1E+02	6.2E+02	8.1E+02	1.1E+03	1.3E+03	1.6E+03	1.8E+03	2.2E+03	2.8E+03
Dairy	99.7	4.8E+02	8.3E+00	5.3E+00	7.0E+01	1.3E+02	2.6E+02	4.3E+02	6.5E+02	8.9E+02	1.1E+03	1.4E+03	2.0E+03
Meat	97.8	5.9E+01	1.2E+00	0.0E+00	6.2E+00	1.2E+01	2.7E+01	5.2E+01	8.2E+01	1.2E+02	1.4E+02	1.9E+02	3.2E+02
Egg	92.5	1.6E+01	7.1E-01	0.0E+00	0.0E+00	1.7E-01	8.1E-01	2.3E+00	2.4E+01	4.9E+01	7.0E+01	1.1E+02	1.9E+02
Fish	60.7	4.9E+00	4.7E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.2E+00	3.9E+00	1.1E+01	2.4E+01	6.9E+01	1.7E+02
Grain	99.6	1.5E+02	2.4E+00	1.6E+01	3.9E+01	5.4E+01	8.7E+01	1.3E+02	1.9E+02	2.6E+02	3.2E+02	4.5E+02	6.5E+02
Vegetable	99.3	1.3E+02	2.5E+00	3.9E+00	1.9E+01	3.4E+01	6.6E+01	1.1E+02	1.6E+02	2.4E+02	3.1E+02	4.4E+02	7.1E+02
Fruit	89.0	2.5E+02	6.4E+00	0.0E+00	0.0E+00	0.0E+00	9.3E+01	2.0E+02	3.6E+02	5.4E+02	7.1E+02	9.2E+02	2.1E+03
Fat[a]	93.9	5.5E+00	1.5E-01	0.0E+00	0.0E+00	6.7E-01	1.9E+00	4.1E+00	7.2E+00	1.2E+01	1.6E+01	2.6E+01	5.0E+01
Total							**Ages 3–5 Years**						
Dietary	100.0	1.0E+03	9.9E+00	3.4E+02	5.0E+02	5.8E+02	7.6E+02	1.0E+03	1.2E+03	1.5E+03	1.7E+03	2.1E+03	2.6E+03
Dairy	99.6	3.9E+02	6.3E+00	7.8E+00	7.4E+01	1.2E+02	2.2E+02	3.6E+02	5.1E+02	7.2E+02	8.3E+02	1.2E+03	1.7E+03
Meat	99.0	7.9E+01	1.3E+00	0.0E+00	1.6E+01	2.4E+01	4.4E+01	7.2E+01	1.0E+02	1.4E+02	1.7E+02	2.4E+02	3.8E+02
Egg	90.8	1.3E+01	7.0E-01	0.0E+00	0.0E+00	8.3E-02	7.3E-01	1.8E+00	2.0E+01	4.3E+01	6.3E+01	1.1E+02	2.5E+02
Fish	61.0	6.1E+00	5.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.7E+00	5.0E+00	1.4E+01	3.4E+01	8.0E+01	2.0E+02
Grain	99.8	1.9E+02	2.8E+00	4.7E+01	7.0E+01	8.8E+01	1.2E+02	1.7E+02	2.4E+02	3.1E+02	3.6E+02	5.3E+02	1.6E+03
Vegetable	99.4	1.4E+02	2.5E+00	3.4E+00	2.4E+01	4.0E+01	7.4E+01	1.2E+02	1.8E+02	2.6E+02	3.2E+02	4.8E+02	7.6E+02
Fruit	84.4	2.1E+02	5.5E+00	0.0E+00	0.0E+00	0.0E+00	6.2E+01	1.6E+02	3.1E+02	4.7E+02	5.6E+02	8.4E+02	1.9E+03
Fat[a]	95.6	7.8E+00	2.0E-01	0.0E+00	1.7E-01	1.0E+00	2.7E+00	5.6E+00	1.1E+01	1.8E+01	2.2E+01	3.7E+01	6.3E+01
Total							**Ages 6–11 Years**						
Dietary	100.0	1.1E+03	1.1E+01	4.0E+02	5.7E+02	6.7E+02	8.3E+02	1.1E+03	1.3E+03	1.7E+03	1.9E+03	2.3E+03	3.6E+03
Dairy	99.7	4.3E+02	6.7E+00	1.4E+01	7.6E+01	1.3E+02	2.5E+02	3.9E+02	5.8E+02	7.7E+02	8.6E+02	1.2E+03	2.7E+03
Meat	99.0	9.4E+01	1.6E+00	2.5E+00	1.8E+01	2.8E+01	5.1E+01	8.5E+01	1.2E+02	1.7E+02	2.0E+02	3.0E+02	4.1E+02
Egg	91.6	1.3E+01	7.3E-01	0.0E+00	0.0E+00	2.1E-01	9.0E-01	2.2E+00	6.5E+00	4.6E+01	6.6E+01	1.3E+02	2.2E+02
Fish	62.4	8.9E+00	7.9E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.4E+00	6.1E+00	1.9E+01	4.4E+01	1.3E+02	2.1E+02
Grain	99.9	2.3E+02	2.9E+00	5.0E+01	8.5E+01	1.1E+02	1.5E+02	2.1E+02	2.8E+02	3.7E+02	4.3E+02	5.9E+02	7.8E+02

Table 3-34. Per capita total intake of major food groups (g/day, as consumed) (continued)

Food Group	Percent Consuming	MEAN	Adjusted SE	Percentile 1st	5th	10th	25th	50th	75th	90th	95th	99th	100th
Total						**Ages 6–11 Years**							
Vegetable	99.7	1.7E+02	3.1E+00	1.0E+01	3.6E+01	5.4E+01	9.1E+01	1.4E+02	2.2E+02	3.2E+02	3.9E+02	5.9E+02	1.2E+03
Fruit	77.0	1.7E+02	5.6E+00	0.0E+00	0.0E+00	0.0E+00	3.0E+01	1.2E+02	2.6E+02	4.3E+02	5.1E+02	8.7E+02	1.2E+03
Fat[a]	96.9	1.1E+01	2.8E-01	0.0E+00	7.8E-01	1.6E+00	3.7E+00	7.7E+00	1.4E+01	2.4E+01	3.0E+01	5.2E+01	8.2E+01
Total						**Ages 12–19 Years**							
Dietary	100.0	1.2E+03	1.7E+01	2.9E+02	4.2E+02	5.6E+02	7.8E+02	1.1E+03	1.5E+03	1.9E+03	2.3E+03	3.2E+03	9.0E+03
Dairy	98.7	3.6E+02	8.8E+00	0.0E+00	1.4E+01	3.2E+01	1.1E+02	2.7E+02	5.1E+02	7.8E+02	1.0E+03	1.5E+03	2.0E+03
Meat	99.1	1.3E+02	2.9E+00	2.9E+00	2.0E+01	3.6E+01	7.0E+01	1.2E+02	1.7E+02	2.5E+02	3.0E+02	4.4E+02	2.1E+03
Egg	92.7	1.8E+01	9.5E-01	0.0E+00	0.0E+00	4.4E-01	1.5E+00	3.3E+00	1.1E+01	6.4E+01	8.8E+01	1.5E+02	3.1E+02
Fish	64.4	1.2E+01	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.7E+00	1.1E+01	2.5E+01	6.0E+01	1.5E+02	3.7E+02
Grain	100.0	2.6E+02	4.2E+00	3.9E+01	7.8E+01	1.1E+02	1.6E+02	2.3E+02	3.4E+02	4.4E+02	5.3E+02	8.4E+02	1.7E+03
Vegetable	99.6	2.4E+02	5.1E+00	1.8E+01	4.8E+01	7.3E+01	1.3E+02	2.1E+02	3.1E+02	4.4E+02	5.4E+02	8.1E+02	3.3E+03
Fruit	61.9	1.6E+02	7.6E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.4E+01	2.4E+02	4.3E+02	6.2E+02	9.3E+02	2.0E+03
Fat[a]	96.7	1.6E+01	4.6E-01	0.0E+00	9.7E-01	2.4E+00	5.3E+00	1.1E+01	2.0E+01	3.7E+01	4.9E+01	8.5E+01	1.3E+02

[a] Includes added fats such as butter, margarine, dressings and sauces, vegetable oil, etc.; does not include fats eaten as components of other foods such as meats.

Source: Based on EPA's analysis of the 1994–96 CSFII

Table 3-35. Per capita intake of major food groups (g/kg-day, as consumed)

Food Group	Percent Consuming	Mean	Adjusted SE	Percentile 1st	5th	10th	25th	50th	75th	90th	95th	99th	100th
Total							**Ages < 1 Year**						
Dietary	88.0	1.4E+02	4.6E+00	0.0E+00	6.9E+00	2.4E+01	1.0E+02	1.4E+02	1.8E+02	2.2E+02	2.4E+02	3.2E+02	5.8E+02
Dairy	83.6	1.1E+02	4.9E+00	0.0E+00	0.0E+00	2.5E+00	6.4E+01	1.0E+02	1.6E+02	2.0E+02	2.4E+02	3.2E+02	5.8E+02
Meat	32.3	1.1E+00	2.0E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E+00	3.9E+00	5.9E+00	1.1E+01	1.2E+01
Egg	29.0	4.1E-01	1.4E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.0E-02	2.3E-01	3.3E+00	8.3E+00	1.1E+01
Fish	20.9	1.1E-01	4.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.3E-01	5.3E-01	1.6E+00	4.7E+00
Grain	64.9	4.1E+00	4.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.6E+00	5.4E+00	1.3E+01	2.0E+01	2.7E+01	4.0E+01
Vegetable	50.1	6.9E+00	7.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E+00	1.2E+01	1.8E+01	2.4E+01	3.6E+01	1.0E+02
Fruit	56.8	1.3E+01	1.1E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.6E+00	2.3E+01	3.6E+01	4.1E+01	6.4E+01	1.1E+02
Fat[a]	29.2	8.3E-02	1.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-01	2.6E-01	4.0E-01	7.2E-01	1.7E+00
Total							**Ages 1–2 Years**						
Dietary	96.0	8.4E+01	1.1E+00	0.0E+00	2.6E+01	3.9E+01	6.0E+01	8.1E+01	1.0E+02	1.3E+02	1.5E+02	1.9E+02	2.6E+02
Dairy	95.7	3.7E+01	7.8E-01	0.0E+00	4.1E-01	6.7E+00	1.8E+01	3.2E+01	5.1E+01	7.4E+01	9.0E+01	1.3E+02	1.8E+02
Meat	94.0	4.4E+00	9.4E-02	0.0E+00	0.0E+00	7.6E-01	1.9E+00	3.8E+00	6.2E+00	8.9E+00	1.0E+01	1.5E+01	2.4E+01
Egg	88.8	1.2E+00	5.5E-02	0.0E+00	0.0E+00	0.0E+00	5.3E-02	1.6E-01	1.8E+00	3.8E+00	5.1E+00	8.3E+00	1.4E+01
Fish	58.2	3.7E-01	3.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.0E-02	2.9E-01	7.8E-01	1.8E+00	4.7E+00	1.4E+01
Grain	95.6	1.1E+01	2.0E-01	0.0E+00	1.7E+00	3.6E+00	6.4E+00	9.8E+00	1.4E+01	2.1E+01	2.5E+01	3.5E+01	4.8E+01
Vegetable	95.4	9.5E+00	2.1E-01	0.0E+00	4.7E-01	1.9E+00	4.5E+00	8.0E+00	1.3E+01	1.9E+01	2.3E+01	3.3E+01	8.3E+01
Fruit	85.5	1.9E+01	5.2E-01	0.0E+00	0.0E+00	0.0E+00	6.4E+00	1.6E+01	2.7E+01	4.2E+01	5.4E+01	7.7E+01	1.3E+02
Fat[a]	90.1	4.2E-01	1.2E-02	0.0E+00	0.0E+00	1.0E-02	1.4E-01	3.1E-01	5.5E-01	9.1E-01	1.2E+00	2.2E+00	3.3E+00
Total							**Ages 3–5 Years**						
Dietary	93.2	5.5E+01	7.3E-01	0.0E+00	0.0E+00	2.6E+01	3.8E+01	5.4E+01	7.0E+01	8.9E+01	1.0E+02	1.3E+02	1.9E+02
Dairy	92.9	2.1E+01	4.0E-01	0.0E+00	0.0E+00	3.5E+00	1.0E+01	1.9E+01	2.9E+01	4.1E+01	4.9E+01	6.6E+01	9.0E+01
Meat	92.2	4.1E+00	8.0E-02	0.0E+00	0.0E+00	7.7E-01	2.1E+00	3.8E+00	5.6E+00	7.8E+00	9.4E+00	1.3E+01	2.1E+01
Egg	84.5	6.5E-01	3.7E-02	0.0E+00	0.0E+00	0.0E+00	3.0E-02	8.8E-02	4.6E-01	2.1E+00	3.4E+00	6.1E+00	1.3E+01
Fish	56.4	3.2E-01	3.0E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.9E-02	2.5E-01	6.6E-01	1.7E+00	4.6E+00	9.6E+00
Grain	93.1	1.0E+01	2.0E-01	0.0E+00	0.0E+00	3.7E+00	6.3E+00	9.2E+00	1.3E+01	1.8E+01	2.1E+01	3.4E+01	1.2E+02
Vegetable	92.7	7.3E+00	1.6E-01	0.0E+00	0.0E+00	1.3E+00	3.4E+00	6.2E+00	9.7E+00	1.4E+01	1.8E+01	2.9E+01	4.6E+01
Fruit	79.0	1.1E+01	3.4E-01	0.0E+00	0.0E+00	0.0E+00	2.3E+00	8.1E+00	1.6E+01	2.6E+01	3.3E+01	5.3E+01	1.1E+02
Fat[a]	89.2	4.2E-01	1.2E-02	0.0E+00	0.0E+00	0.0E+00	1.3E-01	3.0E-01	5.9E-01	9.5E-01	1.3E+00	1.8E+00	3.1E+00
Total							**Ages 6–11 Years**						
Dietary	93.4	3.6E+01	5.1E-01	0.0E+00	0.0E+00	1.5E+01	2.4E+01	3.4E+01	4.6E+01	6.0E+01	6.9E+01	8.9E+01	1.2E+02
Dairy	93.3	1.4E+01	2.8E-01	0.0E+00	0.0E+00	2.2E+00	6.4E+00	1.2E+01	1.9E+01	2.7E+01	3.3E+01	4.3E+01	8.1E+01
Meat	92.4	2.9E+00	6.0E-02	0.0E+00	0.0E+00	5.2E-01	1.4E+00	2.5E+00	4.0E+00	5.6E+00	6.8E+00	1.0E+01	1.8E+01
Egg	85.3	4.0E-01	2.5E-02	0.0E+00	0.0E+00	0.0E+00	2.2E-02	6.3E-02	1.8E-01	1.4E+00	2.2E+00	4.4E+00	9.3E+00
Fish	57.5	2.6E-01	2.5E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.8E-02	1.8E-01	4.8E-01	1.3E+00	4.2E+00	6.7E+00
Grain	93.4	7.2E+00	1.2E-01	0.0E+00	0.0E+00	2.5E+00	4.3E+00	6.7E+00	9.4E+00	1.3E+01	1.6E+01	2.0E+01	3.6E+01

Table 3-35. Per capita intake of major food groups (g/kg/day, as consumed) (continued)

Food Group	Percent Consuming	Mean	Adjusted SE	Percentile									
				1st	5th	10th	25th	50th	75th	90th	95th	99th	100th
Total				**Ages 6–11 Years**									
Vegetable	93.2	5.3E+00	1.2E-01	0.0E+00	0.0E+00	1.1E+00	2.5E+00	4.3E+00	7.1E+00	1.0E+01	1.4E+01	2.1E+01	5.2E+01
Fruit	71.2	5.4E+00	2.0E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.4E+00	7.9E+00	1.4E+01	1.8E+01	2.8E+01	4.5E+01
Fat[a]	90.5	3.4E-01	1.0E-02	0.0E+00	0.0E+00	2.2E-02	9.8E-02	2.3E-01	4.5E-01	8.0E-01	1.1E+00	1.5E+00	3.1E+00
Total				**Ages 12–19 Years**									
Dietary	98.2	2.0E+01	3.1E-01	0.0E+00	6.2E+00	8.1E+00	1.2E+01	1.8E+01	2.6E+01	3.5E+01	4.0E+01	5.8E+01	1.2E+02
Dairy	96.9	6.1E+00	1.6E-01	0.0E+00	1.7E-01	4.1E-01	1.8E+00	4.5E+00	8.8E+00	1.3E+01	1.8E+01	2.8E+01	3.8E+01
Meat	97.3	2.2E+00	4.6E-02	0.0E+00	2.7E-01	5.3E-01	1.1E+00	1.9E+00	2.8E+00	3.9E+00	4.9E+00	7.5E+00	2.7E+01
Egg	91.0	2.9E-01	1.5E-02	0.0E+00	0.0E+00	6.0E-03	2.4E-02	5.5E-02	1.8E-01	1.0E+00	1.4E+00	2.5E+00	4.7E+00
Fish	62.9	2.0E-01	1.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.5E-02	1.7E-01	4.2E-01	1.1E+00	2.5E+00	5.4E+00
Grain	98.2	4.4E+00	8.0E-02	0.0E+00	1.1E+00	1.5E+00	2.5E+00	3.8E+00	5.5E+00	7.9E+00	9.7E+00	1.4E+01	3.5E+01
Vegetable	97.9	4.0E+00	8.5E-02	0.0E+00	6.3E-01	1.1E+00	2.1E+00	3.4E+00	5.1E+00	7.4E+00	9.3E+00	1.5E+01	4.2E+01
Fruit	60.7	2.8E+00	1.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E+00	4.1E+00	8.0E+00	1.1E+01	1.7E+01	3.2E+01
Fat[a]	95.0	2.7E-01	8.0E-03	0.0E+00	1.1E-02	3.6E-02	8.7E-02	1.8E-01	3.4E-01	6.2E-01	8.3E-01	1.4E+00	1.8E+00

[a] Includes added fats such as butter, margarine, dressings and sauces, vegetable oil, etc.; does not include fats eaten as components of other foods such as meats.

Source: Based on EPA's analysis of the 1994–96 CSFII

Table 3-36. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total food intake

Food Group	Consumers Low-end Intake	%	Consumers Mid-range Intake	%	Consumers High-end Intake	%	Consumers Low-end Intake	%	Consumers Mid-range Intake	%	Consumers High-end Intake	%
All	**Age < 1 Year (g/day, as consumed)**						**Age < 1 Year (g/kg/day, as consumed)**					
Foods	1.4E+00	100.0	9.9E+02	100.0	1.8E+03	100.0	0.0E+00	0.0	1.3E+02	100.0	2.6E+02	100.0
Dairy	9.4E-02	6.8	8.4E+02	84.9	1.4E+03	79.9	0.0E+00	0.0	9.6E+01	75.2	2.4E+02	92.1
Meats	0.0E+00	0.0	4.9E+00	0.5	7.7E+00	0.4	0.0E+00	0.0	1.8E+00	1.4	1.8E-01	0.1
Fish	0.0E+00	0.0	4.6E-01	0.0	6.0E-01	0.0	0.0E+00	0.0	1.2E-01	0.1	2.3E-02	0.0
Eggs	0.0E+00	0.0	2.8E+00	0.3	1.4E+00	0.1	0.0E+00	0.0	1.0E+00	0.8	8.0E-03	0.0
Grains	5.8E-01	41.7	2.1E+01	2.1	6.8E+01	3.8	0.0E+00	0.0	5.3E+00	4.1	4.0E+00	1.5
Vegetables	4.0E-01	28.7	2.6E+01	2.6	1.1E+02	6.1	0.0E+00	0.0	7.8E+00	6.1	6.9E+00	2.6
Fruits	3.2E-01	22.8	9.5E+01	9.6	1.7E+02	9.5	0.0E+00	0.0	1.6E+01	12.2	9.6E+00	3.7
Fats[a]	0.0E+00	0.0	5.0E-01	0.1	7.1E-01	0.0	0.0E+00	0.0	1.4E-01	0.1	2.0E-02	0.0
	Ages 1–2 Years (g/day, as consumed)						**Ages 1–2 Years (g/kg/day, as consumed)**					
Foods	4.8E+02	100.0	1.1E+03	100.0	1.9E+03	100.0	1.9E+01	100.0	8.1E+01	100.0	1.6E+02	100.0
Dairy	1.6E+02	33.3	4.5E+02	42.5	9.2E+02	49.1	6.0E+00	31.0	3.4E+01	42.5	8.3E+01	52.3
Meats	4.8E+01	10.0	5.9E+01	5.6	7.0E+01	3.7	2.0E+00	11.0	4.8E+00	5.9	5.6E+00	3.5
Fish	2.4E+00	0.5	5.6E+00	0.5	6.9E+00	0.4	8.9E-02	0.0	5.5E-01	0.7	5.0E-01	0.3
Eggs	1.2E+01	2.5	1.5E+01	1.5	2.3E+01	1.2	6.7E-01	3.0	1.4E+00	1.7	1.6E+00	1.0
Grains	1.0E+02	21.0	1.5E+02	14.5	1.8E+02	9.8	4.2E+00	22.0	1.1E+01	13.6	1.5E+01	9.2
Vegetables	7.4E+01	15.3	1.2E+02	11.5	1.9E+02	10.0	3.2E+00	17.0	1.0E+01	12.5	1.5E+01	9.6
Fruits	8.0E+01	16.7	2.5E+02	23.3	4.7E+02	25.3	2.8E+00	14.0	1.8E+01	22.6	3.8E+01	23.7
Fats[a]	3.7E+00	0.8	5.7E+00	0.5	7.5E+00	0.4	1.6E-01	1.0	4.4E-01	0.5	5.7E-01	0.4
	Ages 3–5 Years (g/day, as consumed)						**Ages 3–5 Years (g/kg/day, as consumed)**					
Foods	4.7E+02	100.0	1.0E+03	100.0	1.8E+03	100.0	6.8E+00	100.0	5.4E+01	100.0	1.1E+02	100.0
Dairy	1.5E+02	31.0	4.0E+02	40.0	7.2E+02	39.9	1.8E+00	27.1	2.2E+01	40.6	4.1E+01	37.9
Meats	6.1E+01	12.9	7.8E+01	7.9	1.0E+02	5.8	9.5E-01	14.0	4.5E+00	8.3	6.3E+00	5.9
Fish	4.1E+00	0.9	6.5E+00	0.7	1.0E+01	0.6	4.1E-02	0.6	3.1E-01	0.6	4.6E-01	0.4
Eggs	1.0E+01	2.1	1.1E+01	1.1	2.5E+01	1.4	2.0E-01	2.9	6.4E-01	1.2	1.1E+00	1.0
Grains	1.1E+02	24.0	1.9E+02	18.6	2.8E+02	15.5	1.8E+00	27.0	1.0E+01	18.6	1.8E+01	16.9
Vegetables	8.1E+01	17.0	1.3E+02	13.2	2.1E+02	11.9	1.2E+00	17.2	7.1E+00	13.1	1.3E+01	12.0
Fruits	5.3E+01	11.1	1.8E+02	17.9	4.4E+02	24.4	6.9E-01	10.1	9.1E+00	16.9	2.7E+01	25.2
Fats[a]	4.7E+00	1.0	7.0E+00	0.7	1.2E+01	0.7	8.3E-02	1.2	4.5E-01	0.8	6.5E-01	0.6
	Ages 6–11 Years (g/day, as consumed)						**Ages 6–11 Years (g/kg/day, as consumed)**					
Foods	5.4E+02	100.0	1.1E+03	100.0	1.9E+03	100.0	3.8E+00	100.0	3.3E+01	100.0	7.2E+01	100.0
Dairy	1.6E+02	30.1	3.9E+02	36.5	7.8E+02	39.9	9.9E-01	26.2	1.3E+01	39.7	3.0E+01	41.4
Meats	7.7E+01	14.3	1.0E+02	9.5	1.2E+02	6.1	5.8E-01	15.3	3.1E+00	9.2	4.7E+00	6.6
Fish	8.2E+00	1.5	7.5E+00	0.7	1.2E+01	0.6	5.3E-02	1.4	2.6E-01	0.8	3.6E-01	0.5
Eggs	7.6E+00	1.4	1.1E+01	1.0	2.0E+01	1.0	9.2E-02	2.4	4.5E-01	1.3	7.7E-01	1.1

Table 3-36. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total food intake (continued)

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
All	**Ages 6–11 Years (g/day, as consumed)**						**Ages 6–11 Years (g/kg/day, as consumed)**					
Grains	1.4E+02	26.2	2.2E+02	20.3	3.4E+02	17.5	1.1E+00	30.0	7.0E+00	21.0	1.3E+01	17.9
Vegetables	9.3E+01	17.4	1.7E+02	16.5	2.8E+02	14.4	7.5E-01	19.7	4.7E+00	13.9	9.9E+00	13.8
Fruits	4.3E+01	8.1	1.5E+02	14.5	3.8E+02	19.7	1.3E-01	3.4	4.4E+00	13.1	1.3E+01	17.9
Fats[a]	5.7E+00	1.1	9.9E+00	0.9	1.5E+01	0.8	6.0E-02	1.6	3.2E-01	1.0	5.6E-01	0.8
	Ages 12–19 Years (g/day, as consumed)						**Ages 12–19 Years (g/kg/day, as consumed)**					
Foods	4.1E+02	100.0	1.1E+03	100.0	2.4E+03	100.0	5.1E+00	100.0	1.8E+01	100.0	4.4E+01	100.0
Dairy	6.2E+01	15.1	2.9E+02	26.8	8.5E+02	35.1	8.7E-01	17.1	4.7E+00	26.7	1.6E+01	36.1
Meats	7.7E+01	18.6	1.2E+02	11.6	2.2E+02	8.9	8.6E-01	17.0	2.1E+00	12.1	3.5E+00	7.9
Fish	6.9E+00	1.7	8.7E+00	0.8	2.2E+01	0.9	8.4E-02	1.7	1.5E-01	0.9	3.6E-01	0.8
Eggs	7.3E+00	1.8	1.7E+01	1.6	2.7E+01	1.1	9.9E-02	1.9	3.0E-01	1.7	4.0E-01	0.9
Grains	1.1E+02	27.6	2.4E+02	22.6	4.3E+02	17.9	1.5E+00	29.3	4.0E+00	22.5	8.6E+00	19.5
Vegetables	1.1E+02	26.6	2.3E+02	21.9	4.4E+02	18.0	1.3E+00	26.5	3.6E+00	20.6	7.3E+00	16.6
Fruits	2.8E+01	6.8	1.4E+02	13.5	4.1E+02	17.0	2.4E-01	4.7	2.5E+00	14.1	7.5E+00	17.1
Fats[a]	7.8E+00	1.9	1.4E+01	1.3	2.6E+01	1.1	9.1E-02	1.8	2.5E-01	1.4	4.4E-01	1.0

[a] Includes added fats such as butter, margarine, dressings and sauces, vegetable oil, etc.; does not include fats eaten as components of other foods such as meats.

Source: Based on U.S. EPA analysis of 1994–96 CSFII

Table 3-37. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total meat intake

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
All	**Age < 1 Year (g/day, as consumed)**						**Age <1 Year (g/kg/day, as consumed)**					
Foods	8.0E+02	100.0	7.6E+02	100.0	1.3E+03	100.0	1.2E+02	100.0	1.1E+02	100.0	1.4E+02	100.0
Dairy	6.5E+02	80.9	6.5E+02	85.9	7.9E+02	61.0	1.1E+02	84.7	1.0E+02	89.8	8.9E+01	61.9
Meats	0.0E+00	0.0	0.0E+00	0.0	5.8E+01	4.4	0.0E+00	0.0	0.0E+00	0.0	6.2E+00	4.3
Fish	0.0E+00	0.0	0.0E+00	0.0	4.6E+00	0.4	0.0E+00	0.0	0.0E+00	0.0	5.3E-01	0.4
Eggs	0.0E+00	0.0	3.5E-01	0.0	1.6E+01	1.2	0.0E+00	0.0	3.9E-02	0.0	1.4E+00	1.0
Grains	8.0E+00	1.0	8.8E+00	1.2	1.0E+02	7.9	1.1E+00	0.9	8.1E-01	0.7	1.0E+01	7.2
Vegetables	3.5E+01	4.3	2.7E+01	3.5	1.4E+02	10.4	4.3E+00	3.4	2.6E+00	2.3	1.7E+01	11.5
Fruits	1.1E+02	13.8	7.0E+01	9.3	1.9E+02	14.5	1.4E+01	11.0	7.9E+00	7.1	1.9E+01	13.4
Fats[a]	0.0E+00	0.0	8.3E-03	0.0	2.7E+00	0.2	0.0E+00	0.0	8.0E-04	0.0	3.0E-01	0.2
	Ages 1–2 Years (g/day, as consumed)						**Ages 1–2 Years (g/kg/day, as consumed)**					
Foods	1.0E+03	100.0	1.0E+03	100.0	1.2E+03	100.0	5.6E+01	100.0	8.4E+01	100.0	1.0E+02	100.0
Dairy	5.9E+02	56.9	4.8E+02	45.8	4.3E+02	35.6	3.2E+01	57.0	3.6E+01	42.9	3.9E+01	38.9
Meats	5.9E+00	0.6	5.2E+01	5.0	1.5E+02	12.5	1.6E-01	0.0	3.9E+00	4.7	1.1E+01	11.3
Fish	3.3E+00	0.3	5.5E+00	0.5	7.9E+00	0.6	9.8E-02	0.0	4.0E-01	0.5	7.0E-01	0.7
Eggs	1.0E+01	1.0	1.5E+01	1.4	2.2E+01	1.8	4.0E-01	1.0	1.4E+00	1.7	1.4E+00	1.4
Grains	1.0E+02	9.7	1.4E+02	13.6	1.7E+02	14.3	4.7E+00	8.0	1.1E+01	13.4	1.4E+01	13.8
Vegetables	1.0E+02	9.8	1.1E+02	10.8	1.7E+02	13.7	6.1E+00	11.0	9.7E+00	11.5	1.3E+01	13.4
Fruits	2.2E+02	21.6	2.3E+02	22.4	2.5E+02	20.8	1.2E+01	22.0	2.1E+01	24.7	2.0E+01	19.9
Fats[a]	2.4E+00	0.2	5.4E+00	0.5	7.9E+00	0.7	8.4E-02	0.0	4.3E-01	0.5	6.1E-01	0.6
	Ages 3–5 Years (g/day, as consumed)						**Ages 3–5 Years (g/kg/day, as consumed)**					
Foods	9.7E+02	100.0	9.6E+02	100.0	1.3E+03	100.0	1.8E+01	100.0	5.8E+01	100.0	7.5E+01	100.0
Dairy	4.0E+02	41.3	3.7E+02	38.8	3.7E+02	29.9	7.9E+00	44.6	2.3E+01	40.2	2.4E+01	31.7
Meats	1.3E+01	1.4	7.0E+01	7.3	1.9E+02	14.9	7.8E-02	0.4	3.8E+00	6.5	1.0E+01	13.9
Fish	6.5E+00	0.7	4.6E+00	0.5	7.7E+00	0.6	1.2E-01	0.7	4.0E-01	0.7	2.8E-01	0.4
Eggs	1.2E+01	1.2	1.6E+01	1.6	1.9E+01	1.5	1.4E-01	0.8	6.6E-01	1.1	1.0E+00	1.4
Grains	1.9E+02	19.6	1.7E+02	17.8	2.3E+02	18.7	3.2E+00	17.7	9.9E+00	17.1	1.4E+01	18.5
Vegetables	1.1E+02	10.9	1.4E+02	14.5	1.9E+02	14.9	1.6E+00	9.0	7.5E+00	13.0	1.1E+01	15.3
Fruits	2.4E+02	24.4	1.8E+02	18.7	2.3E+02	18.7	4.7E+00	26.5	1.2E+01	20.7	1.3E+01	18.1
Fats[a]	4.8E+00	0.5	7.2E+00	0.7	1.1E+01	0.9	6.3E-02	0.4	4.1E-01	0.7	6.1E-01	0.8
	Ages 6–11 Years (g/day, as consumed)						**Ages 6–11 Years (g/kg/day, as consumed)**					
Foods	1.0E+03	100.0	1.1E+03	100.0	1.3E+03	100.0	1.3E+01	100.0	3.4E+01	100.0	5.2E+01	100.0
Dairy	4.3E+02	42.6	4.3E+02	39.4	4.3E+02	32.1	5.5E+00	42.9	1.3E+01	38.7	1.8E+01	34.8
Meats	1.6E+01	1.6	8.8E+01	8.0	2.2E+02	16.7	5.8E-02	0.4	2.6E+00	7.5	7.7E+00	14.7
Fish	4.7E+00	0.5	8.7E+00	0.8	8.8E+00	0.7	9.7E-02	0.8	2.8E-01	0.8	3.0E-01	0.6
Eggs	1.1E+01	1.1	1.2E+01	1.1	1.5E+01	1.1	1.7E-01	1.3	5.0E-01	1.5	6.7E-01	1.3

Table 3-37. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total meat intake (continued)

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
All	**Ages 6-11 Years (g/day, as consumed)**						**Ages 6-11 Years (g/kg/day, as consumed)**					
Grains	2.2E+02	21.4	2.1E+02	19.6	2.5E+02	18.6	2.8E+00	21.7	6.9E+00	20.0	9.8E+00	18.9
Vegetables	1.4E+02	13.4	1.8E+02	16.0	2.5E+02	18.3	1.9E+00	14.7	5.2E+00	15.2	8.7E+00	16.7
Fruits	1.9E+02	18.6	1.6E+02	14.1	1.6E+02	11.7	2.3E+00	17.6	5.2E+00	15.3	6.3E+00	12.2
Fats[a]	8.0E+00	0.8	1.1E+01	1.0	1.2E+01	0.9	7.8E-02	0.6	3.3E-01	0.9	4.4E-01	0.8
	Ages 12–19 Years (g/day, as consumed)						**Ages 12–19 Years (g/kg/day, as consumed)**					
Foods	9.3E+02	100.0	1.1E+03	100.0	1.7E+03	100.0	1.3E+01	100.0	2.0E+01	100.0	3.0E+01	100.0
Dairy	3.1E+02	33.4	3.5E+02	31.2	3.7E+02	22.2	4.3E+00	33.8	6.1E+00	30.9	7.4E+00	24.6
Meats	1.9E+01	2.0	1.2E+02	10.3	3.3E+02	19.8	2.3E-01	1.8	1.9E+00	9.6	5.5E+00	18.2
Fish	8.2E+00	0.9	9.6E+00	0.9	1.7E+01	1.0	9.5E-02	0.7	2.4E-01	1.2	2.7E-01	0.9
Eggs	1.1E+01	1.2	1.0E+01	0.9	2.8E+01	1.7	1.6E-01	1.3	2.4E-01	1.2	4.2E-01	1.4
Grains	2.2E+02	23.7	2.5E+02	22.7	3.5E+02	21.1	3.2E+00	24.9	4.4E+00	22.2	6.4E+00	21.2
Vegetables	1.9E+02	20.0	2.2E+02	19.3	3.8E+02	22.7	2.5E+00	19.9	3.7E+00	18.8	6.2E+00	20.7
Fruits	1.6E+02	17.6	1.5E+02	13.4	1.7E+02	10.1	2.1E+00	16.3	2.9E+00	14.7	3.6E+00	11.8
Fats[a]	1.2E+01	1.3	1.4E+01	1.3	2.4E+01	1.5	1.6E-01	1.2	2.7E-01	1.4	3.9E-01	1.3

[a] Includes added fats such as butter, margarine, dressings and sauces, vegetable oil, etc.; does not include fats eaten as components of other foods such as meats.

Source: Based on U.S. EPA analysis of 1994–96 CSFII

Table 3-38. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total meat and dairy intake

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
All	**Age <1 Year (g/day, as consumed)**						**Age <1 Year (g/kg/day, as consumed)**					
Foods	4.2E+01	100.0	1.0E+03	100.0	1.7E+03	100.0	5.6E+00	100.0	1.3E+02	100.0	2.5E+02	100.0
Dairy	0.0E+00	0.0	7.8E+02	74.9	1.5E+03	89.2	0.0E+00	0.0	9.4E+01	73.0	2.5E+02	98.8
Meats	0.0E+00	0.0	1.3E+01	1.3	5.9E+00	0.3	0.0E+00	0.0	1.7E+00	1.3	3.0E-02	0.0
Fish	0.0E+00	0.0	2.0E+00	0.2	2.6E-01	0.0	0.0E+00	0.0	2.2E-01	0.2	4.3E-03	0.0
Eggs	0.0E+00	0.0	6.0E+00	0.6	1.0E+00	0.1	0.0E+00	0.0	2.9E-01	0.2	1.1E-03	0.0
Grains	3.5E+00	8.5	5.2E+01	4.9	3.2E+01	1.9	4.8E-01	8.6	5.0E+00	3.9	7.7E-01	0.3
Vegetables	1.1E+01	25.7	7.1E+01	6.8	5.1E+01	3.0	1.7E+00	29.9	9.2E+00	7.1	9.6E-01	0.4
Fruits	2.7E+01	65.8	1.2E+02	11.2	9.4E+01	5.5	3.4E+00	61.5	1.8E+01	14.2	1.4E+00	0.5
Fats[a]	0.0E+00	0.0	1.1E+00	0.1	3.3E-01	0.0	0.0E+00	0.0	8.5E-02	0.1	6.7E-03	0.0
	Ages 1–2 Years (g/day, as consumed)						**Ages 1–2 Years (g/kg/day, as consumed)**					
Foods	7.2E+02	100.0	1.1E+03	100.0	1.7E+03	100.0	3.2E+01	100.0	8.3E+01	100.0	1.5E+02	100.0
Dairy	7.4E+01	10.3	4.2E+02	39.6	1.1E+03	66.4	2.4E+00	7.0	3.2E+01	38.3	9.7E+01	66.7
Meats	4.9E+01	6.7	6.2E+01	5.8	5.9E+01	3.5	1.9E+00	6.0	5.0E+00	6.0	4.9E+00	3.4
Fish	3.7E+00	0.5	5.7E+00	0.5	4.4E+00	0.3	7.6E-02	0.0	3.5E-01	0.4	4.0E-01	0.3
Eggs	2.0E+01	2.8	1.6E+01	1.5	1.5E+01	0.9	1.1E+00	3.0	1.3E+00	1.6	1.3E+00	0.9
Grains	1.6E+02	22.8	1.6E+02	14.8	1.3E+02	7.9	7.5E+00	24.0	1.2E+01	14.3	1.1E+01	7.7
Vegetables	1.2E+02	16.9	1.2E+02	11.0	1.3E+02	7.6	5.5E+00	17.0	1.1E+01	12.7	1.2E+01	8.0
Fruits	2.8E+02	39.3	2.8E+02	26.2	2.2E+02	13.0	1.3E+01	41.0	2.2E+01	26.2	1.9E+01	12.7
Fats[a]	4.6E+00	0.6	5.8E+00	0.5	5.3E+00	0.3	2.1E-01	1.0	4.7E-01	0.6	4.1E-01	0.3
	Ages 3–5 Years (g/day, as consumed)						**Ages 3–5 Years (g/kg/day, as consumed)**					
Foods	7.0E+02	100.0	9.8E+02	100.0	1.6E+03	100.0	1.3E+01	100.0	5.5E+01	100.0	9.5E+01	100.0
Dairy	7.8E+01	11.2	3.6E+02	37.1	8.9E+02	55.4	7.9E-01	6.2	1.9E+01	34.3	5.2E+01	54.9
Meats	5.9E+01	8.4	7.5E+01	7.6	8.7E+01	5.4	8.4E-01	6.6	4.6E+00	8.4	5.5E+00	5.9
Fish	5.9E+00	0.8	7.5E+00	0.8	6.7E+00	0.4	6.8E-02	0.5	3.5E-01	0.6	3.2E-01	0.3
Eggs	1.4E+01	2.0	1.5E+01	1.5	1.7E+01	1.1	2.9E-01	2.3	7.6E-01	1.4	8.3E-01	0.9
Grains	1.8E+02	26.1	1.8E+02	18.4	2.2E+02	13.5	3.2E+00	25.7	1.1E+01	19.4	1.3E+01	14.1
Vegetables	1.3E+02	17.9	1.3E+02	13.3	1.5E+02	9.4	2.4E+00	18.9	7.8E+00	14.3	9.2E+00	9.8
Fruits	2.3E+02	32.6	2.0E+02	20.5	2.3E+02	14.2	4.9E+00	38.6	1.1E+01	20.9	1.3E+01	13.7
Fats[a]	6.6E+00	0.9	7.5E+00	0.8	8.9E+00	0.6	1.5E-01	1.1	4.1E-01	0.8	4.5E-01	0.5
	Ages 6–11 Years (g/day, as consumed)						**Ages 6–11 Years (g/kg/day, as consumed)**					
Foods	7.2E+02	100.0	1.1E+03	100.0	1.8E+03	100.0	5.9E+00	100.0	3.5E+01	100.0	6.7E+01	100.0
Dairy	8.4E+01	11.7	3.9E+02	36.7	9.1E+02	51.2	4.4E-01	7.4	1.2E+01	33.7	3.4E+01	51.3
Meats	7.2E+01	10.0	1.0E+02	9.5	1.2E+02	7.0	5.7E-01	9.6	3.3E+00	9.4	4.6E+00	6.9
Fish	9.9E+00	1.4	6.8E+00	0.6	8.6E+00	0.5	3.7E-02	0.6	2.5E-01	0.7	3.0E-01	0.5
Eggs	1.3E+01	1.8	1.4E+01	1.4	1.5E+01	0.8	1.6E-01	2.7	5.7E-01	1.6	6.0E-01	0.9

Table 3-38. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total meat and dairy intake (continued)

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
	Ages 6-11 Years (g/day, as consumed)						Ages 6-11 Years (g/kg/day, as consumed)					
Grains	1.9E+02	26.2	2.2E+02	20.9	2.8E+02	16.0	1.6E+00	27.7	7.7E+00	21.9	1.1E+01	16.6
Vegetables	1.7E+02	23.0	1.7E+02	15.9	2.0E+02	11.5	1.5E+00	26.0	5.4E+00	15.2	8.1E+00	12.1
Fruits	1.8E+02	24.6	1.5E+02	14.0	2.2E+02	12.2	1.5E+00	24.7	5.8E+00	16.5	7.3E+00	11.0
Fats[a]	9.8E+00	1.4	9.6E+00	0.9	1.3E+01	0.7	8.5E-02	1.4	3.6E-01	1.0	5.0E-01	0.8
	Ages 12-19 Years (g/day, as consumed)						Ages 12-19 Years (g/kg/day, as consumed)					
Foods	6.2E+02	100.0	1.1E+03	100.0	2.2E+03	100.0	7.9E+00	100.0	1.8E+01	100.0	3.9E+01	100.0
Dairy	3.0E+01	4.9	2.7E+02	25.0	1.0E+03	47.4	3.7E-01	4.7	4.4E+00	24.4	1.9E+01	47.6
Meats	5.6E+01	9.1	1.4E+02	13.0	2.0E+02	9.0	6.6E-01	8.4	2.2E+00	12.4	3.3E+00	8.4
Fish	8.2E+00	1.3	9.3E+00	0.9	1.3E+01	0.6	1.3E-01	1.6	1.9E-01	1.0	2.5E-01	0.6
Eggs	2.0E+01	3.2	1.8E+01	1.6	2.2E+01	1.0	2.3E-01	2.9	2.4E-01	1.4	3.9E-01	1.0
Grains	1.8E+02	28.7	2.6E+02	24.4	3.6E+02	16.6	2.4E+00	30.2	4.5E+00	25.1	6.7E+00	17.0
Vegetables	1.7E+02	28.2	2.3E+02	21.5	3.3E+02	15.2	2.1E+00	27.3	3.6E+00	19.9	5.6E+00	14.3
Fruits	1.4E+02	22.9	1.3E+02	12.2	2.0E+02	9.2	1.8E+00	23.1	2.6E+00	14.6	4.0E+00	10.2
Fats[a]	9.9E+00	1.6	1.5E+01	1.4	2.2E+01	1.0	1.4E-01	1.7	2.2E-01	1.2	3.7E-01	0.9

[a] Includes added fats such as butter, margarine, dressings and sauces, vegetable oil, etc.; does not include fats eaten as components of other foods such as meats.

Source: Based on U.S. EPA analysis of 1994-96 CSFII

Table 3-39. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total fish intake

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
All	Age <1 Year (g/day, as consumed)						Age <1 Year (g/kg/day, as consumed)					
Foods	8.8E+02	100.0	8.4E+02	100.0	1.2E+03	100.0	1.3E+02	100.0	1.2E+02	100.0	1.4E+02	100.0
Dairy	6.9E+02	78.0	7.0E+02	83.0	6.8E+02	58.5	1.1E+02	82.0	1.0E+02	85.8	8.1E+01	59.2
Meats	3.6E+00	0.4	7.7E+00	0.9	3.7E+01	3.2	4.0E-01	0.3	7.7E-01	0.7	4.3E+00	3.1
Fish	0.0E+00	0.0	0.0E+00	0.0	6.7E+00	0.6	0.0E+00	0.0	0.0E+00	0.0	7.7E-01	0.6
Eggs	1.1E+00	0.1	3.2E+00	0.4	7.2E+00	0.6	1.3E-01	0.1	3.7E-01	0.3	7.7E-01	0.6
Grains	1.4E+01	1.6	3.0E+01	3.5	9.2E+01	7.9	1.6E+00	1.2	3.6E+00	3.0	1.1E+01	7.8
Vegetables	4.4E+01	5.0	4.8E+01	5.7	1.4E+02	12.0	5.6E+00	4.2	5.3E+00	4.5	1.7E+01	12.7
Fruits	1.3E+02	14.9	5.3E+01	6.3	2.0E+02	16.9	1.6E+01	12.2	6.5E+00	5.5	2.2E+01	15.8
Fats[a]	1.3E-01	0.0	8.3E-01	0.1	2.9E+00	0.2	1.7E-02	0.0	1.2E-01	0.1	3.3E-01	1.3E+02
	Ages 1-2 Years (g/day, as consumed)						Ages 1-2 Years (g/kg/day, as consumed)					
Foods	1.1E+03	100.0	9.5E+02	100.0	1.2E+03	100.0	8.4E+01	100.0	7.8E+01	100.0	9.4E+01	100.0
Dairy	4.5E+02	41.1	4.5E+02	48.0	4.6E+02	39.1	3.6E+01	43.0	3.8E+01	48.7	3.7E+01	40.0
Meats	5.5E+01	5.0	4.7E+01	5.0	7.4E+01	6.3	4.0E+00	5.0	3.8E+00	4.9	6.1E+00	6.5
Fish	0.0E+00	0.0	1.2E+00	0.1	3.7E+01	3.1	0.0E+00	0.0	7.9E-02	0.1	2.8E+00	2.9
Eggs	1.6E+01	1.4	1.2E+01	1.3	1.6E+01	1.4	1.1E+00	1.0	9.2E-01	1.2	1.3E+00	1.3
Grains	1.6E+02	14.4	1.3E+02	13.7	1.6E+02	13.5	1.2E+01	14.0	1.0E+01	12.9	1.3E+01	13.5
Vegetables	1.2E+02	10.6	1.1E+02	11.4	1.4E+02	12.0	8.5E+00	10.0	8.7E+00	11.2	1.1E+01	12.1
Fruits	3.0E+02	27.0	1.9E+02	20.0	2.8E+02	24.0	2.3E+01	27.0	1.6E+01	20.7	2.2E+01	23.1
Fats[a]	5.2E+00	0.5	4.5E+00	0.5	6.7E+00	0.6	3.8E-01	0.0	3.4E-01	0.4	5.5E-01	0.6
	Ages 3-5 Years (g/day, as consumed)						Ages 3-5 Years (g/kg/day, as consumed)					
Foods	1.1E+03	100.0	9.4E+02	100.0	1.1E+03	100.0	5.9E+01	100.0	5.5E+01	100.0	6.4E+01	100.0
Dairy	4.1E+02	38.7	3.5E+02	37.7	4.0E+02	35.7	2.2E+01	38.2	2.1E+01	38.2	2.4E+01	36.6
Meats	6.5E+01	6.1	7.4E+01	7.9	8.4E+01	7.4	3.5E+00	6.0	4.3E+00	7.8	4.6E+00	7.2
Fish	0.0E+00	0.0	1.6E+00	0.2	4.2E+01	3.7	0.0E+00	0.0	6.2E-02	0.1	2.2E+00	3.5
Eggs	1.0E+01	1.0	1.2E+01	1.3	1.4E+01	1.3	5.6E-01	1.0	5.5E-01	1.0	7.7E-01	1.2
Grains	2.2E+02	20.6	1.7E+02	18.4	2.0E+02	17.6	1.2E+01	21.3	1.0E+01	18.6	1.1E+01	17.3
Vegetables	1.3E+02	11.7	1.3E+02	14.3	1.6E+02	14.4	6.9E+00	11.8	6.9E+00	12.6	9.3E+00	14.5
Fruits	2.3E+02	21.2	1.8E+02	19.5	2.2E+02	19.2	1.2E+01	21.0	1.1E+01	20.9	1.2E+01	18.9
Fats[a]	7.1E+00	0.7	6.9E+00	0.7	9.9E+00	0.9	3.9E-01	0.7	3.8E-01	0.7	5.5E-01	0.9
	Ages 6-11 Years (g/day, as consumed)						Ages 6-11 Years (g/kg/day, as consumed)					
Foods	1.1E+03	100.0	1.1E+03	100.0	1.2E+03	100.0	3.7E+01	100.0	3.3E+01	100.0	4.3E+01	100.0
Dairy	4.5E+02	41.6	4.3E+02	40.4	4.2E+02	34.6	1.5E+01	41.5	1.2E+01	37.0	1.6E+01	36.5
Meats	9.1E+01	8.3	8.0E+01	7.6	1.0E+02	8.4	3.0E+00	8.2	2.8E+00	8.4	3.8E+00	8.7
Fish	0.0E+00	0.0	2.2E+00	0.2	5.7E+01	4.7	0.0E+00	0.0	5.3E-02	0.2	1.7E+00	3.9
Eggs	1.1E+01	1.0	1.3E+01	1.2	1.6E+01	1.3	3.7E-01	1.0	3.8E-01	1.2	5.2E-01	1.2

Table 3-39. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total fish intake (continued)

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
All	Age <1 Year (g/day, as consumed)						Age <1 Year (g/kg/day, as consumed)					
Grains	2.1E+02	19.3	2.2E+02	20.5	2.3E+02	18.7	6.9E+00	19.0	7.0E+00	21.3	8.0E+00	18.5
Vegetables	1.3E+02	11.4	1.6E+02	15.3	1.8E+02	14.6	4.1E+00	11.3	5.4E+00	16.6	6.4E+00	14.8
Fruits	1.9E+02	17.5	1.5E+02	13.9	2.0E+02	16.8	6.6E+00	18.1	4.7E+00	14.4	6.7E+00	15.4
Fats[a]	9.6E+00	0.9	8.6E+00	0.8	1.1E+01	0.9	3.2E-01	0.9	2.9E-01	0.9	3.8E-01	0.9
	Ages 12-19 Years (g/day, as consumed)						Ages 12-19 Years (g/kg/day, as consumed)					
Foods	1.1E+03	100.0	1.1E+03	100.0	1.4E+03	100.0	1.9E+01	100.0	1.8E+01	100.0	2.5E+01	100.0
Dairy	4.1E+02	36.2	3.3E+02	30.9	3.3E+02	23.2	7.0E+00	36.5	5.7E+00	32.0	6.3E+00	24.7
Meats	1.1E+02	9.5	1.2E+02	11.2	1.7E+02	11.9	1.8E+00	9.4	1.8E+00	10.3	3.0E+00	11.6
Fish	0.0E+00	0.0	3.4E+00	0.3	7.5E+01	5.2	0.0E+00	0.0	5.4E-02	0.3	1.2E+00	4.8
Eggs	1.4E+01	1.2	1.5E+01	1.4	2.1E+01	1.4	2.3E-01	1.2	2.4E-01	1.3	3.5E-01	1.4
Grains	2.4E+02	21.1	2.4E+02	22.2	2.9E+02	20.5	4.0E+00	20.7	3.9E+00	21.6	5.5E+00	21.7
Vegetables	2.0E+02	17.9	2.1E+02	20.0	3.1E+02	21.7	3.4E+00	17.6	3.4E+00	19.3	5.2E+00	20.3
Fruits	1.5E+02	12.9	1.3E+02	12.7	2.1E+02	14.5	2.6E+00	13.5	2.5E+00	13.9	3.6E+00	14.0
Fats[a]	1.4E+01	1.2	1.3E+01	1.3	2.2E+01	1.5	2.2E-01	1.2	2.1E-01	1.2	3.7E-01	1.5

[a] Includes added fats such as butter, margarine, dressings and sauces, vegetable oil, etc.; does not include fats eaten as components of other foods such as meats.

Source: Based on U.S. EPA analysis of 1994-96 CSFII

Table 3-40. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total fruit and vegetable intake

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
All	**Age <1 Year (g/day, as consumed)**						**Age <1 Year (g/kg/day, as consumed)**					
Foods	6.7E+02	100.0	8.9E+02	100.0	1.3E+03	100.0	1.3E+02	100.0	1.1E+02	100.0	1.6E+02	100.0
Dairy	6.7E+02	99.5	7.2E+02	81.4	7.0E+02	51.9	1.3E+02	99.6	9.0E+01	84.6	8.1E+01	52.0
Meats	0.0E+00	0.0	1.2E+01	1.3	2.1E+01	1.5	0.0E+00	0.0	1.1E+00	1.1	2.0E+00	1.3
Fish	0.0E+00	0.0	6.3E-01	0.1	2.3E+00	0.2	0.0E+00	0.0	6.8E-02	0.1	2.0E-01	0.1
Eggs	0.0E+00	0.0	9.4E+00	1.1	7.1E+00	0.5	0.0E+00	0.0	9.1E-01	0.9	2.5E-01	0.2
Grains	3.1E+00	0.5	4.5E+01	5.1	6.4E+01	4.7	5.5E-01	0.4	4.2E+00	4.0	7.4E+00	4.8
Vegetables	0.0E+00	0.0	4.9E+01	5.5	1.6E+02	11.9	0.0E+00	0.0	4.3E+00	4.1	2.1E+01	13.6
Fruits	0.0E+00	0.0	4.9E+01	5.5	3.9E+02	29.2	0.0E+00	0.0	5.7E+00	5.3	4.3E+01	28.0
Fats[a]	0.0E+00	0.0	7.6E-01	0.1	1.2E+00	0.1	0.0E+00	0.0	7.9E-02	0.1	1.2E-01	0.1
	Ages 1-2 Years (g/day, as consumed)						**Ages 1-2 Years (g/kg/day, as consumed)**					
Foods	7.5E+02	100.0	1.0E+03	100.0	1.6E+03	100.0	3.4E+01	100	8.3E+01	100.0	1.3E+02	100.0
Dairy	4.7E+02	63.5	4.6E+02	44.3	4.4E+02	27.8	2.3E+01	66	3.8E+01	45.5	3.8E+01	29.1
Meats	5.4E+01	7.3	6.4E+01	6.1	6.4E+01	4.0	2.5E+00	7	5.2E+00	6.2	5.1E+00	3.9
Fish	4.1E+00	0.5	7.5E+00	0.7	7.8E+00	0.5	1.5E-01	0	6.1E-01	0.7	4.3E-01	0.3
Eggs	1.5E+01	2.0	1.3E+01	1.3	2.1E+01	1.3	7.4E-01	2	1.2E+00	1.5	1.8E+00	1.4
Grains	1.2E+02	16.3	1.6E+02	15.0	1.5E+02	9.5	5.6E+00	16	1.2E+01	14.7	1.3E+01	9.9
Vegetables	5.7E+01	7.6	1.2E+02	11.5	2.0E+02	12.7	2.1E+00	6	9.5E+00	11.4	1.7E+01	12.9
Fruits	1.7E+01	2.3	2.1E+02	20.6	6.9E+02	43.7	4.1E-01	1	1.6E+01	19.5	5.6E+01	42.2
Fats[a]	3.9E+00	0.5	5.5E+00	0.5	6.4E+00	0.4	1.5E-01	0	3.8E-01	0.5	5.2E-01	0.4
	Ages 3-5 Years (g/day, as consumed)						**Ages 3-5 Years (g/kg/day, as consumed)**					
Foods	7.0E+02	100.0	1.0E+03	100.0	1.6E+03	100.0	1.2E+01	100.0	5.4E+01	100.0	9.6E+01	100.0
Dairy	3.9E+02	56.3	3.9E+02	39.4	4.1E+02	26.2	7.1E+00	57.5	2.2E+01	40.9	2.6E+01	26.9
Meats	6.5E+01	9.3	8.2E+01	8.3	8.4E+01	5.4	1.1E+00	9.2	4.7E+00	8.7	5.0E+00	5.3
Fish	5.2E+00	0.7	7.5E+00	0.8	8.7E+00	0.6	9.6E-02	0.8	3.5E-01	0.6	4.8E-01	0.5
Eggs	1.1E+01	1.5	1.2E+01	1.2	2.3E+01	1.4	1.9E-01	1.5	5.0E-01	0.9	1.1E+00	1.2
Grains	1.5E+02	22.1	1.9E+02	19.4	2.1E+02	13.4	3.1E+00	25.1	1.0E+01	19.0	1.3E+01	13.9
Vegetables	5.4E+01	7.8	1.5E+02	14.7	2.2E+02	14.3	6.0E-01	4.9	7.1E+00	13.1	1.3E+01	14.0
Fruits	1.0E+01	1.5	1.5E+02	15.5	6.0E+02	38.0	3.0E-02	0.2	8.6E+00	15.9	3.6E+01	37.7
Fats[a]	4.9E+00	0.7	8.1E+00	0.8	1.1E+01	0.7	8.2E-02	0.7	4.5E-01	0.8	6.0E-01	0.6
	Ages 6-11 Years (g/day, as consumed)						**Ages 6-11 Years (g/kg/day, as consumed)**					
Foods	7.3E+02	100.0	1.1E+03	100.0	1.7E+03	100.0	6.5E+00	100.0	3.5E+01	100.0	6.3E+01	100.0
Dairy	3.7E+02	51.0	4.5E+02	40.4	4.6E+02	27.2	3.2E+00	50.3	1.5E+01	42.7	1.8E+01	29.4
Meats	7.5E+01	10.3	1.0E+02	9.0	1.0E+02	6.1	6.6E-01	10.2	3.2E+00	9.2	3.9E+00	6.2
Fish	9.7E+00	1.3	9.8E+00	0.9	1.1E+01	0.7	3.5E-02	0.5	2.4E-01	0.7	3.5E-01	0.6
Eggs	1.0E+01	1.4	1.2E+01	1.1	1.8E+01	1.0	1.3E-01	2.0	3.5E-01	1.0	7.4E-01	1.2

Table 3-40. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total fruit and vegetable intake (continued)

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
All	Ages 6-11 Years (g/day, as consumed)						Ages 6-11 Years (g/kg/day, as consumed)					
Grains	1.8E+02	25.5	2.4E+02	21.2	2.5E+02	15.0	1.9E+00	29.6	7.1E+00	20.5	1.0E+01	16.2
Vegetables	6.2E+01	8.5	1.7E+02	15.0	3.0E+02	17.9	3.9E-01	6.0	4.8E+00	13.8	1.1E+01	17.2
Fruits	8.6E+00	1.2	1.3E+02	11.5	5.3E+02	31.3	4.1E-02	0.6	3.9E+00	11.1	1.8E+01	28.6
Fats[a]	5.2E+00	0.7	1.1E+01	1.0	1.4E+01	0.9	3.9E-02	0.6	3.1E-01	0.9	4.9E-01	0.8
	Ages 12-19 Years (g/day, as consumed)						Ages 12-19 Years (g/kg/day, as consumed)					
Foods	6.8E+02	100.0	1.1E+03	100.0	2.1E+03	100.0	8.4E+00	100.0	1.8E+01	100.0	3.8E+01	100.0
Dairy	2.9E+02	42.5	3.4E+02	31.4	4.5E+02	21.7	3.6E+00	43.2	6.1E+00	32.8	8.5E+00	22.6
Meats	1.0E+02	15.2	1.3E+02	11.7	1.8E+02	8.7	1.3E+00	15.0	2.3E+00	12.2	2.9E+00	7.7
Fish	5.0E+00	0.7	1.1E+01	1.0	2.0E+01	1.0	6.9E-02	0.8	2.0E-01	1.1	3.3E-01	0.9
Eggs	1.3E+01	1.9	1.8E+01	1.7	2.4E+01	1.1	1.5E-01	1.8	2.7E-01	1.5	4.3E-01	1.1
Grains	2.0E+02	28.5	2.6E+02	23.7	3.6E+02	17.1	2.4E+00	28.5	4.3E+00	23.2	6.8E+00	18.1
Vegetables	6.6E+01	9.6	2.4E+02	22.2	4.5E+02	21.6	7.6E-01	9.1	4.0E+00	21.8	7.8E+00	20.7
Fruits	3.3E+00	0.5	7.5E+01	6.9	5.8E+02	27.5	4.5E-02	0.5	1.1E+00	6.0	1.0E+01	27.7
Fats[a]	7.6E+00	1.1	1.6E+01	1.5	2.5E+01	1.2	8.6E-02	1.0	2.6E-01	1.4	4.2E-01	1.1

[a] Includes added fats such as butter, margarine, dressings and sauces, vegetable oil, etc.; does not include fats eaten as components of other foods such as meats.

Source: Based on U.S. EPA analysis of 1994-96 CSFII

Table 3-41. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total dairy intake

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
All	**Age <1 Year (g/day, as consumed)**						**Age <1 Year (g/kg/day, as consumed)**					
Foods	2.2E+01	100.0	1.0E+03	100.0	1.7E+03	100.0	2.5E+00	100.0	1.3E+02	100.0	2.5E+02	100.0
Dairy	0.0E+00	0.0	7.8E+02	74.4	1.5E+03	89.2	0.0E+00	0.0	9.4E+01	73.4	2.5E+02	98.8
Meats	0.0E+00	0.0	1.4E+01	1.4	5.9E+00	0.3	0.0E+00	0.0	1.9E+00	1.5	3.0E-02	0.0
Fish	0.0E+00	0.0	1.8E+00	0.2	2.6E-01	0.0	0.0E+00	0.0	3.1E-01	0.2	4.3E-03	0.0
Eggs	0.0E+00	0.0	4.4E+00	0.4	1.0E+00	0.1	0.0E+00	0.0	3.0E-01	0.2	1.1E-03	0.0
Grains	2.5E+00	11.7	5.1E+01	4.9	3.2E+01	1.9	1.1E-01	4.6	4.8E+00	3.8	7.7E-01	0.3
Vegetables	5.8E+00	26.9	6.9E+01	6.6	5.1E+01	3.0	7.6E-01	30.4	8.9E+00	7.0	9.6E-01	0.4
Fruits	1.3E+01	61.4	1.3E+02	12.0	9.4E+01	5.5	1.6E+00	65.0	1.8E+01	13.8	1.4E+00	0.5
Fats[a]	0.0E+00	0.0	9.2E-01	0.1	3.3E-01	0.0	0.0E+00	0.0	1.1E-01	0.1	6.7E-03	0.0
	Ages 1-2 Years (g/day, as consumed)						**Ages 1-2 Years (g/kg/day, as consumed)**					
Foods	7.4E+02	100.0	1.1E+03	100.0	1.6E+03	100.0	3.3E+01	100	8.2E+01	100.0	1.4E+02	100.0
Dairy	6.5E+01	8.8	4.2E+02	39.7	1.1E+03	67.2	1.9E+00	6	3.2E+01	38.7	9.8E+01	67.6
Meats	6.8E+01	9.1	6.5E+01	6.1	5.0E+01	3.1	2.8E+00	8	4.8E+00	5.9	4.1E+00	2.8
Fish	4.3E+00	0.6	6.5E+00	0.6	4.5E+00	0.3	7.4E-02	0	5.3E-01	0.7	3.2E-01	0.2
Eggs	2.4E+01	3.2	1.7E+01	1.6	1.5E+01	0.9	1.2E+00	4	1.1E+00	1.3	1.2E+00	0.9
Grains	1.7E+02	22.8	1.5E+02	14.3	1.3E+02	7.8	8.0E+00	24	1.2E+01	14.6	1.1E+01	7.6
Vegetables	1.4E+02	18.4	1.1E+02	10.4	1.2E+02	7.4	6.3E+00	19	1.0E+01	12.4	1.1E+01	7.8
Fruits	2.7E+02	36.4	2.8E+02	26.6	2.1E+02	13.0	1.3E+01	39	2.1E+01	26.0	1.9E+01	12.9
Fats[a]	5.8E+00	0.8	5.6E+00	0.5	5.2E+00	0.3	2.5E-01	1	4.1E-01	0.5	3.8E-01	0.3
	Ages 3-5 Years (g/day, as consumed)						**Ages 3-5 Years (g/kg/day, as consumed)**					
Foods	7.0E+02	100.0	9.8E+02	100.0	1.6E+03	100.0	1.3E+01	100.0	5.3E+01	100.0	9.4E+01	100.0
Dairy	6.6E+01	9.4	3.6E+02	36.7	9.0E+02	56.8	4.8E-01	3.7	1.9E+01	35.5	5.2E+01	55.4
Meats	8.3E+01	11.9	8.6E+01	8.8	7.5E+01	4.7	1.6E+00	12.1	4.1E+00	7.8	4.7E+00	5.0
Fish	5.3E+00	0.8	5.9E+00	0.6	6.2E+00	0.4	1.0E-01	0.8	2.9E-01	0.5	3.4E-01	0.4
Eggs	1.6E+01	2.2	9.5E+00	1.0	1.6E+01	1.0	3.3E-01	2.5	5.9E-01	1.1	8.9E-01	0.9
Grains	1.8E+02	25.8	1.8E+02	18.8	2.1E+02	13.2	3.4E+00	25.5	9.5E+00	17.9	1.3E+01	13.9
Vegetables	1.3E+02	18.4	1.4E+02	14.7	1.5E+02	9.2	2.6E+00	19.9	7.8E+00	14.7	9.3E+00	9.9
Fruits	2.2E+02	30.7	1.8E+02	18.7	2.2E+02	14.1	4.5E+00	34.4	1.1E+01	21.6	1.3E+01	13.9
Fats[a]	6.7E+00	1.0	7.1E+00	0.7	8.5E+00	0.5	1.6E-01	1.2	4.1E-01	0.8	4.5E-01	0.5
	Ages 6-11 Years (g/day, as consumed)						**Ages 6-11 Years (g/kg/day, as consumed)**					
Foods	7.3E+02	100.0	1.0E+03	100.0	1.7E+03	100.0	7.3E+00	100.0	3.3E+01	100.0	6.6E+01	100.0
Dairy	7.1E+01	9.7	3.9E+02	38.0	9.2E+02	52.6	2.3E-01	3.2	1.2E+01	36.4	3.5E+01	52.9
Meats	1.0E+02	14.0	9.2E+01	9.0	9.9E+01	5.7	1.2E+00	16.0	2.9E+00	8.8	3.8E+00	5.9
Fish	1.0E+01	1.4	7.4E+00	0.7	7.4E+00	0.4	5.9E-02	0.8	2.1E-01	0.6	3.6E-01	0.5
Eggs	1.4E+01	2.0	1.2E+01	1.2	1.2E+01	0.7	1.4E-01	1.9	4.5E-01	1.4	5.5E-01	0.8

Table 3-41. Per capita intake of total foods and major food groups, and percent of total food intake for individuals with low-end, mid-range, and high-end total dairy intake (continued)

Food Group	Consumers						Consumers					
	Low-end		Mid-range		High-end		Low-end		Mid-range		High-end	
	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%	Intake	%
All	**Age 6-11 Years (g/day, as consumed)**						**Age 6-11 Years (g/kg/day, as consumed)**					
Grains	1.9E+02	26.3	2.1E+02	20.9	2.9E+02	16.3	2.0E+00	27.0	7.0E+00	21.3	1.1E+01	16.4
Vegetables	1.7E+02	22.8	1.5E+02	14.9	1.9E+02	10.9	1.9E+00	25.3	4.8E+00	14.6	7.7E+00	11.8
Fruits	1.6E+02	22.4	1.4E+02	14.2	2.2E+02	12.7	1.8E+00	24.2	5.3E+00	16.0	7.2E+00	11.0
Fats[a]	1.1E+01	1.5	1.1E+01	1.0	1.3E+01	0.7	1.2E-01	1.6	3.2E-01	1.0	4.7E-01	0.7
	Ages 12-19 Years (g/day, as consumed)						**Ages 12-19 Years (g/kg/day, as consumed)**					
Foods	6.9E+02	100.0	1.1E+03	100.0	2.1E+03	100.0	8.9E+00	100.0	1.8E+01	100.0	3.8E+01	100.0
Dairy	1.3E+01	2.0	2.7E+02	23.9	1.1E+03	51.6	1.4E-01	1.6	4.4E+00	24.5	1.9E+01	50.9
Meats	1.2E+02	17.0	1.6E+02	13.9	1.4E+02	6.9	1.5E+00	17.3	2.1E+00	11.7	2.4E+00	6.5
Fish	1.1E+01	1.6	1.0E+01	0.9	1.1E+01	0.6	1.5E-01	1.7	1.2E-01	0.7	2.3E-01	0.6
Eggs	1.4E+01	2.1	1.7E+01	1.5	2.0E+01	1.0	2.2E-01	2.4	3.0E-01	1.7	3.1E-01	0.8
Grains	2.0E+02	28.1	2.6E+02	22.8	3.4E+02	16.4	2.4E+00	26.7	4.5E+00	25.2	6.5E+00	17.2
Vegetables	1.8E+02	26.8	2.5E+02	22.0	2.8E+02	13.7	2.4E+00	26.6	3.7E+00	20.5	4.9E+00	13.0
Fruits	1.4E+02	20.8	1.6E+02	13.8	1.8E+02	8.9	2.0E+00	22.3	2.6E+00	14.5	3.8E+00	10.0
Fats[a]	9.7E+00	1.4	1.3E+01	1.2	2.0E+01	1.0	1.2E-01	1.4	2.2E-01	1.2	3.4E-01	0.9

[a] Includes added fats such as butter, margarine, dressings and sauces, vegetable oil, etc.; does not include fats eaten as components of other foods such as meats.

Source: Based on U.S. EPA analysis of 1994-96 CSFII.

Table 3-42. Weighted (w) and unweighted (uw) number of observations (individuals) for NFCS data used in analysis of food intake

Age (years)	All Regions		Northeast		Midwest		South		West	
	w	uw	w	uw	w	uw	w	uw	w	uw
< 1	2,814,000	156	545,000	29	812,000	44	889,000	51	568,000	32
1–2	5,699,000	321	1,070,000	56	1,757,000	101	1,792,000	105	1,080,000	59
3–5	8,103,000	461	1,490,000	92	2,251,000	133	2,543,000	140	1,789,000	95
6–11	16,711,000	937	3,589,000	185	4,263,000	263	5,217,000	284	3,612,000	204
12–19	20,488,000	1084	4,445,000	210	5,490,000	310	6,720,000	369	3,833,000	195

Source: Based on U.S. EPA analyses of the 1987/1988 NFCS

Table 3-43. Consumer-only intake of homegrown foods (g/kg-day), all regions combined[a]

Age (years)	N w	N uw	Percent Consuming	Mean	SE	Percentile P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Homegrown Fruits															
1–2	360,000	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
3–5	550,000	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
6–11	1,044,000	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	1,189,000	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
Homegrown Vegetables															
1–2	951,000	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
3–5	1,235,000	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
6–11	3,024,000	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	3,293,000	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
Home Produced Meats															
1–2	276,000	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
3–5	396,000	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
6–11	1,064,000	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	1,272,000	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
Home Caught Fish															
1–2	82,000	6	1.44	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]
3–5	142,000	11	1.75	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]
6–11	382,000	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+01
12–19	346,000	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+00

[a] Data are not provided for intake of home-produced dairy because intake data were not provided for subpopulations for which there were fewer than 20 observations.
[b] Fewer than 20 observations, w = weighted number of consumers, u = unweighted number of consumers.

Source: Based on EPA's analyses of the 1987/88 NFCS

Table 3-44. Percent weight losses from food preparation

Food group	Mean net cooking loss (%)	Mean net post-cooking, paring, or preparation loss (%)
Meat	30	30
Fish	32	11
Fruits	31	25
Vegetables	12	22[a]

[a] Based on potatoes only.

Source: U.S. EPA, 1997

Table 3-45. Quantity (as consumed) of food groups consumed per eating occasion and the percentage of individuals using these foods over a 3-day period in a 1997–1978 survey, by age group

	< 1 year old			1-2 years old			3-5 years old			6-8 years old			9-14 years old						15-18 years ols					
	M/F			M/F			M/F			M/F			M			F			M			F		
Food category	%	Mean	SD	%	Mean	SD	%	Mean	SD	%	Mean	SD	%	Mean	SD	%	Mean	SD	%	Mean	SD	%	Mean	SD
Fruits and Vegetables																								
Raw vegetables																								
White potatoes	18.1	72	58	74.5	70	56	76.3	86	62	80.7	100	69	81.8	124	87	77.0	112	80	81.2	149	112	77.2	116	86
Cabbage and coleslaw	0	0	0	3.4	33	22	4.9	41	31	8.5	51	31	9.6	60	34	9.3	61	40	9.8	77	51	9.5	66	41
Carrots	0.8	37	12	3.4	28	25	5.4	38	33	9.8	38	41	8.6	39	36	6.5	33	31	4.5	42	39	5.5	39	35
Cucumbers	0.6	63	63	1.6	40	36	3.5	58	50	4.1	68	73	3.2	75	58	4.6	72	82	3.9	76	64	6.3	62	64
Lettuce and tossed salad	0	0	0	16.6	30	29	30.4	34	26	42.8	43	33	45.8	54	47	47.5	51	43	47.7	61	56	49.0	57	49
Mature onions	0	0	0	1.4	22	18	3.1	19	30	3.9	20	19	6.0	27	20	5.3	26	27	9.9	29	29	7.9	25	26
Tomatoes	0.3	21	7	10.6	46	32	15.7	52	44	18.3	55	33	20.1	74	58	21.0	71	49	24.4	75	56	24.3	66	44
Cooked vegetables																								
Broccoli	1.0	42	27	5.7	55	33	3.8	65	43	5.6	83	50	4.6	96	72	5.1	88	55	4.3	100	48	4.1	106	55
Cabbage	0.4	77	52	3.2	57	48	3.3	77	51	3.8	92	54	3.9	117	79	4.5	121	91	4.5	129	65	4.3	119	81
Carrots	21.7	71	41	11.7	54	38	8.0	49	31	8.7	59	33	8.5	79	48	8.8	75	46	8.5	86	48	7.0	71	46
Corn, whole kernel	3.2	22	17	25.8	56	40	30.1	68	45	34.6	78	41	32.0	95	62	31.0	83	47	28.8	116	70	24.5	94	59
Lima beans	1.0	71	67	2.4	54	38	1.9	49	31	1.9	79	47	1.8	114	133	2.3	86	45	2.6	141	94	1.8	91	78
Mixed vegetables	11.4	81	47	3.7	89	78	3.1	69	40	4.0	82	44	3.7	116	75	3.4	101	50	2.7	107	60	1.8	124	80
Cowpeas, field peas,	0.5	127	64	2.1	63	50	2.5	84	60	2.7	97	57	2.7	109	60	2.3	96	67	3.2	151	63	2.4	163	10
black-eyed peas																								0
Green peas	16.0	61	45	21.8	53	36	20.9	61	42	22.1	72	46	20.9	86	52	19.4	83	46	18.1	112	73	16.9	96	
Spinach	0.9	26	19	2.8	58	48	3.2	73	53	5.1	93	56	5.2	105	59	3.6	102	62	4.5	127	80	3.0	108	62
String beans	19.7	69	47	25.1	48	33	25.4	51	46	31.6	64	38	31.1	75	54	29.4	74	55	29.5	93	58	24.8	83	64
Summer squash	0.7	26	19	1.3	96	63	1.4	97	91	1.1	136	121	1.2	103	50	1.7	102	56	2.1	155	76	1.2	121	51
Sweet potatoes	10.8	82	47	3.8	97	70	3.1	96	50	3.2	99	62	3.4	144	79	2.1	134	92	3.2	150	75	3.3	166	78
Tomato juice	0	0	0	0.8	147	73	0.9	156	61	0.9	133	48	1.2	159	63	1.0	183	95	2.1	191	94	2.2	194	84
Cucumber pickles	0.2	6	0	4.6	32	26	6.2	38	36	8.1	45	46	8.6	47	50	9.1	50	59	9.9	45	46	8.5	58	84
																								71
Fruits																								
Grapefruit	0	0	0	1.1	145	57	1.0	149	56	1.5	158	64	1.6	160	56	2.4	153	50	2.2	150	68	2.3	159	57
Grapefruit juice	0.6	143	44	1.0	156	66	1.2	174	47	1.6	184	52	1.3	194	73	1.5	173	72	1.7	248	202	2.2	210	66
Oranges	0.9	87	34	8.1	117	45	10.0	134	44	12.6	134	46	10.7	150	51	11.2	137	49	8.9	158	84	9.4	142	51
Orange juice	20.9	122	51	40.9	153	70	41.7	167	73	43.7	178	68	39.4	195	80	41.0	188	77	37.3	228	116	36.6	208	81
Apples	1.7	94	51	23.6	105	44	23.8	124	39	25.8	132	41	22.0	146	55	24.5	140	41	16.7	151	48	19.1	142	46
Applesauce, cooked apples	35.6	71	49	13.6	104	65	10.4	126	61	14.1	132	76	13.6	151	107	11.1	134	82	10.2	171	125	7.7	146	73
Apple juice	19.2	125	56	13.1	148	64	8.5	170	65	5.5	193	87	3.0	190	69	4.0	204	74	2.7	259	180	3.1	236	13
Cantaloupe	0.2	136	0	1.1	68	35	1.5	125	73	2.2	135	76	2.2	165	85	2.5	152	77	2.0	209	111	2.5	189	9
Raw peaches	1.2	118	39	3.5	129	48	3.8	128	36	4.5	145	68	3.5	170	77	4.9	153	68	4.0	205	111	3.3	142	11
Raw pears	1.2	56	40	2.3	131	43	2.9	150	57	4.0	163	42	2.7	163	46	3.3	161	42	3.2	195	219	1.4	167	3
Raw strawberries	0.2	120	30	1.5	87	41	1.2	69	34	1.6	87	44	1.2	95	53	2.2	91	50	1.6	121	63	1.9	82	66
																								57
																								45

Table 3-45. Quantity (as consumed) of food groups consumed per eating occasion and the percentage of individuals using these foods over a 3-day period in a 1997–1978 survey, by age group (continued)

	< 1 year old			1-2 years old			3-5 years old			6-8 years old		
	M/F			M/F			M/F			M/F		
Food category	%	Mean	SD	%	Mean	SD	%	Mean	SD	%	Mean	SD
Grain Products												
Yeast Breads	17.6	20	11	88.0	28	16	95.1	36	17	97.2	40	19
Pancakes	3.0	39	27	12.2	59	50	12.7	76	52	11.9	96	59
Waffles	0.6	30	13	3.4	56	45	5.7	69	41	5.9	69	45
Tortillas	0.8	16	7	3.9	26	11	5.1	36	16	4.7	55	29
Cakes and Cupcakes	1.6	53	37	17.4	51	38	25.3	61	45	34.4	66	42
Cookies	11.9	15	13	46.3	21	15	48.1	25	22	53.2	28	21
Pies	0.5	53	30	4.7	88	50	7.1	106	48	8.1	116	58
Doughnuts	0.8	36	22	6.6	47	26	8.6	54	28	10.9	60	30
Crackers	13.8	10	9	38.1	14	14	32.8	18	20	26.2	20	19
Popcorn	0.1	72	0	5.7	9	12	8.5	12	11	9.5	14	9
Pretzels	0.7	4	4	3.2	18	18	3.1	21	20	3.3	25	21
Corn-based Salty Snacks	0.6	8	2	6.6	24	20	8.6	27	22	10.3	29	26
Pasta	3.4	58	42	14.1	82	59	14.7	99	58	14.5	116	74
Rice	4.3	53	42	20.9	81	50	22.2	95	58	23.4	120	77
Cooked Cereals	16.3	116	82	33.1	149	87	26.0	177	97	21.3	198	104
Ready-to-Eat Cereals	68.7	13	11	68.0	23	14	75.8	29	17	76.8	33	19
Meat, Poultry, and Dairy Products												
Meat[a]	23.2	58	42	78.2	53	40	82.8	66	46	84.6	82	55
Beef	15.6	56	41	60.1	64	38	65.5	79	43	67.2	97	52
Pork	10.1	66	44	44.2	37	36	46.0	47	44	46.7	57	49
Lamb	2.6	52	29	1.4	72	46	0.6	90	59	0.5	139	86
Veal	3.2	54	37	1.2	80	28	1.6	75	33	2.0	115	72
Poultry	18.2	60	38	42.2	73	44	42.6	90	50	45.1	103	56
Chicken	15.6	62	39	38.8	73	43	39.3	92	50	41.4	106	55
Turkey	5.1	53	34	4.4	73	59	4.5	74	39	5.7	74	44
Dairy Products												
Eggs	17.7	49	30	61.3	59	27	55.2	66	34	48.5	70	37
Butter	5.2	6	4	29.2	7	6	28.7	9	10	31.7	10	11
Margarine	8.5	5	4	43.8	6	6	46.1	8	8	42.9	9	8
Milk[b]	89.0	170	71	96.9	179	80	97.0	198	83	98.5	227	89
Cheese[c]	6.1	25	21	35.9	31	19	37.0	31	17	35.3	35	23

	9-14 years old						15-18 years ols					
	M			F			M			F		
Food category	%	Mean	SD	%	Mean	SD	%	Mean	SD	%	Mean	SD
Grain Products												
Yeast Breads	96.9	49	28	96.4	44	23	96.2	59	35	93.7	44	2[illegible]
Pancakes	13.5	118	72	10.7	101	89	9.8	161	110	9.8	121	9[illegible]
Waffles	5.2	87	62	4.1	80	68	3.5	125	70	2.4	79	5[illegible]
Tortillas	4.0	74	31	4.3	66	33	3.4	100	48	4.0	69	3[illegible]
Cakes and Cupcakes	36.4	80	56	35.2	77	55	31.0	93	71	26.5	80	5[illegible]
Cookies	44.4	36	36	43.1	32	29	37.9	45	50	34.9	31	2[illegible]
Pies	10.2	133	55	10.6	129	62	13.6	144	66	9.2	126	4[illegible]
Doughnuts	12.0	67	39	12.9	62	36	13.2	91	74	12.9	63	3[illegible]
Crackers	22.1	24	24	22.1	20	16	18.0	32	29	19.6	23	2[illegible]
Popcorn	9.6	18	17	9.1	17	15	6.1	20	20	7.8	18	2[illegible]
Pretzels	4.1	29	25	3.5	30	26	2.9	52	50	3.1	25	1[illegible]
Corn-based Salty Snacks	9.9	33	29	11.3	32	30	8.3	46	44	10.7	34	2[illegible]
Pasta	14.0	162	102	14.5	145	89	11.2	198	133	10.8	158	9[illegible]
Rice	18.9	149	86	22.4	138	77	20.9	195	117	19.0	160	8[illegible]
Cooked Cereals	19.5	223	126	17.3	212	107	14.3	259	132	12.1	229	10[illegible]
Ready-to-Eat Cereals	69.8	41	28	64.0	36	21	50.4	49	31	43.7	37	2[illegible]
Meat, Poultry, and Dairy Products												
Meat[a]	87.1	103	71	84.2	94	69	87.9	123	90	82.6	102	7[illegible]
Beef	69.0	124	66	68.2	111	70	70.3	152	87	65.9	123	7[illegible]
Pork	48.8	68	65	47.0	64	57	56.1	79	75	46.2	68	6[illegible]
Lamb	0.9	171	80	0.7	127	68	0.5	156	81	1.0	112	4[illegible]
Veal	1.5	124	75	1.5	96	46	1.5	170	87	2.1	131	6[illegible]
Poultry	44.3	131	75	44.0	112	58	43.8	153	85	43.7	123	6[illegible]
Chicken	39.8	136	77	39.6	115	57	38.9	160	87	39.5	128	7[illegible]
Turkey	6.5	103	56	6.2	90	54	7.5	120	68	6.2	89	4[illegible]
Dairy Products												
Eggs	49.1	85	47	44.3	75	40	52.3	101	49	44.4	79	4[illegible]
Butter	32.4	12	15	30.9	10	9	32.4	14	12	32.0	13	1[illegible]
Margarine	44.8	12	12	40.7	11	12	41.4	16	14	38.6	11	[illegible]
Milk[b]	97.4	265	125	95.1	242	103	93.2	314	164	88.0	244	11[illegible]
Cheese[c]	31.2	39	22	34.9	35	23	39.0	46	30	39.8	37	2[illegible]

[a] Meat includes beef, pork, lamb, and veal.
[b] Milk includes fluid milk, milk beverages, and milk-based infant formulas.
[c] Cheese - natural and processed cheese.

Source: Pao et al., 1982 (based on 1977-78 NFCS data)

Table 3-46. Mean moisture content of selected food groups expressed as percentages of edible portions

Food	Moisture Content (%) Raw	Cooked	Comment
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 and French	84.38	86.50	Boiled, drained
Artichokes - Jerusalem	78.01		

Table 3-46. Mean moisture content of selected food groups expressed as percentages of edible portions (continued)

Food	Moisture Content (%) Raw	Moisture Content (%) Cooked	Comment
Vegetables (continued)			
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 and 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 3-46. Mean moisture content of selected food groups expressed as percentages of edible portions (continued)

Food	Moisture Content (%)		Comment
	Raw	Cooked	
Vegetables (continued)			
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
Grains			
Barley - pearled	10.09	68.80	
Corn - grain - endosperm	10.37		
Corn - grain - bran	3.71		Crude
Millet	3.71	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		
Meat			
Beef	71.60		Composite, trimmed, retail cuts
Beef liver	68.99		
Chicken (light meat)	74.86		Without skin
Chicken (dark meat)	75.99		Without skin
Duck - domestic	73.77		
Duck - wild	75.51		
Goose - domestic	68.30		
Ham - cured	66.92		
Horse	72.63	63.98	Roasted
Lamb	73.42		Composite, trimmed, retail cuts
Lard	0.00		
Pork	70.00		Roasted
Rabbit - domestic	72.81	69.11	Roasted
Turkey		74.16	Roasted

Table 3-46. Mean moisture content of selected food groups expressed as percentages of edible portions (continued)

Food	Moisture Content (%) Raw	Cooked	Comment
Dairy Products			
Eggs	74.57		
Butter	15.87		
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 (1%)	90.80		

Source: USDA, 1979–1986

Table 3-47. Percent moisture content for selected fish species[a]

Species	Moisture Content (%)	Comment
Finfish		
Anchovy, European	73.37	Raw
	50.30	Canned in oil, drained solids
Bass	75.66	Freshwater, mixed species, raw
Bass, striped	79.22	Raw
Bluefish	70.86	Raw
Butterfish	74.13	Raw
Carp	76.31	Raw
	69.63	Cooked, dry heat
Catfish	76.39	Channel, raw
	58.81	Channel, cooked, breaded and fried
Cod, Atlantic	81.22	Atlantic, raw
	75.61	Canned, solids and liquids
	75.92	Cooked, dry heat
	16.14	Dried and salted
Cod, Pacific	81.28	Raw
Croaker, Atlantic	78.03	Raw
	59.76	Cooked, breaded and fried
Dolphinfish, mahimahi	77.55	Raw
Drum, freshwater	77.33	Raw
Flatfish, flounder and sole	79.06	Raw
	73.16	Cooked, dry heat
Grouper	79.22	Raw, mixed species
	73.36	Cooked, dry heat
Haddock	79.92	Raw
	74.25	Cooked, dry heat
	71.48	Smoked
Halibut, Atlantic and Pacific	77.92	Raw
	71.69	Cooked, dry heat
Halibut, Greenland	70.27	Raw
Herring, Atlantic and turbot, domestic species	72.05	Raw
	64.16	Cooked, dry heat
	59.70	Kippered
	55.22	Pickled
Herring, Pacific	71.52	Raw
Mackerel, Atlantic	63.55	Raw
	53.27	Cooked, dry heat
Mackerel, Jack	69.17	Canned, drained solids
Mackerel, King	75.85	Raw
Mackerel, Pacific and Jack	70.15	Canned, drained solids
Mackerel, Spanish	71.67	Raw
	68.46	Cooked, dry heat
Monkfish	83.24	Raw
Mullet, striped	77.01	Raw
	70.52	Cooked, dry heat
Ocean Perch, Atlantic	78.70	Raw
	72.69	Cooked, dry heat
Perch, mixed species	79.13	Raw
	73.25	Cooked, dry heat
Pike, northern	78.92	Raw
	72.97	Cooked, dry heat
Pike, walleye	79.31	Raw

Table 3-47. Percent moisture content for selected fish species[a] (continued)

Species	Moisture Content (%)	Comment
Pollock, Alaska and Walleye	81.56	Raw
	74.06	Cooked, dry heat
Pollock, Atlantic	78.18	Raw
Rockfish, Pacific, mixed species	79.26	Raw (Mixed species)
	73.41	Cooked, dry heat (mixed species)
Roughy, orange	75.90	Raw
Salmon, Atlantic	68.50	Raw
Salmon, chinook	73.17	Raw
	72.00	Smoked
Salmon, chum	75.38	Raw
	70.77	Canned, drained solids with bone
Salmon, coho	72.63	Raw
	65.35	Cooked, moist heat
Salmon, Pink	76.35	Raw
	68.81	Canned, solids with bone and liquid
Salmon, red and sockeye	70.24	Raw
	68.72	Canned, drained solids with bone
	61.84	Cooked, dry heat
Sardine, Atlantic	59.61	Canned in oil, drained solids with bone
Sardine, Pacific	68.30	Canned in tomato sauce, drained solids with bone
Sea Bass, mixed species	78.27	Cooked, dry heat
	72.14	Raw
Seatrout, mixed species	78.09	Raw
Shad, American	68.19	Raw
Shark, mixed species	73.58	Raw
	60.09	Cooked, batter-dipped and fried
Snapper, mixed species	76.87	Raw
	70.35	Cooked, dry heat
Sole, spot	75.95	Raw
Sturgeon, mixed species	76.55	Raw
	69.94	Cooked, dry heat
	62.50	Smoked
Sucker, white	79.71	Raw
Sunfish, pumpkinseed	79.50	Raw
Swordfish	75.62	Raw
	68.75	Cooked, dry heat
Trout, mixed species	71.42	Raw
Trout, rainbow	71.48	Raw
	63.43	Cooked, dry heat
Tuna, light meat	59.83	Canned in oil, drained solids
	74.51	Canned in water, drained solids
Tuna, white meat	64.02	Canned in oil
	69.48	Canned in water, drained solids
Tuna, bluefish, fresh	68.09	Raw
	59.09	Cooked, dry heat
Turbot, European	76.95	Raw
Whitefish, mixed species	72.77	Raw
	70.83	Smoked
Whiting, mixed species	80.27	Raw
	74.71	Cooked, dry heat
Yellowtail, mixed species	74.52	Raw

Table 3-47. Percent moisture content for selected fish species[a] (continued)

Species	Moisture Content (%)	Comment
Shellfish		
Crab, Alaska king	79.57	Raw
	77.55	Cooked, moist heat
		Imitation, made from surimi
Crab, blue	79.02	Raw
	79.16	Canned (dry pack or drained solids of wet pack)
	77.43	Cooked, moist heat
	71.00	Crab cakes
Crab, dungeness	79.18	Raw
Crab, queen	80.58	Raw
Crayfish, mixed species	80.79	Raw
	75.37	Cooked, moist heat
Lobster, Northern	76.76	Raw
	76.03	Cooked, moist heat
Shrimp, mixed species	75.86	Raw
	72.56	Canned (dry pack or drained solids of wet pack)
	52.86	Cooked, breaded and fried
	77.28	Cooked, moist heat
Spiny Lobster, mixed species	74.07	Imitation made from surimi, raw
Clam, mixed species	81.82	Raw
	63.64	Canned, drained solids
	97.70	Canned, liquid
	61.55	Cooked, breaded and fried
	63.64	Cooked, moist heat
Mussel, blue	80.58	Raw
	61.15	Cooked, moist heat
Octopus, common	80.25	Raw
Oyster, eastern	85.14	Raw
	85.14	Canned (solids and liquid based) raw
	64.72	Cooked, breaded and fried
	70.28	Cooked, moist heat
Oyster, Pacific	82.06	Raw
Scallop, mixed species	78.57	Raw
	58.44	Cooked, breaded and fried
	73.82	Imitation, made from Surimi
Squid	78.55	Raw
	64.54	Cooked, fried

Source: USDA, 1979–1986

Table 3-48. Percentage lipid content (expressed as percentages of 100 grams of edible portions) of selected meat, dairy, and fish products[a]

Product	Fat %	Comment
Meats		
Beef		
Lean only	6.16	Raw
Lean and fat, 1/4 in. fat trim	9.91	Cooked
Brisket (point half)	19.24	Raw
Lean and fat	21.54	Cooked
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
Dairy		
Milk		
Whole	3.16	3.3% fat, raw or pasteurized
Human	4.17	Whole, mature, fluid
Lowfat (1%)	0.83	Fluid
Lowfat (2%)	1.83	Fluid
Skim	0.17	Fluid

Table 3-48. Percentage lipid content (expressed as percentages of 100 grams of edible portions) of selected meat, dairy, and fish products[a] (continued)

Product	Fat %	Comment
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—hard	24.50	
Parmesan—grated	28.46	
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

Table 3-48. Percentage lipid content (expressed as percentages of 100 grams of edible portions) of selected meat, dairy, and fish products[a] (continued)

Product	Fat %	Comment
Finfish		
Anchovy, European	4.101	Raw
	8.535	Canned in oil, drained solids
Bass	3.273	Freshwater, mixed species, raw
Bass, Striped	1.951	Raw
Bluefish	3.768	Raw
Butterfish	NA	Raw
Carp	4.842	Raw
	6.208	Cooked, dry heat
Catfish	3.597	Channel, raw
	12.224	Channel, cooked, breaded, and fried
Cod, Atlantic	0.456	Atlantic, raw
	0.582	Canned, solids and liquids
	0.584	Cooked, dry heat
	1.608	Dried and salted
Cod, Pacific	0.407	Raw
Croaker, Atlantic	2.701	Raw
	11.713	Cooked, breaded, and fried
Dolphinfish, mahimahi	0.474	Raw
Drum, freshwater	4.463	Raw
Flatfish, flounder and Sole	0.845	Raw
	1.084	Cooked, dry heat
Grouper	0.756	Raw, mixed species
	0.970	Cooked, dry heat
Haddock	0.489	Raw
	0.627	Cooked, dry heat
	0.651	Smoked
Halibut, Atlantic and Pacific	1.812	Raw
	2.324	Cooked, dry heat
Halibut, Greenland	12.164	Raw
Herring, Atlantic and Turbot, domestic species	7.909	Raw
	10.140	Cooked, dry heat
	10.822	Kippered
	16.007	Pickled

Table 3-48. Percentage lipid content (expressed as percentages of 100 grams of edible portions) of selected meat, dairy, and fish products[a] (continued)

Product	Fat %	Comment
Herring, Pacific	12.552	Raw
Mackerel, Atlantic	9.076	Raw
	15.482	Cooked, dry heat
Mackerel, Jack	4.587	Canned, drained solids
Mackerel, king	1.587	Raw
Mackerel, Pacific and Jack	6.816	Canned, drained solids
Mackerel, Spanish	5.097	Raw
	5.745	Cooked, dry heat
Monkfish	NA	Raw
Mullet, striped	2.909	Raw
	3.730	Cooked, dry heat
Ocean perch, Atlantic	1.296	Raw
	1.661	Cooked, dry heat
Perch, mixed species	0.705	Raw
	0.904	Cooked, dry heat
Pike, Northern	0.477	Raw
	0.611	Cooked, dry heat
Pike, walleye	0.990	Raw
Pollock, Alaska and walleye	0.701	Raw
	0.929	Cooked, dry heat
Pollock, Atlantic	0.730	Raw
Rockfish, Pacific, mixed species	1.182	Raw (Mixed species)
	1.515	Cooked, dry heat (mixed species)
Roughy, orange	3.630	Raw
Salmon, Atlantic	5.625	Raw
Salmon, chinook	9.061	Raw
	3.947	Smoked
Salmon, chum	3.279	Raw
	4.922	Canned, drained solids with bone
Salmon, coho	4.908	Raw
	6.213	Cooked, moist heat
Salmon, pink	2.845	Raw
	5.391	Canned, solids with bone and liquid
Salmon, Red and sockeye	4.560	Raw
	6.697	Canned, drained solids with bone
	9.616	Cooked, dry heat
Sardine, Atlantic	10.545	Canned in oil, drained solids with bone
Sardine, Pacific	11.054	Canned in tomato sauce, drained solids with bone
Sea bass, mixed species	1.678	Cooked, dry heat
	2.152	Raw
Seatrout, mixed species	2.618	Raw
Shad, American	NA	Raw
Shark, mixed species	3.941	Raw
	12.841	Cooked, batter-dipped and fried
Snapper, mixed species	0.995	Raw
	1.275	Cooked, dry heat
Sole, Spot	3.870	Raw
Sturgeon, mixed species	3.544	Raw
Sucker, white	4.544	Cooked, dry heat
Sunfish, pumpkinseed	3.829	Smoked
Swordfish	1.965	Raw
	0.502	Raw
Trout, mixed species	3.564	Raw
Trout, rainbow	4.569	Cooked, dry heat
	5.901	Raw
	2.883	Raw
	3.696	Cooked, dry heat

Table 3-48. Percentage lipid content (expressed as percentages of 100 grams of edible portions) of selected meat, dairy, and fish products[a] (continued)

Product	Fat %	Comment
Tuna, light meat	7.368	Canned in oil, drained solids
	0.730	Canned in water, drained solids
Tuna, white meat	NA	Canned in oil
	2.220	Canned in water, drained solids
Tuna, bluefish, fresh	4.296	Raw
	5.509	Cooked, dry heat
Turbot, European	NA	Raw
Whitefish, mixed species	5.051	Raw
	0.799	Smoked
Whiting, mixed species	0.948	Raw
	1.216	Cooked, dry heat
Yellowtail, mixed species	NA	Raw
Shellfish		
Crab, Alaska king	NA	Raw
	0.854	Cooked, moist heat
		Imitation, made from surimi
Crab, blue	0.801	Raw
	0.910	Canned (dry pack or drained solids of wet pack)
	1.188	Cooked, moist heat
	6.571	Crab cakes
Crab, dungeness	0.616	Raw
Crab, queen	0.821	Raw
Crayfish, mixed species	0.732	Raw
	0.939	Cooked, moist heat
Lobster, northern	NA	Raw
	0.358	Cooked, moist heat
Shrimp, mixed species	1.250	Raw
	1.421	Canned (dry pack or drained solids of wet pack)
	10.984	Cooked, breaded and fried
	0.926	Cooked, moist heat
Spiny Lobster, mixed species	1.102	Imitation made from surimi, raw
Clam, mixed species	0.456	Raw
	0.912	Canned, drained solids
	NA	Canned, liquid
	10.098	Cooked, breaded and fried
	0.912	Cooked, moist heat
Mussel, blue	1.538	Raw
	3.076	Cooked, moist heat
Octopus, common	0.628	Raw
Oyster, Eastern	1.620	Raw
	1.620	Canned (solids and liquid based) raw
	11.212	Cooked, breaded and fried
	3.240	Cooked, moist heat
Oyster, Pacific	1.752	Raw
Scallop, mixed species	0.377	Raw
	10.023	Cooked, breaded and fried
	NA	Imitation, made from Surimi
Squid	0.989	Raw
	6.763	Cooked, fried

[a] Based on the lipid content in 100 grams, edible portion. Total Fat Content - saturated, monosaturated and polyunsaturated. For additional information, consult the USDA nutrient database.

Source: USDA, 1979–1986.

Table 3-49. Fat content of meat products

Meat Product[a]	Total Fat (g)	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

[a] 3-oz cooked serving (85.05 g).

Source: National Livestock and Meat Board, 1993

Table 3-50. Summary of recommended values (g/kg-day) for per capita intake of foods, as consumed

Age	Mean	95th Percentile	Multiple Percentiles	Study
Total Fruit Intake				
< 1 year	13.20	41.20	see Table 3-35	EPA Analysis of CSFII 1994-96 Data (U.S. EPA, 2000)
1–2 years	19.30	53.90		
3–5 years	11.00	32.70		
6–11 years	5.40	18.00		
12–19 years	2.80	11.00		
Total Vegetable Intake				
< 1 year	6.90	24.20	see Table 3-35	EPA Analysis of CSFII 1994-96 Data (U.S. EPA, 2000)
1–2 years	9.50	23.30		
3–5 years	7.30	18.30		
6–11 years	5.30	13.50		
12–19 years	4.00	9.30		
Total Grain Intake				
< 1 year	4.10	20.20	See Table 3-35	EPA Analysis of CSFII 1994-96 Data (U.S. EPA, 2000)
1–2 years	11.20	24.70		
3–5 years	10.30	21.10		
6–11 years	7.20	15.60		
12–19 years	4.40	9.70		
Total Meat Intake				
< 1 year	1.10	5.90	See Table 3-35	EPA Analysis of CSFII 1994-96 Data (U.S. EPA, 2000)
1–2 years	4.40	10.20		
3–5 years	4.10	9.40		
6–11 years	2.90	6.80		
12–19 years	2.20	4.90		
Total Dairy Intake				
< 1 year	111.00	235.00	See Table 3-35	EPA Analysis of CSFII 1994-96 Data (U.S. EPA, 2000)
1–2 years	37.50	90.20		
3–5 years	20.90	48.80		
6–11 years	13.90	33.50		
12–19 years	6.10	17.80		
Total Fish Intake				
< 1 year	0.11	0.53	See Table 3-35	EPA Analysis of CSFII 1994-96 Data (U.S. EPA, 2000)
1–2 years	0.37	1.79		
3–5 years	0.32	1.74		
6–11 years	0.26	1.35		
12–19 years	0.20	1.10		
Individual Foods Intake	see Table 3-3	—	—	EPA Analysis of CSFII 1994-96 Data (U.S. EPA, 2000)

Table 3-50. Summary of recommended values for per capita intake of foods, as consumed (continued)

Age	Mean	95th Percentile	Multiple Percentiles	Study
Freshwater Total Fish Intake (General Population)				
14 years and under	70.6 mg/kg-day	556 mg/kg-day	See Table 3-6	EPA Analysis of CSFII 1989-91 Data
Marine Fish Intake (General Population)				
14 years and under	163 mg/kg-day	894 mg/kg-day	See Table 3-6	EPA Analysis of CSFII 1989-91 Data
Recreational Fish Intake—Freshwater				
1–5 years 6–10 years	370 mg/kg-day 280 mg/kg-day	— —	See Table 3-13	EPA Analysis of West et al.(1989) data
Native American Subsistence Fish Intake				
< 5 years	11 g/kg-day	—	—	CRITFC, 1994
Total Fat Intake				
	See Tables 3-30 and 3-31	See Tables 3-30 and 3-31	See Tables 3-30 and 3-31	Frank et al., 1986
Homeproduced Food Intake				
	See Table 3-43	See Table 3-43	See Table 3-43	EPA Analysis of 1987/88 NFCS

Table 3-51. Confidence intake recommendations for various foods, including fish (general population)

Considerations	Rationale	Rating
Study Elements		
Level of peer review	USDA CSFII survey receives high level of peer review. EPA analysis of these data has been peer-reviewed outside the Agency.	High
Accessibility	CSFII data are publicly available.	High Medium
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	The most current data publicly available at the time the analysis was conducted for the handbook.	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 good.	High
Measurement error	No measurements were taken. The study relied on survey data.	N/A
Other Elements		
Number of studies	One for most foods, two for fish; CSFII was the most recent data set publicly available at the time the analysis was conducted for the handbook.	Low
Agreement between researchers	Although the CSFII was the only study classified as a key study for most foods, the results are in good agreement with earlier data.	High
Overall Rating		
	The survey is representative of the U.S. population. Although only one study considered key, these data are the most recent and are in agreement with earlier data. The approach used to analyze 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 3-52. Confidence intake recommendations for fish consumption, recreational freshwater angler population

Considerations	Rationale	Rating
Study Elements		
Level of peer review	Study is in a technical report and has been reviewed by EPA.	High
Accessibility	The original study analyses are reported in a technical report. Subsequent EPA analyses are detailed in this handbook.	High
Reproducibility	Enough information is available to reproduce results.	High
Focus on factor of interest	Study focused on ingestion of fish by the recreational freshwater angler and family.	High
Data pertinent to U.S.	The study was conducted in the U.S.	High
Primary data	Data are from a primary reference.	High
Currency	The study was conducted between January and May 1989.	High
Adequacy of data collection period	Data were collected for 1 week.	Low
Validity of approach	Data presented are from a 1-week recall study of fish consumption. Weight of fish consumed was estimated using approximate weight of fish catch and edible fraction or approximate weight of fish meal.	Medium
Study size	Study population was 621 children.	Medium
Representativeness of the population	The study was localized to a single state.	Low
Characterization of variability	Distributions were not generated.	High
Lack of bias in study design (high rating is desirable)	Response rate was 47%.	Medium
Measurement error	Weight of fish portions were estimated in one study, fish weight was estimated from reported fish length in another study.	Medium
Other Elements		
Number of studies	There is one study.	Low
Agreement between researchers	There is only one study. EPA performed an analysis using these data.	Low
Overall Rating		
	The study is not nationally representative and not representative of long-term consumption.	**Low**

Table 3-53. Summary of fish intake rates among Native American children (consumers only)

Age (years)	Mean	Upper Percentile	Reference
< 5 (N = 153)	25 g/day	63.0 g/day (90th percentile) 73.0 g/day (95th percentile)	CRITFC, 1994
≤ 5 (N = 51)	0.72 g/kg-day 11 g/day[a]	1.4 g/kg-day (86th percentile) 21.0 g/day (86th percentile)	Toy et al., 1996
< 6 (N = 31)	1.5 g/kg-day 21 g/day[b]	3.4 g/kg-day (90th percentile) 7.3 g/kg-day (95th percentile) 48.0 g/day (90th percentile)[b] 103.0 g/day (95th percentile)[b]	The Suquamish Tribe, 2000

[a] Intake rate calculated using the average body weight of 15.2 kg reported in Toy et al. (1996).
[b] Intake rate calculated using the average body weight for children < 6 years of age (14.1 kg), based on NHANES III (see Table 11-6).

Table 3-54. Confidence intake recommendations for fish consumption, Native American subsistence population

Considerations	Rationale	Rating
Study Elements		
Level of peer review	Studies are in technical reports.	Medium
Accessibility	Studies are technical reports that are publicly available	Medium
Reproducibility	The studies were adequately detailed and enough information is available to reproduce results.	High
Focus on factor of interest	Studies focused on fish ingestion among Native American tribes.	High
Data pertinent to U.S.	The studies were specific in the U.S.	High
Primary data	The studies used primary data.	High
Currency	Data were from 1991–2000.	High
Adequacy of data collection period	Data were collected for three studies.	High Low confidence for long term percentile distribution
Validity of approach	Individual intake was measured directly, but some respondents provided same information for the children as for themselves.	Low
Study size	The sample population was 204 children < 5 years old for CRIFTC, birth to 5 years for Toy et al., and < 6 years for the Suquamish Indian Tribe.	Medium
Representativeness of the population	Only two states were represented.	Low
Characterization of variability	Individual variations were not described.	Medium
Lack of bias in study design (high rating is desirable)	The response rate was 69, 64, and 77% for CRIFTC, Suquamish Indian Tribe, and Toy et al., respectively.	Medium
Measurement error	The weight of the fish was estimated for one study, measured for the other study.	Medium
Other Elements		
Number of studies	There are three studies.	Low - Medium
Agreement between researchers		Medium
Overall Rating		
	Studies are tribal-specific.	Low

APPENDIX A FOR CHAPTER 3
Calculations Used in the 1994–1996 CSFII Analysis to Correct for Mixtures

Distributions of intake for various food groups were generated for the food/items groups using the USDA 1994–96 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 3A-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 following example for meats:

$$IR_{meat-adjusted} = (IR_{gr\ mixtures} * Fr_{meat/gr}) + (IR_{mt\ mixtures} * Fr_{meat/mt}) + (IR_{meat})$$

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 3A-1. Fraction of grain and meat mixture intake represented by various food items/groups

Grain Mixtures	
total vegetables	0.2584
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
fish	0.0000
eggs	0.0112
fat	0.0225
Meat Mixtures	
total vegetables	0.3000
tomatoes	0.1111
white potatoes	0.0333
total meats	0.3111
beef	0.2000
pork	0.0222
poultry	0.0778
dairy	0.0556
total grains	0.1333
fish	0.0444
eggs	0.0111
fats	0.0222

APPENDIX B FOR CHAPTER 3

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data

Food Product	Food Codes		
Major Food Groups			
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. Also includes the average portion of grain mixtures (13.48%) and the average portion of meat mixtures (5.56%) made up by dairy.
Total meats	20- 21- 22- 23- 24- 25-	Meat, type not specified Beef Pork Lamb, veal, game, carcass meat Poultry Organ meats, sausages, lunchmeats, meat spreads	Also includes the average portion of grain mixtures (7.87%) and the average portion of meat mixtures (31.11%) made up by meats.
Total fish	26-	Fish, all types	Also includes the average portion of meat mixtures (4.44%) made up by fish.
Eggs	3-	Eggs Eggs Egg mixtures Egg substitutes Eggs baby food Frozen meals with egg as main ingredient	Includes baby foods. Also includes the average portion of grain mixtures (1.12%) and the average portion of meat mixtures (1.11%) made up by eggs.
Total grains	50- 51- 52- 53- 54- 55- 561- 562- 57-	Flour Breads Tortillas Sweets Snacks Breakfast foods Pasta Cooked cereals and rice Ready-to-eat and baby cereals	Also includes the average portion of grain mixtures (31.46%) and the average portion of meat mixtures (13.33%) made up by grain.
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- 411- 412- 413- 414- 415- 416- 418- 419-	Vegetables (all forms) White potatoes and Puerto Rican starchy Dark green vegetables Deep yellow vegetables Tomatoes and tom. mixtures Other vegetables Vegetables and mixtures/baby food Vegetables with meat mixtures Beans/legumes Beans/legumes Beans/legumes Soybeans Bean dinners and soups Bean dinners and soups Meatless items Soyburgers	Includes baby foods; mixtures, mostly vegetables; does not include nuts and seeds. Also includes the average portion of grain mixtures (25.84%) and the average portion of meat mixtures (30%) made up by vegetables.

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data (continued)

Food Product	Food Codes		
Major Food Groups continued			
Total fats	8-	Fats (all forms)	Includes butter, margarine, animal fat, sauces, vegetable oils, dressings, and mayonnaise. Also includes the average portion of grain mixtures (2.25%) and the average portion of meat mixtures (2.22%) made up by meats.
Individual Meats			
Beef	21-	Beef Beef, no form specified Beef steak Beef oxtails, neckbones, ribs Roasts, stew meat, corned, brisket, sandwich Steaks Ground beef, patties, meatballs Other beef items Beef baby food	Also includes the average portion of grain mixtures (4.49%) and the average portion of meat mixtures (20.0%) made up by beef.
Pork	22-	Pork Pork, nfs; ground dehydrated Chops Steaks, cutlets Ham Roasts Canadian bacon Bacon, salt pork Other pork items Pork baby food	Also includes the average portion of grain mixtures (1.12%) and the average portion of meat mixtures (2.22%) made up by pork.
Game	233-	Game	
Poultry	24-	Poultry Chicken Turkey Duck Other poultry Poultry baby food	Also includes the average portion of grain mixtures (1.12%) and the average portion of meat mixtures (7.78%) made up by poultry.
Individual Grains			
Breads	51- 52-	Breads, rolls, muffins, bagel, biscuits, corn bread tortillas	
Sweets	53-	Cakes, cookies, pies, pastries, doughnuts, breakfast bars, coffee cakes	
Snacks	54-	Crackers, salty snacks, popcorn, pretzels	
Breakfast foods	55-	Pancakes, waffles, french toast	
Pasta	561-	Macaroni, noodles, spaghetti	
Cooked cereals	56200- 56201- 56202- 56203- 56206- 56207- 56208- 56209- 56210-		Includes grits, oatmeal, cornmeal mush, millet, etc.
Rice	56204- 56205-		Includes all varieties of rice.

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data (continued)

Food Product	Food Codes	
Individual Grains continued		
Ready-to-eat cereals	570- 571- 572- 573- 574- 576-	Includes all varieties of ready-to-eat cereals.
Baby cereals	578- Baby cereals	
Fruit Categories		
Citrus fruits	61- Citrus fruits and juices 6720500 Orange juice, baby food 6723050 Orange/carrot baby juice	63403150 Lime souffle 6721100 Orange-apple-banana juice, baby food Includes some citrus mixtures.
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 672300 Apple sweet potato juice 6725- Baby juice 673- Baby fruits 674- Baby fruits 675- Apples with meat Includes some mixtures (i.e., salads, baby foods).
Apples	6210110 Apples, dried, uncooked 6210115 Apples, dried, uncooked, low sodium 6210120 Apples, dried, cooked, not specifiied as to sweetener 6210122 Apples, dried, cooked, unsweetened 6210123 Apples, dried, cooked, with sugar 6210130 Apple chips 6310100 Apples, raw 6310111 Applesauce, not specified as to sweetener 6310112 Applesauce, unsweetened 6310113 Applesauce with sugar 6310114 Applesauce with low calorie sweetener 6310115 Applesauce/other fruits 6310121 Apples, cooked or canned with syrup 6310131 Apple, baked not specified as to sweetener 6310132 Apple, baked, unsweetened 6310133 Apple, baked with sugar 6310141 Apple rings, fried 6310142 Apple, pickled 6310150 Apple, fried 634010 Apple/other fruit salad 6340106 Apple, candied 6410101 Apple cider 6410401 Apple juice 6410405 Apple juice with vitamin C 6410409 Apple juice with calcium 6410415 Apple-cherry juice 6410420 Apple-pear juice	6410445 Apple-raspberry juice 6410450 Apple-grape juice 6710030 Applesauce, baby toddler 6710100 Apple-raspberry, baby, not specified as to strained or junior 6710101 Apple-raspberry, baby, strained 6710102 Apple-raspberry, baby, junior 6710200 Applesauce baby foodd., NS as to strained or junior 6710201 Applesauce baby food, strained 6710202 Applesauce baby food, junior 67104- Applesauce and other fruit, baby 67113- Apples and pears, baby 6720200 Apple juice, baby food 6720300 Apple w/other fruit juice, baby 6720320 Apple-banana juice, baby 6720340 Apple-cherry juice, baby 6720345 Apple-cranberry juice, baby 6720350 Apple-grape juice, baby 6720360 Apple-peach juice, baby 6720370 Apple-prune juice, baby 6723000 Apple-sweet potato juice, baby food 6725005 Apple juice w/lowfat yogurt, baby food 67301- Apples and cranberries w/tapioca, baby 6740407 Apple yogurt dessert, baby, strained 67412- Dutch apple dessert, baby 675- Apples and meat, baby Includes some mixtures.
Bananas	6210710 Banana flakes, dehydrated 6210720 Banana chips 63107- Bananas, various 6340199 Banana, chocolate covered 6340201 Bana whip 6420150 Banana nectar 6710503 Banana, baby 6711500 Banana, baby	6725010 Banana juice with yogurt, baby 67308- Banana, baby 67309- Banana, baby 6740411 Banana apple dessert, baby 6740420 Banana pineapple dessert, baby 67408- Banana, baby 674041- Banana, baby

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data (continued)

Food Product	Food Codes	
Fruit Categories continued		
Peaches	62116- Dried peaches 63135- Peaches 6412203 Peach juice 6420501 Peach nectar	67108- Peaches, baby 6711450 Peaches, dry, baby 67405- Peach cobbler, baby 67413700 Peach yogurt dessert, baby
Pears	62119- Dried pears 63137- Pears 6341201 Pear salad 6421501 Pear Nectar 67109- Pears, baby	6711455 Pears, dry, baby 6721200 Pear juice, baby 6412300 Pear/white grape/passion fruit juice 67114- Pear/pineapple, baby 6725020 Pear/peach juice with yogurt, baby
Strawberries	6322- Strawberries 6413250 Strawberry juice	
Other Berries	6210910 Cranberries, dried 6320- Other berries 6321- Other berries 6322400 Youngberries, raw 6341101 Cranberry salad	6410460 Blackberry juice 64105- Cranberry juice 6740430 Blueberry yogurt dessert, baby
Exposed Fruits	621011- Apple, dried 621012- Apple, dried 6210130 Apple chips 62104- Apricot, dried 62108- Currants, dried 6210910 Cranberries, 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 6340101 Apple salad w/dressing (include waldorf salad) 6340102 Apple & cabbage salad w/dressing 6340103 Apple & fruit salad w/dressing 6340106 Apple, candied (include caramel apples) 6340203 Prune whip 6341101 Cranberry salad, congealed 6341201 Pear salad w/dressing	6710102 Apple-raspberry, baby, junior 67102- Applesauce, baby 6710400 Applesauce & apricots, baby, ns as to str or jr 6710401 Applesauce & apricots, baby, strained 6710402 Applesauce & apricots, baby, junior 6710407 Applesauce w/cherries, baby, strained 6710408 Applesauce w/cherries, baby, junior 6710409 Applesauce w/cherries, baby, ns str/jr 67108- Peaches, baby 67109- Pears, baby 6711000 Prunes, baby 6711300 Apples & pears, baby, ns as to str or jr 6711301 Apples & pears, baby, strained 6711302 Apples & pears, baby, junior 6711450 Peaches, baby, dry 6711455 Pears, baby, dry 67202- Apple Juice, baby 6720340 Apple-cherry juice, baby 6720345 Apple-cranberry juice, baby 6720350 Apple-grape juice, baby 6720360 Apple-peach juice, baby 6720370 Apple-prune juice, baby 6720380 White Grape Juice, baby 67212- Pear Juice, baby 6723000 Apple-sweet potato juice, baby food 6725005 Apple juice w/lowfat yogurt, baby food 6725020 Pear-peach juice w/lowfat yogurt, baby food 6730100 Apples & cranberries w/tapioca, baby, ns str/jr 6730101 Apples & cranberries w/tapioca, baby, strained 6730102 Apples & cranberries w/tapioca, baby, junior 6730400 Plums w/tapioca, baby, ns as to str/jr 6730401 Plums w/tapioca, baby, strained 6730402 Plums w/tapioca, baby, junior 6730403 Plums, bananas & rice, baby, strained 6730450 Prunes w/oatmeal, baby, strained 6730501 Prunes w/tapioca, baby, strained
Fruit Categories continued		

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data (continued)

Food Product	Food Codes	
Exposed Fruits continued	6341500 Soup, sour cherry 64101- Apple cider 64104- Apple Juice 6410409 Apple juice with calcium 64105- Cranberry Juice 64116- Grape Juice 64122- Peach Juice 6412300 Pear-white-grape-passion fruit juice, w/added vitamin C 64132- Prune/strawberry juice 6420101 Apricot nectar 64205- Peach nectar 64215- Pear nectar 6710030 Applesauce, baby toddler 6710100 Apple-raspberry, baby, ns as to strained or junior 6710101 Apple-raspberry, baby, strained	6730600 Ciruelas w/tapioca, baby 6730700 Apricots w/tapioca, baby, ns as to str/jr 6730701 Apricots w/tapioca, baby, strained 6730702 Apricots w/tapioca, baby, junior 6740407 Apple yogurt dessert, baby, strained 6740430 Blueberry yogurt dessert, baby, strained 6740455 Cherry cobbler, baby, junior 6740500 Peach cobbler, baby, ns as to str/jr 6740501 Peach cobbler, baby, strained 6740502 Peach cobbler, baby, junior 6741000 Cherry vanilla pudding, baby 6741200 Dutch apple dessert, baby, ns as to str/jr 6741201 Dutch apple dessert, baby, strained 6741202 Dutch apple dessert, baby, junior 6741370 Peach yogurt dessert, baby, strained 675- Apples & meat
Protected Fruits	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 6312665 Loquats, raw 63127- Honeydew 63129- Mango 63133- Papaya 63134- Passion Fruit 63141- Pineapple 63145- Pomegranate 63148- Sweetsop, Soursop, Tamarind 63149- Watermelon 6340199 Banana, chocolate-covered, w/nuts 6340201 Banana whip 6340205 Fried dwarf banana w/cheese, Puerto Rican style 6340315 Lime souffle (include other citrus fruits) 6340801 Guacamole w/tomatoes 6340820 Guacamole w/tomatoes & chile peppers 63490901 Guacamole, nfs 64120- Papaya Juice	64121- Passion Fruit Juice 64124- Pineapple Juice 64125- Pineapple juice 64133- Watermelon Juice 6420150 Banana Nectar 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 6723050 Orange-carrot juice, baby food 6725010 Banana juice w/lowfat yogurt, baby food 6730800 Bananas w/tapioca, baby, ns as to str/jr 6730801 Bananas w/tapioca, baby, strained 6730802 Bananas w/tapioca, baby, junior 6730900 Bananas & pineapple w/tapioca, baby, ns as to str/jr 6730901 Bananas & pineapple w/tapioca, baby, strained 6730902 Bananas & pineapple w/tapioca, baby, junior 6740411 Banana apple dessert, baby food, strained 6740420 Banana pineapple dessert, w/tapioca, baby 6740801 Banana pudding, baby, strained 6740850 Banana yogurt dessert, baby, strained 6741400 Pineapple dessert, baby, ns as to str/jr 6741401 Pineapple dessert, baby, strained 6741402 Pineapple dessert, baby, junior 6741410 Mango dessert w/tapioca, baby
Vegetable Categories		
Asparagus	7510080 Asparagus, raw 75202- Asparagus, cooked 7540101 Asparagus, creamed or with cheese	756010 Asparagus soup Does not include vegetables with meat mixtures.
Beets	72101- Beet greens 7510250 Beets, raw 752080- Beets, cooked 752081- Beets, canned 7540501 Beets, Harvard	7550021 Beets, pickled 7560110 Beet soup 76403- Beets, baby Does not include vegetable with meat mixtures.
Vegetable Categories continued		

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data (continued)

Food Product	Food Codes	
Broccoli	722- Broccoli (all forms) 7230200 Broccoli soup (include cream of broccoli soup) 7230210 Broccoli cheese soup, prep w/milk 7230200 Broccoli soup (include cream of broccoli soup)	7514050 Broccoli salad w/cauliflower, cheese, bacon, & dressing Does not include vegetable with meat mixtures.
Cabbage	7510300 Cabbage, raw 7510400 Cabbage, Chinese, raw 7510500 Cabbage, red, raw 7514100 Cabbage salad or coleslaw 7514110 Cabbage salad or coleslaw, w/apples, raisins, dress 7514120 Cabbage salad or coleslaw, w/pineapple, dressing 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 7560120 Cabbage soup 7560121 Cabbage w/meat soup Does not include vegetable with meat mixtures.
Carrots	7310- Carrots (all forms) 7311140 Carrots in Sauce 7311200 Carrot Chips 735- Carrot soup	76201- Carrots, baby 7620200 Carrots & peas, baby Does not include vegetable with meat mixtures.
Corn	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, yellow, canned, low sod., fat not add 7521632 Corn, yellow, canned, low sod., fat added 7521749 Hominy, cooked 752175- Hominy, cooked 7530301 Corn w/peppers, red or green, cooked, no fat added 7541101 Corn scalloped or pudding 7541102 Corn fritter 7541103 Corn with cream sauce 7550101 Corn relish 756040- Corn soup 76405- Corn, baby Does not include vegetable with meat 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 7560451 Cucumber soup, cream of, w/milk Does not include 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 with meat mixtures.
Lima Beans	4110300 Lima beans, dry, cooked, ns as to added fat 4110301 Lima beans, dry, cooked, fat added 4110302 Lime beans, dry, cooked, no fat added 4121011 Stewed dry lima beans, p.r. 4130104 Lima bean soup 4160104 Lima bean soup	7510200 Lima beans, raw 752040- Lima beans, cooked 752041- Lima beans, canned 75301- Beans, lima & corn (succotash) 75402- Lima beans with sauce Does not include vegetable with meat mixtures.
Vegetable Categories continued		

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data (continued)

Food Product	Food Codes	
Okra	7522000 Okra, cooked, not specified 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 with meat mixtures.
Peas	413010- Cowpeas, dry, cooked 413020- Chickpeas, dry, cooked 41303- Split peas, dry, cooked 413035- Stewed green peas 4130403 Peas, dry, cooked w/pork 4130413 Cowpeas, dry, cooked w/pork 4131010 Stewed pigeon peas, p.r. 4131015 Stewed chickpeas, p.r. 4131016 Stewed chickpeas, w/potatoes, p.r. 4131020 Chickpeas, w/pig's feet, p.r. 4131021 Chickpeas, w/spanish sausage, p.r. 4131022 Fried chickpeas, p.r. 4131031 Stewed cowpeas, p.r. 4160201 Chunky pea & ham soup 4160202 Garbanzo or chickpea soup 4160203 Split pea & ham soup 4160204 Pea soup, instant type 4160205 Split pea soup 4160206 Pigeon pea asopao 4160207 Split pea soup, can, reduced sodium, w/water/rts	4160209 Split pea & ham soup, can, reduced sodium, w/water/rts 731110- & 731112- Peas & carrots 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 75315- Peas & corn onions, mushrooms, beans, or potatoes 7541650 Pea salad 7541660 Pea salad with cheese 75417- Peas, with sauce or creamed 75609- Pea soup 76409- Peas, baby 76411- Peas, creamed, baby 7650200 Peas & brown rice, baby Does not include vegetable with meat mixtures.
Peppers	7512140 Pepper, poblano, raw 7512100 Pepper, hot chili, raw 7512150 Pepper, serrano, raw 7512200 Pepper, raw 7512210 Pepper, sweet green, raw 7512220 Pepper, sweet red, raw 7512400 Pepper, banana, 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 7530700 Green peppers & onions, cooked, fat added in cooking 7551101 Peppers, hot, sauce 7551102 Peppers, pickled 7551104 Pepper, hot pickled 7551105 Peppers, hot pickled Does not include vegetable with meat mixtures.
Pumpkin	732- Pumpkin (all forms) 733- Winter squash (all forms) 76205- Squash, baby	Does not include vegetable with meat mixtures.
Snap Beans	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	7530205 Beans, green & potatoes, cooked, no fat added 7530206 Beans, green w/pinto beans, cooked, no fat added 7530207 Beans, green w/spaetzel, cooked, no fat added 7530208 Bean salad, yellow &/or green string beans 7530220 Beans, green string w/onions, ns as to added fat 7530221 Beans, green string w/onions, fat added 7530250 Beans, green & potatoes, ns as to added fat 7530251 Beans, green & potatoes, fat added 7540301 Beans, string, green, creamed 7540302 Beans, string, green, w/mushroom sauce 7540401 Beans, string, yellow, creamed
Vegetable Categories continued		

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data (continued)

Food Product	Food Codes	
Snap Beans continued	7530201 Beans, green string w/tomatoes (assume w/o fat) 7530202 Beans, green string w/onions, cooked, no fat added 7530203 Beans, green string w/chickpeas, cooked, no fat added 7530204 Beans, green string w/almonds, cooked, no fat added	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 7640106 Beans, green string, baby Does not include vegetable with meat mixtures.
Tomatoes	74- Tomatoes and Tomato Mixtures raw, cooked, juices, sauces, mixtures, soups, sandwiches	Also includes the average portion of grain mixtures (16.85%) and the average portion of meat mixtures (i.e., 11.11 percent) made up by tomatoes.
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	76420000 Potatoes, baby Also includes the average portion of meat mixtures (3.33%) made up by meats.
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, sweet potatoes, dp. yellow veg. soups	
Other Vegetables	75- Other Vegetables all forms	
Exposed Vegetables	721- Dark Green Leafy Veg. 722- Dark Green Nonleafy Veg. 7230200 Broccoli soup (include cream of broccoli soup) 7230210 Broccoli cheese soup, prep w/milk 7230500 Escarole soup 7230600 Watercress broth w/shrimp 7230700 Spinach soup 7230800 Dark-green leafy vegetable soup w/meat, oriental 7230850 Dark-green leafy vegetable soup, meatless, oriental 74- Tomatoes and Tomato Mixtures 7510050 Alfalfa Sprouts 7510075 Artichoke, Jerusalem, raw 7510080 Asparagus, raw 75101- Beans, sprouts and green, raw 7510260 Broccoflower, 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 7510955 Cilantro, raw 7511100 Cucumber, raw	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 7514800 Cob salad w/dressing 7520060 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 752087- Broccoflower, cooked 752090- Brussel Sprouts, cooked 75210- Cabbage, Chinese, cooked 75211- Cabbage, green, cooked 75212- Cabbage, red, cooked 752130- Cabbage, savoy, cooked 75214- Cauliflower 75215- Celery, Chives, Christophine (chayote) 752167- Cucumber, cooked
Vegetable Categories continued		

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data (continued)

Food Product	Food Codes			
Exposed Vegetables continued	7511120	Eggplant, raw	7522116	Palm Hearts, cooked
	7511200	Kohlrabi, raw	7522121	Parsley, cooked
	75113-	Lettuce, raw	75226-	Peppers, pimento, cooked
	7511500	Mushrooms, raw	75230-	Sauerkraut, cooked/canned
	7511900	Parsley	75231-	Snowpeas, cooked
	7512100	Pepper, hot chili	75232-	Seaweed
	75122-	Peppers, raw	75233-	Summer Squash
	7512400	Pepper, banana, raw	7530201	Beans, green string w/tomatoes (assume w/o fat)
	7512750	Seaweed, raw	7530202	Beans, green string w/onions, no fat added
	7512775	Snowpeas, raw	7530203	Beans, green string w/chickpeas, cooked, no fat added
	75128-	Summer Squash, raw	7530204	Beans, green string w/almonds, cooked, no fat added
	7513210	Celery Juice	7530205	Beans, green & potatoes, cooked, no fat added
	7514050	Broccoli salad w/cauliflower, cheese, bacon, dressing	7530206	Beans, green w/pinto beans, cooked, no fat added
	7514100	Cabbage or cole slaw	7530207	Beans, green w/spaetzel, cooked, no fat added
	7514110	Cabbage salad or coleslaw w/apples/raisins, dressing	7530208	Bean salad, yellow &/or green string beans
	7514120	Cabbage salad or coleslaw w/pineapple, dressing	7530220	Beans, green string w/onions, ns as to added fat
	7514130	Chinese Cabbage Salad	7530221	Beans, green string w/onions, fat added
	7514150	Celery with cheese	7530250	Beans, green & potatoes, ns as to added fat
	75142-	Cucumber salads	7530251	Beans, green & potatoes, fat added
	75143-	Lettuce salads	7530601	Eggplant in tom sauce, cooked, no fat added
	7514410	Lettuce, wilted with bacon dressing	7530700	Green peppers & onions, cooked, fat added in cooking
	7514500	Seven-layer salad (lettuce, mayo, cheese, egg, peas)	7550314	Cucumber pickles, sweet, reduced salt
	7514600	Greek salad	7550500	Mushrooms, pickled
	7514700	Spinach salad	7550700	Okra, pickled
	7531600	Squash, summer & onions, cooked, no fat added	75510-	Olives
	7531601	Zucchini w/tom sauce, cooked, no fat added in cooking	7551101	Peppers, hot
	7531602	Squash, summer & onions, cooked, fat added	7551102	Peppers, pickled
	7540050	Artichokes, stuffed	7551104	Peppers, hot pickled
	7540101	Asparagus, creamed or with cheese	7551301	Seaweed, pickled
	75403-	Beans, green with sauce	7553500	Zucchini, pickled
	75404-	Beans, yellow with sauce	756010-	Asparagus soup
	7540601	Brussel Sprouts, creamed	756012-	Cabbage soup
	7540701	Cabbage, creamed	756020-	Cauliflower soup, cream of, w/milk
	75409-	Cauliflower, creamed	756030-	Celery soup
	75410-	Celery/Chiles, creamed	7560451	Cucumber soup, cream of, w/milk
	75412-	Eggplant, fried, with sauce, etc.	756046-	Gazpacho
	75413-	Kohlrabi, creamed	75607-	Mushroom soup
	75414-	Mushrooms, Okra, fried, stuffed, creamed	7561201	Zucchini soup, cream of, prep w/milk
	754180-	Squash, baked, fried, creamed, etc.	7564700	Seaweed soup
	7541822	Christophine, creamed	76102-	Dark Green Veg., baby
	7550011	Beans, pickled	76401-	Beans, baby (excl. most soups & mixtures)
	7550051	Celery, pickled	7660400	Broccoli & chicken, baby, strained
	7550201	Cauliflower, pickled	7661150	Green beans & turkey, baby, strained
	755025-	Cabbage, pickled	7731601	Stuffed cabbage w/meat, p.r. (repollo relleno con carne)
	7550301	Cucumber pickles, dill	7731651	Stuffed cabbage w/meat & rice, syrian dish, puerto rican style
	7550302	Cucumber pickles, relish	7731660	Eggplant and meat casserole
	7550303	Cucumber pickles, sour	7756301	Puerto rican stew (sancocho)
	7550304	Cucumber pickles, sweet	Does not include vegetable with meat mixtures.	
	7550305	Cucumber pickles, fresh		
	7550307	Cucumber, Kim Chee		
	7550308	Eggplant, pickled		
	7550311	Cucumber pickles, dill, reduced salt		

Vegetable Categories continued

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data (continued)

Food Product	Food Codes	
Protected Vegetables	411-, 412-, 413- Beans and lentils 414- Soy products 415-, 416-Bean meals 7185-, 7190- Plantains soups etc. 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 7531500 Peas & corn, cooked, ns as to added fat 7531501 Peas & corn, cooked, no fat added	7531502 Peas & corn, cooked, fat added 7531510 Peas & onions, cooked, ns as to added fat 7531511 Peas & onions, cooked, fat not added 7531512 Peas & onions, cooked, fat added 7531521 Peas w/mushrooms, cooked, no fat added 7531525 Cowpeas w/snap beans, cooked, no fat added in cooking 7531530 Peas & potatoes, cooked, no fat added in cooking 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 7560401 Corn soup, cream of, w/milk 7560402 Corn soup, cream of, prepared w/water 7560900 Pea soup, nfs 7560901 Pea soup, prep w/milk 7560802 Pea soup, prepared w/water 7560905 Pea soup, prepared w/water, low sodium 7560906 Pea soup, prepared w/lowfat milk 76205- Squash, yellow, baby 76405- Corn, baby 76409- Peas, baby 76411- Peas, creamed, baby 7650200 Peas and brown rice, baby 7720121 Green plantain w/cracklings, p.r. (Mofongo) 7720511 Ripe plantain fritters, p.r. (Pionono) 7720561 Ripe plantainmeat pie, p.r. (Pinon) Does not include vegetable with meat mixtures.
Root Vegetables	710-, 711-, 712-, 713-, 714-, 715-, 716-, 717-, 7180-, 1793-, 7194-, 7195-, 7196-, 7198- White Potatoes and Puerto Rican St. Veg. 7310- Carrots 7311140 Carrots in sauce 7311200 Carrot chips 734- Sweet potatoes 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 7521840 Leek, cooked 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 7560110 Beet soup (borscht) 7560501 Leek soup, cream of, prep w/milk 7560503 Leek soup, made from dry mix 7560801 Onion soup, cream of, prep w/milk 7560803 Onion soup, cream of, canned, undiluted 7560810 Onion soup, french 7560820 Onion soup, made from dry mix 7560830 Onion soup, dry mix, not reconstituted 76201- Carrots, baby 76209- Sweet potatoes, baby 76403- Beets, baby 7642000 Potatoes, baby 7660200 Carrots & beef, baby, strained 7712101 Fried stuffed potatoes, p.r. (Rellenos de papas) 7712111 Potato & ham fritters, p.r. (frituras de papa y jamon) 7714101 Potato chicken pie, p.r. (Pastelon de pollo) 7723021 Cassava pasteles, p.r. (Pasteles de yuca) 7723051 Cassava pie stuffed w/crab meat, p.r. 7725011 Stuffed tannier fritters, p.r. (Alcapurrias) 7725071 Tannier fritters, p.r. (Frituras de yautia) Does not include vegetable with meat mixtures.
Fat Categories		

Table 3B-1. Food codes and definitions used in analysis of the 1994–1996 USDA CSFII data (continued)

Food Product	Food Codes	
Animal Fat	81201- Bacon grease 81202- Lard 812032- Shortening, animal 8133011 Lard	
Butter	811005- Butter 81101- Butter 81105- Butter 81204- Clarified butter 8132200 Honey butter	
Dressing	83100- 83101- 83102- 83103- 83104- 83105- 83106- 8311- 83200- 83201-	83202- 83203- 83205- 83206- 83207- 83208- 83209- 83210- 83220-
Margarine	81102- 81103- 81104- 81106-	
Mayonnaise	83204- 83107- 83108-	
Sauce	81301– Lemon butter sauce 81302- Sauces, various 81312- Tartar sauce	
Vegetable Oil	812031- Shortening, vegetable 81324- Lechithin 8133021 Adobo fresco 82101- Vegetable oil 82102- Corn oil 82103- Cottonseed & flax seed oil	82104- Olive oil 82105- Peanut, rapeseed, & canola oil 82106- Safflower oil 82107- Sesame oil 82108- Soy and sunflower oil 82109- Wheat germ oil

APPENDIX C FOR CHAPTER 3
Sample Calculation of Mean Daily Fat Intake Based on CDC (1994) Data

CDC (1994) provided data on the mean daily total food energy intake (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% (or 82 g) of their TFEI was from total dietary fat (CDC, 1994). Based on this information, the amount of fat per kcal was calculated as shown in the following example.

$$0.34 \times 2{,}095 \ \frac{\text{kcal}}{\text{day}} \times X \ \frac{\text{g}-\text{fat}}{\text{day}} = 82 \ \frac{\text{g}-\text{fat}}{\text{day}}$$

$$\therefore \ X = 0.12 \ \frac{\text{g}-\text{fat}}{\text{kcal}}$$

where 0.34 is the fraction of fat intake, 2,095 is the total food intake, and X is the conversion factor from kcal/day to g-fat/day.

Using the conversion factor shown above (i.e., 0.12 g-fat/kcal) and the information on the mean daily TFEI and percentage of TFEI for the various age/gender groups, the daily fat intake was calculated for these groups. An example of obtaining the grams of fat from the daily TFEI (1,591 kcal/day) for children ages 3–5 years and their percent TFEI from total dietary fat (33%) is as follows:

$$1{,}591 \ \frac{\text{kcal}}{\text{day}} \times 0.33 \times 0.12 \ \frac{\text{g}-\text{fat}}{\text{kcal}} = 63 \ \frac{\text{g}-\text{fat}}{\text{day}}$$

APPENDIX D FOR CHAPTER 3

Table 3D-1. 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 ruit fjuice 534- Frozen fruit juice 535- Aseptically packed fruit juice 536- Fresh 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
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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
Individual Foods continued		
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
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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
Individual Foods continued		
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
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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
Individual Foods continued		
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
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. rozen 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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
Individual Foods continued		
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
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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
Individual Foods continued		
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
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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
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 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	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 uice 6420101 Apricot nectar 64205- Peach nectar 64215- Pear nectar 67102- Applesauce, baby 67108- Peaches, baby 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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
Exposed/Protected Fruits/Vegetables, Root Vegetables continued		
Exposed Fruits continued	5423106 Peaches, dry 5423107 Pears, dry 5423114 Berries, dry 5423115 Cherries, dry Includes baby foods	
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 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	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 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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition		Individual Code	
Exposed/Protected Fruits/Vegetables, Root Vegetables continued				
Protected Fruits continued	5423111	Mangos, dry		
	5423117	Litchis, dry		
	5423118	Tamarind, dry		
	5423119	Plantain, dry		
	Includes baby foods			
Exposed Vegetables	491-	Fresh dark green vegetables	721-	Dark green leafy Veg.
	493-	Fresh tomatoes	722-	Dark green nonleafy Veg.
	4941-	Fresh asparagus	74-	Tomatoes and tomato mixtures
	4943-	Fresh beans, snap or wax	7510050	Alfalfa sprouts
	4944-	Fresh cabbage	7510075	Artichoke, Jerusalem, raw
	4945-	Fresh lettuce	7510080	Asparagus, raw
	4946-	Fresh okra	75101-	Beans, sprouts and green, raw
	49481-	Fresh artichokes	7510275	Brussels sprouts, raw
	49483-	Fresh Brussel sprouts	7510280	Buckwheat Sprouts, raw
	4951-	Fresh celery	7510300	Cabbage, raw
	4952-	Fresh cucumbers	7510400	Cabbage, Chinese, raw
	4955-	Fresh cauliflower	7510500	Cabbage, red, raw
	4958103	Fresh kohlrabi	7510700	Cauliflower, raw
	4958111	Fresh Jerusalem artichokes	7510900	Celery, raw
	4958112	Fresh mushrooms	7510950	Chives, raw
	4958113	Mushrooms, home canned	7511100	Cucumber, raw
	4958114	Mushrooms, home frozen	7511120	Eggplant, raw
	4958118	Fresh eggplant	7511200	Kohlrabi, raw
	4958119	Eggplant, cooked	75113-	Lettuce, raw
	4958120	Eggplant, home frozen	7511500	Mushrooms, raw
	4958200	Fresh Summer squash	7511900	Parsley
	4958201	Summer squash, cooked	7512100	Pepper, hot chili
	4958202	Summer squash, home canned	75122-	Peppers, raw
	4958203	Summer squash, home frozen	7512750	Seaweed, raw
	4958402	Fresh bean sprouts	7512775	Snowpeas, raw
	4958403	Fresh alfalfa sprouts	75128-	Summer squash, raw
	4958504	Bamboo shoots	7513210	Celery juice
	4958506	Seaweed	7514100	Cabbage or cole slaw
	4958508	Tree fern, fresh	7514130	Chinese cabbage Salad
	4958601	Sauerkraut	7514150	Celery with cheese
	5111-	Dark green Vegetables (all are exposed)	75142-	Cucumber salads
	5113-	Tomatoes	75143-	Lettuce salads
	5114101	Asparagus, comm. canned	7514410	Lettuce, wilted with bacon dressing
	51144-	Beans, green, snap, yellow, comm. canned	7514600	Greek salad
	5114704	Snow Peas, comm. canned	7514700	Spinach salad
	5114801	Sauerkraut, comm. canned	7520600	Algae, dried
	5114901	Artichokes, comm. canned	75201-	Artichoke, cooked
	5114902	Bamboo Shoots, comm. canned	75202-	Asparagus, cooked
	5114903	Bean Sprouts, comm. canned	75203-	Bamboo shoots, cooked
	5114904	Cabbage, comm. canned	752049-	Beans, string, cooked
	5114905	Cabbage, comm. canned, no sauce	75205-	Beans, green, cooked/canned
	5114906	Cauliflower, comm. canned, no sauce	75206-	Beans, yellow, cooked/canned
	5114907	Eggplant, comm. canned, no sauce	75207-	Bean sprouts, cooked
	5114913	Mushrooms, comm. canned	752085-	Breadfruit
	5114914	Okra, comm. canned	752090-	Brussels sprouts, cooked
	5114918	Seaweeds, comm. canned	75210-	Cabbage, Chinese, cooked
	5114920	Summer squash, comm. canned	75211-	Cabbage, green, cooked
	5114923	Chinese or celery cabbage, comm. canned	75212-	Cabbage, red, cooked

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
Exposed/Protected Fruits/Vegetables, Root Vegetables continued		
Protected Vegetable	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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
Exposed/Protected Fruits/Vegetables, Root Vegetables continued		
Rooted Vegetable	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
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

Table 3D-1. Food codes and definitions used in analysis of the 1987–88 USDA NFCS data (continued)

Food Product	Household Code/Definition	Individual Code
USDA Subcategories continued		
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- Dried 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 672110 Orange-Apple-Banana Juice, baby food Excludes dried fruits
Other Fruits	62- Fresh Other Vitamin C-Rich Fruits 503- Fresh Other Fruits 5122- Comm. Canned Fruits Other than Citrus 5222- Frozen Strawberries 5332- Frozen Other than Citr. or Vitamin C-Rich Fr. 5333- Canned Fruit Juice Other than Citrus 5352- Frozen Juices Other than Citrus 5362- Aseptically Packed Fruit Juice Other than Citr. 542- Fresh Fruit Juice Other than Citrus Dry Fruits Includes baby foods; excludes dried fruits)	543- 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

APPENDIX E FOR CHAPTER 3
Statistical Notes

Estimates based on small cell sizes may tend to be less statistically reliable than estimates based on larger cell sizes. Cell size refers to the unweighted number of individuals in a given sex- age group or demographic group. The guidelines (listed below) for determining when a cell size is small take into account the average design effect for the survey. The design effect results from the complex sample design and from the procedures used to weight the data. When the design effect is 1.00, its effect on accuracy is negligible; a larger design effect implies a greater effect on variance. The guidelines derive from a policy statement (FASEB/LSRO 1995) that specifies the use of a broadly calculated design effect. In that role a variance inflation factor is being used. Variance inflation factors used to generate the estimates in this table set were calculated on individuals 19 years of age and under; they are as follows:

Day-1, CSFII 1994- 96, 1998 – 2.24
2-day, CSFII 1994- 96, 1998 – 2.50

In the tables, estimates that may tend to be less statistically reliable are flagged with a footnote directing the reader to this appendix. The rules used for flagging estimates are listed below, and tables to which each rule applies are identified.

1. An estimated mean is flagged when it is based on a cell size of less than 30 times the average design effect or when its coefficient of variation (CV) is equal to or greater than 30%. The CV is the ratio of the estimated standard error of the mean to the estimated mean, expressed as a percentage.

   Rule 1 has been applied to data in Tables 3-28, 3-30, 3-32, 3-34, 3-36, 3-38, and 3-40 to flag estimates that should be used with caution. It applies to mean nutrient intakes, mean food intakes, and means expressed as percentages, such as mean intakes of nutrients expressed as percentages of Recommended Dietary Allowances and percentages of nutrients from foods eaten as snacks.

2. An estimated proportion (percent) that falls above 25% and below 75% is flagged when it is based on a cell size of less than 30 times the average design effect or when the CV is equal to or greater than 30%.

3. An estimated proportion of 25% or lower or 75% or higher is flagged when the smaller of np and n(1- p) is less than 8 times the average design effect, where "n" is the cell size on which the estimate is based and "p" is the proportion expressed as a fraction.

   Rules 2 and 3 have been applied to data in Tables 3-29, 3-31, 3-33, 3-35, 3-37, 3-39, and 3-41 to flag estimates that should be used with caution.

REFERENCES FOR CHAPTER 3

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4. DRINKING WATER INTAKE

4.1. INTRODUCTION

Drinking water is a potential source of human exposure to toxic substances among children. 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 toxicants 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 among children (section 4.2) and to provide recommendations of consumption rate values that should be used in exposure assessments (section 4.3).

EPA's current default drinking water intake rate uses the quantity for infants (individuals of 10 kg body mass or less) and children is 1 L/day (U.S. EPA, 1980, 1991). This rate includes drinking water consumed in the form of juices and other beverages containing tapwater. The National Academy of Sciences has estimated that daily consumption of water may vary with levels of physical activity and fluctuations in temperature and humidity (NAS, 1977). It is reasonable to assume that children engaging in physically demanding activities or living in warmer regions may have higher levels of water intake.

Two studies cited in this chapter have generated data on drinking water intake rates. In general, these sources support EPA's use of 1 L/day as an upper-percentile tapwater intake rate for children under 10 years of age. The studies have reported intake rates for direct and indirect ingestion of water. *Direct intake* is defined as direct consumption of water as a beverage; *indirect intake* includes water added during food preparation but not water intrinsic to purchased foods. Data for consumption of various sources (i.e., community water supply, bottled water, and other sources) are also presented. For the purposes of exposure assessments involving site-specific contaminated drinking water, intake rates based on the community supply are most appropriate. Given the assumption that bottled water and other purchased foods and beverages are widely distributed and less likely to contain source-specific water, the use of total water intake rates may overestimate the potential exposure to toxic substances present only in local water supplies; therefore, tapwater intake of community water rather than total water intake is emphasized in this section.

The 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 available drinking water surveys 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 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 they are 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 the 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.

Other studies based on older data were presented in *Exposure Factors Handbook* (U.S. EPA, 1997a).

4.2. DRINKING WATER INTAKE STUDIES

4.2.1. U.S. EPA, 2000a

EPA used data from a USDA survey from 1994 through 1996 to estimate drinking water ingestion rates by the U.S. population. The Continuous Study of Food Intakes by Individuals (CSFII) is a continuing survey of food consumption habits in the U.S. More than 15,000 persons responded to the study conducted between 1994 and 1996 on what they ate and drank over two nonconsecutive days (USDA, 1998). EPA used the drinking water ingestion data to derive estimates of consumption rates by age groups, gender, water source, and vulnerable subsets of the population (i.e., lactating and pregnant women) (U.S. EPA, 2000a). The ingestion rates are expressed in both volume (mL) per day per person and volume per kilogram (kg) body weight per day. The purpose of the report was to provide data to assist in estimating human health risks from the ingestion of contaminated or potentially contaminated drinking water.

In the study, EPA reported that community water (i.e., tapwater from the public water supply) accounts for approximately 75% of the mean ingested water. The total water consumption consists of community water supply, bottled water, other sources, and missing sources. Other sources include household wells or cisterns or a spring, either household or community. In addition to these sources, the data also distinguish between direct and indirect water consumption. Direct consumption is water consumed directly from the tap, whereas indirect consumption is water added during final food or beverage preparation in the home or food establishment (e.g., restaurants, school cafeterias). Indirect water does not include water added by the food manufacturer during food processing. Table 4-1 provides the estimates for the mean total direct and indirect water consumption by water source for 1994 to 1996 per person combined for all ages. The estimates also include consumption rates for the 90th percentile and the 95th percentile plus the upper and lower bounds for each percentile.

Table 4-2 shows the estimated total direct and indirect water ingestion by all sources by broad age groups and percentiles. Tables 4-3 and 4-4 show daily community water consumption rate estimates by fine and broad age groups in units of mL/day and mL per mass of body weight per day. Tables 4-5 and 4-6 present data for bottled water ingestion. Water consumption rates for other sources of water are compiled in Tables 4-7 and 4-8. The data are broken down into multiple population subsets including children's age groups: less than 1 year, 1 to 10 years, and 11 to 19 years. The data show that although the total quantity of water ingested (mL/kg/day) decreases with age, the quantity consumed per unit mass of body weight (mL/person-day) increases. For instance, Table 4-4 shows that the mean community water consumption is 342 mL/child/day for under 1 year, 400 mL/child/day for 1 to 10 years, and 683 mL/child/day for 11 to 19 years. The consumption as a function of unit mass, however, is 46 mL/kilogram-day for under 1 year, 19 mL/kg-day for 1 to 10 years, and 12 mL/kg-day for 11 to 19 years. The significance of this finding is that although children may encounter lower overall doses, the younger, vulnerable ages (i.e., infants) have significantly higher dose rates per unit of body weight.

These two sources comprise nearly one-quarter of total water consumption. The trend in the data is similar to that shown for community water consumption; that is, the younger ages consume less of these sources of water, but the quantity consumed per unit mass of body weight increases as age decreases. Missing water sources have not been included in the summary of water sources because of negligible quantity. Missing water sources comprise only about 1% of water consumption.

The data collected from the CSFII study for the USDA have both strengths and limitations. The strengths lie in the design of the survey in that it was intended to collect a statistically representative sample of the U.S. population (i.e., to obtain data from a sufficiently large sample set), and the survey was sufficiently specific in detailing types of food and drink. The large size of the sample population (> 15,000 total and 6000 children) enhances the precision and accuracy of the estimates for the overall population and population subsets. The survey was conducted on nonconsecutive days, which improves the variance over consecutive days of consumption. In addition, the survey was administered such that an interviewer went through the data collection process for the initial day to show the participants the proper response methodology. The second day of the survey was reported by the participant. The survey also represents the most up-to-date water consumption information, and it incorporated sufficient parameters to differentiate sources of water, ages, gender, weight, and vulnerable populations.

The limitations of the survey involve the short duration of the study and some of the data reporting methods. The short duration (2 nonconsecutive days)—although an advantage over 2 consecutive days—diminishes the precision of an individual's water ingestion rate. The mean for an individual can easily be skewed for numerous reasons. The large number of the sample population would hopefully contribute to greater accuracy, but the precision may still be low. The data reporting did not always support variance estimation for some reported population subsets. The means differences could not always be statistically tested except for the larger population subsets. Therefore, the reported differences were derived empirically instead of statistically.

4.2.2. U.S. EPA, 2000b

U.S. EPA (2000b) presented a system of procedures to fit distributions to selected data from the draft *Exposure Factors Handbook* (EFH) (U.S. EPA, 1996). The system was based on EPA's *Guiding Principles for Monte Carlo Analysis* (U.S. EPA, 1997b). The system was applied to the dataset of total tapwater intake reported in Table 3-7 of the EFH; the data summaries analyzed by U.S. EPA (2000b) consist of nine estimated percentiles for total daily tapwater intake in mL/kg-day. Only the values for infants, children, and teens are reported here.

The statistical methodology recommended by U.S. EPA (2000b) incorporates: (1) a dataset and its underlying experimental design, (2) a family of models, and (3) an approach to inference (e.g., estimation, assessment of fit, and uncertainty analysis). The system used a 12-model hierarchy, with the most general model being a five-parameter generalized F distribution with a point mass at zero. The point mass at zero represents the proportion of nonconsuming or nonexposed individuals. As described in U.S. EPA (2000b), the 12 models of the generalized F hierarchy were fit to each of the three tapwater datasets (i.e., three age groups of children) using three different estimation criteria: maximum likelihood estimation (MLE), minimum chi-square estimation, and weighted least squares (WLS). The Pearson chi-square tests and likelihood ratio tests of goodness-of-fit (GOF) were used. Tables 4-9 and 4-10 present chi-square values and associated p-values for chi-square GOF tests, respectively. U.S. EPA (2000b) noted that in each case the null hypothesis tested is that the data arose from the given type of model and that a low p-value casts doubt on the null hypothesis. The GenF5 model that appears to fit most of the datasets is the five-parameter generalized F distribution with a point mass at zero (U.S. EPA, 2000b). According to Table 4-9, the gamma model provides the best fit (smallest chi-square) of the two-parameter models to the data for each individual age groups.

Table 4-11 presents the results of the statistical modeling of tapwater data using five-parameter generalized F and two-parameter gamma, lognormal, and Weibull models. The authors noted that the infants group does not contain results from the five-parameter generalized F because the selected model had infinite variance. For the gamma and Weibull models, there was little difference between the three estimation criteria, and the MLE performed best overall; for the lognormal model, results from the WLS estimation criterion are shown in addition to the MLE.

U.S. EPA (2000b) recommends use of the gamma model with parameters estimated by MLE if a two-parameter model for tapwater consumption is used. U.S. EPA (2000b) also noted that the five-parameter generalized F distribution could be used for sensitivity analyses, and the age effect seems sufficiently strong to justify the use of separate age groups in risk assessment.

4.3. RECOMMENDATIONS

The studies described in this section were used in selecting recommended drinking water (tapwater) consumption rates for children. A summary of the recommended values for drinking water intake rates is presented in Table 4-12. The intake rates generally increase with age, and the data are consistent across ages for the studies.

A characterization of the overall confidence in the accuracy and appropriateness of the recommendations for drinking water is presented in Table 4-13. *Exposure Factors Handbook* (U.S. EPA, 1997a) gave this factor a medium confidence rating. However, the confidence score of the overall recommendations has been increased to high for this report because of the addition of the newer EPA study (U.S. EPA, 2000a).

Table 4-1. Estimated direct and indirect community total water ingestion by source for U.S. population[a]

Source	Mean[b]			90th percentile[b]			95th percentile[b]		
	Estimate	Lower bound	Upper bound	Estimate	Lower bound	Upper bound	Estimate	Lower bound	Upper bound
Community water supply	927	902	951	2016	1991	2047	2544	2485	2576
Bottled water	161	147	176	591	591	632	1036	1006	1065
Other sources	128	101	155	343	305	360	1007	947	1074
Missing sources	16	13	20	0	0	0	0	0	0
All sources	1232	1199	1265	2341	2308	2366	2908	2840	2960

[a] Estimates are based on 2-day averages for nonconsecutive days, sample size = 15,303.
[b] Units are mL/person/day; 90% CI.

Source: USDA Continuing Survey of Food Intakes by Individuals (1994-1996), in U.S. EPA, 2000a

Table 4-2. Estimate of total direct and indirect water ingestion, all sources by broad age category for U.S. children

Age (years)	Sample Size	Mean	Percentile								
			1th	5th	10th	25th	50th	75th	90th	95th	99th
Quantity (mL/person-day)											
< 1	359	484	0	0	0	124	449	747	949	1182	1,645[a]
1–10	3980	528	4	75	133	254	444	710	1001	1242	1891
11–19	1641	907	0	118	219	395	715	1188	1780	2185	3805
Quantity (mL/kg-day)											
< 1	359	67	0	0	0	16	57	101	156	170	218[a]
1–10	3980	25	0	4	6	12	21	33	49	64	98
11–19	1641	16	0	2	4	7	13	20	30	39	64

[a] Sample size was insufficient for minimum reporting requirements according to "Third Report on Nutritional Monitoring in the U.S. (1994–96)."

Source: 1994–96 USDA Survey of Food Intakes by Individuals (CSFII), in USEPA 2000a

Table 4-3. Estimate of direct and indirect community water ingestion by fine age category for U.S. children

Age (years)	Sample Size	Mean	Percentile								
			1th	5th	10th	25th	50th	75th	90th	95th	99th
Quantity (mL/person-day)											
< 0.5	199	280	0[a]	0	0	0	35	552	861	945[b]	1,286[b]
0.5–0.9	160	412	0	0	0	36	322	712	884	1,101[b]	1,645[b]
1–3	1834	313	0	0	0	74	236	469	691	942	1,358
4–6	1203	420	0	0	22	133	330	591	917	1165	1,902[b]
7–10	943	453	0	0	29	139	355	671	978	1219	1,914[b]
11–14	816	594	0	0	27	181	435	801	1365	1722	2,541[b]
15–19	825	760	0	0	25	201	540	1030	1610	2062	3,830[b]
Quantity (mL/kg-day)											
< 0.5	191	47	0	0	0	0	5	90	139	170[b]	217[b]
0.5–0.9	153	45	0	0	0	4	36	79	103	122[b]	169[b]
1–3	1752	23	0	0	1	6	17	33	51	67	109[b]
4–6	1113	21	0	0	1	6	16	29	44	64	91[b]
7–10	879	15	0	0	1	5	11	21	32	39	60[b]
11–14	790	12	0	0	1	4	9	17	26	34	54[b]
15–19	816	12	0	0	0	3	9	16	25	32	61[b]

[a] Denotes zero.
[b] Sample size was insufficient for minimum reporting requirements according to "Third Report on Nutritional Monitoring in the U.S. (1994-96)."

Source: 1994–96 USDA Survey of Food Intakes by Individuals (CSFII), in USEPA 2000a

Table 4-4. Estimate of direct and indirect community water ingestion by broad age category for U.S. children

Age (years)	Sample Size	Mean	Percentile								
			1th	5th	10th	25th	50th	75th	90th	95th	99th
Quantity (mL/person-day)											
< 1	344	342	0[a]	0	0	0	173	652	878	1040	1438[b]
1–10	3744	400	0	0	12	118	302	571	905	1118	1731
11–19	1606	683	0	0	26	191	473	937	1533	1946	3671
Quantity (mL/kg-day)											
< 1	344	46	0	0	0	0	19	82	127	156	205[b]
1–10	3744	19	0	0	0	5	15	27	42	56	91
11–19	1606	12	0	0	1	3	9	16	26	33	59

[a] Denotes zero.
[b] Sample size was insufficient for minimum reporting requirements according to "Third Report on Nutritional Monitoring in the U.S. (1994–96)."

Source: 1994–96 USDA Survey of Food Intakes by Individuals (CSFII), in USEPA 2000a

Table 4-5. Estimate of direct and indirect bottled water ingestion by fine age category for U.S. children

Age (years)	Sample Size	Mean	Percentile								
			1th	5th	10th	25th	50th	75th	90th	95th	99th
Quantity (mL/person-day)											
< 0.5	199	110	0[a]	0	0	0	0	38	519	809	1045[b]
0.5–0.9	160	113	0	0	0	0	0	5	496	727[b]	1006[b]
1–3	1834	62	0	0	0	0	0	0	235	411	820
4–6	1203	73	0	0	0	0	0	0	279	521	915[b]
7–10	943	76	0	0	0	0	0	0	271	497	917[b]
11–14	816	100	0	0	0	0	0	0	344	679	1415[b]
15–19	825	130	0	0	0	0	0	0	468	867	1775[b]
Quantity (mL/kg-day)											
< 0.5	191	20	0	0	0	0	0	6	81	152[a]	170[b]
0.5–0.9	153	14	0	0	0	0	0	2	51	92[a]	125[b]
1–3	1752	5	0	0	0	0	0	0	17	30	61
4–6	1113	4	0	0	0	0	0	0	13	24	49[b]
7–10	879	2	0	0	0	0	0	0	8	14	26[b]
11–14	790	2	0	0	0	0	0	0	7	13	27[b]
15–19	816	2	0	0	0	0	0	0	7	12	28[b]

[a] Denotes zero.
[b] Sample size was insufficient for minimum reporting requirements according to "Third Report on Nutritional Monitoring in the U.S. (1994–96)."

Source: 1994–96 USDA Survey of Food Intakes by Individuals (CSFII), in USEPA (2000a)

Table 4-6. Estimate of direct and indirect bottled water ingestion by broad age category for U.S. children

Age (years)	Sample Size	Mean	Percentile								
			1th	5th	10th	25th	50th	75th	90th	95th	99th
Quantity (mL/person-day)											
< 1	359	111	0[a]	0	0	0	0	23	522	793	1083[b]
1–10	3980	71	0	0	0	0	0	0	264	472	906
11–19	1641	116	0	0	0	0	0	0	414	764	1648
Quantity (mL/kg-day)											
< 1	344	17	0	0	0	0	0	5	76	123	169[b]
1–10	3744	3	0	0	0	0	0	0	12	22	49
11–19	1606	2	0	0	0	0	0	0	7	13	28

[a] Denotes zero.
[b] Sample size was insufficient for minimum reporting requirements according to “Third Report on Nutritional Monitoring in the U.S. (1994–96).”

Source: 1994–96 USDA Survey of Food Intakes by Individuals (CSFII), in USEPA 2000a

Table 4-7. Estimate of direct and indirect other water ingestion by fine age category for U.S. children

Age (years)	Sample Size	Mean	Percentile								
			1th	5th	10th	25th	50th	75th	90th	95th	99th
Quantity (mL/person-day)											
< 0.5	199	18	0[a]	0	0	0	0	0	0	86[a]	468[b]
0.5–0.9	160	30	0	0	0	0	0	0	23	202[a]	554[b]
1–3	1834	35	0	0	0	0	0	0	8	295	710
4–6	1203	43	0	0	0	0	0	0	32	322	830[b]
7–10	943	67	0	0	0	0	0	0	206	554	1049[b]
11–14	816	106	0	0	0	0	0	0	341	800	1811[b]
15–19	825	77	0	0	0	0	0	0	234	552	1411[b]
Quantity (mL/kg-day)											
< 0.5	191	3	0	0	0	0	0	0	0	15[a]	86[b]
0.5–0.9	153	3	0	0	0	0	0	0	5	24[a]	63[b]
1–3	1752	3	0	0	0	0	0	0	2	21	48
4–6	1113	2	0	0	0	0	0	0	2	15	42[b]
7–10	879	2	0	0	0	0	0	0	7	18	37[b]
11–14	790	2	0	0	0	0	0	0	7	16	36[b]
15–19	816	1	0	0	0	0	0	0	4	9	21[b]

[a] Denotes zero.
[b] Sample size was insufficient for minimum reporting requirements according to “Third Report on Nutritional Monitoring in the U.S. (1994–96).”

Source: 1994–96 USDA Survey of Food Intakes by Individuals (CSFII), in USEPA 2000a

Table 4-8. Estimate of direct and indirect other water ingestion by broad age category for U.S. children

Age (years)	Sample Size	Mean	Percentile								
			1th	5th	10th	25th	50th	75th	90th	95th	99th
Quantity (mL/person-day)											
< 1	359	23	0[a]	0	0	0	0	0	0	148	556[b]
1–10	3980	50	0	0	0	0	0	0	103	405	920
11–19	1641	90	0	0	0	0	0	0	286	666	1710
Quantity (mL/kg-day)											
< 1	344	3	0	0	0	0	0	0	0	21	66[b]
1–10	3744	2	0	0	0	0	0	0	5	18	43
11–19	1606	2	0	0	0	0	0	0	5	11	29

[a] Denotes zero.
[b] Sample size was insufficient for minimum reporting requirements according to "Third Report on Nutritional Monitoring in the U.S. (1994–96)."

Source: 1994–96 USDA Survey of Food Intakes by Individuals (CSFII), in USEPA 2000a

Table 4-9. Chi-square GOF statistics for 12 models[a], tapwater data, based on maximum likelihood method of parameter estimation

Age group (years)	CHI Gam2	CHI Log2	CHI Tic2	CHI Wei2	CHI Ggam3	CHI GenF4	CHI Gam3	CHI Log3	CHI Tic3	CHI Wei3	CHI Ggam4	CHI GenF5
Infants (< 1)	19.8	26.6	39.4	20.6	18.1	10.6	19.8	13.7	10.8	20.6	18.1	8.10
Children (1–10)	84.5	315	295	198	84.7	40.3	46.6	129	195	198	27.5	15.2
Teens (11–19)	89.5	606	557	125	81.4	38.4	23.4	286	377	110	23.1	7.88

[a] Prefix indicates model type; Gam = gamma, Log = lognormal, Tic = log-logistic, Wei = Weibull, Ggam = generalized gamma, GenF = generalized F; suffix indicates number of free or adjustable parameters.

Source: U.S. EPA, 2000b

Table 4-10. P-values for chi-square GOF tests of 12 models[a], tapwater data

Age Group (years)	PGOF Gam2	PGOF Log2	PGOF Tic2	PGOF Wei2	PGOF Ggam3	PGOF GenF4	PGOF Gam3	PGOF Log3	PGOF Tic3	PGOF Wei3	PGOF Ggam4	PGOF GenF5
Infants (< 1)	0.001	0.000	0.000	0.000	0.000	0.005	0.000	0.003	0.013	0.000	0.000	0.013
Children (1–10)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
Teens (11–19)	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.096

[a] Prefix indicates model type; Gam = gamma, Log = lognormal, Tic = log-logistic, Wei = Weibull, Ggam = generalized gamma, GenF = generalized F; Model suffix indicates number of free or adjustable parameters.

Source: U.S. EPA, 2000b

Table 4-11. Results of statistical modeling of tapwater data (intake rates in dL/kg-day) using 5-parameter generalized F and 2-parameter gamma, lognormal and Weibull models

Source[a]	N	P01	P05	P10	P25	P50	P75	P90	P95	P99	MEAN	SDEV	CHIDF[b]	PGOF[c]
Infants (< 1 year)[d]														
data	403	0.010	0.050	0.100	0.250	0.500	0.750	0.900	0.950	0.990	0.435	0.425		
gammle					0.252	0.526	0.702	0.908	0.951	0.996	0.448	0.410	40.945	0.0006
weimle					0.260	0.526	0.699	0.906	0.950	0.996	0.447	0.412	50.145	0.0004
logmle					0.227	0.561	0.735	0.903	0.937	0.984	0.470	0.548	60.660	0.0000
logwls					0.216	0.559	0.738	0.908	0.942	0.986	0.462	0.512	60.974	0.0000
Children (1–10 years)														
data	5605	0.010	0.050	0.100	0.250	0.500	0.750	0.900	0.950	0.990	0.355	0.229		
gammle		0.010	0.047	0.106	0.250	0.495	0.752	0.900	0.952	0.989	0.356	0.234	30.792	0.0044
gf5mle		0.004	0.052	0.118	0.263	0.492	0.738	0.895	0.953	0.993	0.355	0.224	120.07	0.0000
weimle		0.000	0.024	0.091	0.266	0.529	0.765	0.895	0.943	0.984	0.356	0.250	270.18	0.0000
logmle		0.011	0.070	0.134	0.264	0.474	0.721	0.894	0.959	0.997	0.355	0.218	280.34	0.0000
logwls		0.000	0.036	0.113	0.288	0.532	0.750	0.878	0.929	0.977	0.366	0.286	450.07	0.0000
Teens (11–19 years)														
data	5801	0.010	0.050	0.100	0.250	0.500	0.750	0.900	0.950	0.990	0.182	0.108		
gf5mle		0.010	0.048	0.103	0.253	0.498	0.747	0.953	0.953	0.989	0.182	0.110	10.969	0.0962
gammle		0.002	0.046	0.110	0.274	0.511	0.740	0.947	0.947	0.989	0.182	0.111	120.79	0.0000
weimle		0.006	0.061	0.122	0.267	0.487	0.725	0.957	0.957	0.995	0.182	0.106	170.86	0.0000
logmle		0.000	0.017	0.076	0.270	0.544	0.768	0.942	0.942	0.981	0.182	0.119	450.35	0.0000
logwls		0.000	0.032	0.108	0.303	0.548	0.747	0.920	0.920	0.968	0.189	0.144	860.56	0.0000

[a] Data = data summary, gammle = gamma model using maximum likelihood estimation (MLE), weimle = Weibull modeling use MLE, logmle = lognormal= model using MLE, logwls = lognormal model using weighted least square (WLS), gf5mle = five parameter generalized F with a point mass at zero.
[b] CHIDF is the value of the chi-square statistic divided by its degrees of freedom.
[c] PGOF is the p-value for model goodness-of-fit, based on the chi-square test.
[d] The infants group does not contain results for gf5mle because the selected model had infinite variance.

Source: U.S. EPA, 2000b

Table 4-12. Summary of recommended community drinking water intake rates

Age Group/ Population	Mean	Percentiles				Fitted Distributions
		50th	90th	95th	Multiple	
<1 year[a]	0.34 L/day 46 mL/kg-day	0.17 L/day 19 mL/kg-day	0.88 L/day 127 mL/kg-day	1.0 L/day 156 mL/kg-day	Tables 4-4	Table 4-11[b]
1-3 years[a]	0.31 L/day 23 mL/kg-day	0.24 17 mL/kg-day	0.69 L/day 51 mL/kg-day	0.94 L/day 67 mL/kg-day	Table 4-3	
1-10 years[a]	0.40 L/day 19 mL/kg-day	0.30 L/day 15 mL/kg-day	0.90 L/day 42 mL/kg-day	1.1 L/day 56 mL/kg-day	Table 4-4	Table 4-11[b]
11-19 years[a]	0.68 L/day 12 mL/kg-day	0.47 L/day 9 mL/kg-day	1.5 L/day 26 mL/kg-day	1.9 L/day 33 mL/kg-day	Tables 4-4	Table 4-11[b]

[a] Source: U.S. EPA, 2000a
[b] Source: U.S. EPA, 2000b

Table 4-13. Confidence in tapwater intake recommendations

Considerations	Rationale	Rating
Study Elements		
Level of peer review	U.S. EPA (2000) had thorough expert panel review. Other reports presented are published in scientific journals.	High
Accessibility	The monograph is available from the sponsoring agency; the other is library-accessible.	High
Reproducibility	Methods are well-described.	High
Focus on factor of interest	The studies are directly relevant to tapwater. In addition, U.S. EPA (2000) included consumption for other drinking water sources	High
Data pertinent to U.S.	See “representativeness” below.	NA
Primary data	The three monographs used recent primary data (less than 1 week) on recall of intake.	High
Currency	Data collected for USDA (1998) and used in U.S. EPA (2000) are current.	High
Adequacy of data collection period	These are 1- to 3-day intake data. However, long term variability may be small. Their use as a chronic intake measure can be assumed.	Medium
Validity of approach	The approach was competently executed.	High
Study size	U.S. EPA (2000) had sufficient sample populations (i.e., 6000) for the study.	High
Representativeness of the population	The U.S. EPA (2000) survey was validated as demographically representative.	High
Characterization of variability	The full distributions were given in the main study.	High
Lack of bias in study design (high rating is desirable)	Bias was not 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	There were two key studies for the recommendations.	High
Agreement between researchers	This agreement was good.	High

Overall Rating	The data are excellent and current.	**High**

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5. SOIL INGESTION AND PICA

5.1. INTRODUCTION

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 do 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. 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. Recommended intake rates are based on the results of key studies presented in *Exposure Factors Handbook* (U.S. EPA, 1997) and summarized here. Relevant information on the prevalence of pica and intake among individuals exhibiting pica behavior is also presented.

5.2. SOIL INTAKE STUDIES

5.2.1. Binder et al., 1986

Binder et al. (1986) used a tracer technique modified from a method previously used to measure soil ingestion among grazing animals to study the ingestion of soil among children 1 to 3 years of age who wore diapers. 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, MT. 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 the 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 on the basis of each of the three tracer elements using a standard assumed fecal dry weight of 15 g/day and the following equation:

$$T_{i,e} = \frac{f_{i,e} \times F_i}{s_{i,e}} \qquad (5\text{-}1)$$

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 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) 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 was estimated to be 181 mg/day (range 25 to 1324), based on the aluminum tracer; 184 mg/day (range 31 to 799), based on the silicon tracer; and 1834 mg/day (range 4 to 17,076), based on the titanium tracer (Table 5-1). 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 median values were 121, 136, and 618 mg/day for aluminum, silicon, and titanium, respectively. The 95th percentile values for aluminum, silicon, and titanium were 584, 578, and 9590 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 they 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 (> 1000 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.

5.2.2. Clausing et al., 1987

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 years who attended 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, soil ingestion was estimated for each tracer. Eight daily fecal samples were also collected from six hospitalized, bedridden children. These children served as a control group, representing children who had very limited access to soil.

The average quantity of soil ingested by the school children in this study was as follows: 230 mg/day (range 23 to 979) for aluminum, 129 mg/day (range 48 to 362) for AIR, and 1430 mg/day (range 64 to 11,620) for titanium (Table 5-2). As in the Binder et al. (1986) study, a fraction of the children (6/19) showed titanium values well above 1000 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). 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 on the assumption that the maximum amount of soil ingested cannot be higher than the lowest estimate for the individual tracers.

Mean (arithmetic) soil intake for the hospitalized children was estimated to be 56 mg/day, based on aluminum (Table 5-3). For titanium, three of the children had estimates well in excess of 1000 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). The geometric mean soil intake rate was 45 mg/day. The data on the 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) were not considered. AIR measurements were not reported for the hospitalized children. Assuming that the tracer-based soil ingestion rates observed in the 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).

The advantages of this study are that the investigators evaluated soil ingestion among two populations of children that had differences in access to soil, and they corrected soil intake rates based on background estimates derived from the hospitalized group. However, a smaller number of children was 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. In addition, one of the factors that could affect soil intake rates is hygiene (e.g., hand-washing frequency). Hygienic practices can vary across countries and cultures and may be more stringently emphasized in a more structured environment such as child care centers in The Netherlands and other European countries than in child care centers in the United States.

5.2.3. Calabrese et al., 1989

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 study, eight tracer elements—aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium—were analyzed instead of only three (aluminum, silicon, and titanium). A total of 64 children between the ages of 1 and 4 years were included in the study. These children were all selected from the greater Amherst, MA area and were predominantly from two-parent households where the parents were highly educated. The study was conducted over 8 days during a 2-week period and included the use of a mass-balance methodology in which—in addition to soil and dust samples collected from the child's home and play area—duplicate samples of food, beverages, medicines, and vitamins were collected and analyzed on a daily basis,. Fecal and urine samples were also collected and analyzed for tracer elements. Toothpaste, which is low in tracer content, was provided to all participants.

In order to validate the mass-balance methodology used to estimate soil ingestion rates among the children and to determine which tracer elements provided the most reliable data on soil ingestion, known amounts of soil (300 mg over 3 days and 1500 mg over 3 days) containing eight tracers were administered to six adult volunteers (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. On the basis of the adult validation study, the investigators confirmed that the tracer methodology could adequately detect tracer elements in feces at levels expected to correspond with soil intake rates in children. They 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%. The recovery of these three tracers ranged from 120 to 153% when 300 mg of soil had been ingested over a 3-day period and from 88 to 94% when 1500 mg soil had been ingested over a 3-day period (Table 5-4).

Using the three most reliable tracer elements, the mean soil intake rate for the 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 5-5). Median intake rates were somewhat lower (29 mg/day for aluminum, 40 mg/day for silicon, and 9 mg/day for yttrium). Upper-percentile (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 ingestions were combined (Table 5-5). Intake of soil and dust was estimated using a weighted ingestion for one child in the study and ranged from approximately 10 to 14 g/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 it may not be entirely representative of the U.S. population because it was selected from a single location.

5.2.4. Davis et al., 1990

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 7-day period, primarily during the summer. Daily soil ingestion was evaluated for aluminum, silicon, and titanium by collecting and analyzing soil and house dust samples, feces, urine, and duplicate food samples. 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:

$$S_{i,e} = \frac{\{[(DW_f + DW_P) \times 2E_f] + 3E_u\} - (_{Dwfd} \times E_{fd})}{E_{soil}} \qquad (5\text{-}2)$$

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 5-6). Median values were 25 mg/day for aluminum, 59 mg/day for silicon, and 81 mg/day for titanium. The investigators 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. It was also observed that the following demographic characteristics were associated with high soil intake rates: male sex, nonwhite racial group, low income, operator/laborer as the principal occupation of the parent, and city of residence. However, none of these factors was predictive of soil intake rates when tested using multiple linear regression.

The advantages of this study are that soil intake rates were corrected on the basis of the tracer content of foods and medicines and that a relatively large number of children was sampled. Also, demographic and behavioral information was collected for the survey group. However, although the sample was relatively large sample, the 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 1-week period during the summer and may not be representative of long-term (i.e., annual) patterns of intake.

5.2.5. Van Wïjnen et al., 1990

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 (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 day care 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 (at the beginning and near the end of the summer of 1986). In addition, total of 78 children vacationing at campgrounds and 15 hospitalized children were sampled. The mean values for three groups were 162 mg/day for children in daycare centers, 213 mg/day for campers, and 93 mg/day for hospitalized children.

The authors also 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 day care centers, 174 mg/day for children vacationing at campgrounds (Table 5-7), and 74 mg/day for hospitalized children (70–120 mg/day, based on the 95% confidence limits of the mean). AIR was the limiting tracer in about 80 percent of the samples. Among children attending day care centers, soil intake was also found to be higher when the weather was good (< 2 days/wk precipitation) than when the weather was bad (> 4 days/wk precipitation (Table 5-8).

The authors 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 day care 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 Wijnen et al. (1990) considered the tracer measurements for the hospitalized cihildred as background levels and used the average of these values to correct soil intake rates for children in daycare centers and in campgrounds. Among the limitations of this study is that tracer concentrations in food and medicine were not evaluated. Also, the population of children studied was relatively large, but it may not be representative of the U.S. population. The 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. An additional limitation is that values were not reported element-by-element, which would be the preferred way of reporting. Furthermore, one of the factors that could affect soil intake rates is hygiene (e.g., hand-washing frequency). Hygienic practices can vary across countries and cultures and may be more stringently emphasized in a more structured environment such as child care centers in The Netherlands and other European countries than in child care centers in the United States.

5.2.6. Stanek and Calabrese, 1995a

Stanek and Calabrese (1995a) presented a methodology that links the physical passage of food and fecal samples to construct daily soil ingestion estimates from daily food and fecal trace-element concentrations. The investigators reanalyzed soil ingestion data for children obtained from the Amherst study (Calabrese et al., 1989). In the Amherst study, soil ingestion measurements were made over a period of 2 weeks for a nonrandom sample of 64 children (ages 1–4 years) 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 were aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium.

Stanek and Calabrese (1995a) 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 noon on Monday to noon on Tuesday. On the basis of 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 lognormal distributions to the "overall" daily soil ingestion estimates.

Table 5-9 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 estimating ingestion, the mean estimates decreased for aluminum (153 mg/day to 122 mg/day) and silicon (154 mg/day to 139 mg/day) but increased for titanium (218 mg/day to 271 mg/day) and yttrium (85 mg/day to 165 mg/day). The "overall" mean estimate from this reanalysis was 179 mg/d. Table 5-9 presents the empirical distribution of the the "overall" mean daily 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% of the children and 208 mg/day or less for 95% 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 on the lognormal models fit to the daily ingestion estimates (Table 5-10). The estimated median value of the 64 respondents' daily soil ingestion averaged over a year is 75 mg/day, wheras the 95th percentile is 1751 mg/day.

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. Although the authors attempted to address this through lognormal modeling of the long-term intake, new uncertainties were 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 5-9, are substantially more reliable than any available distributional estimates.

5.2.7. Stanek and Calabrese, 1995b

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 considerably smaller compared as with 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 children, the investigators used data on eight tracers from Calabrese et al. (1989) and data on three 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 aluminum, silicon, titanium, yttrium, and zirconium. The mean soil ingestion rate was 132 mg/day and the median was 33 mg/day based on the median of soil ingestion estimates from the best four tracers. 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 (aluminum, silicon, and titanium) 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 (95^{th} percentile), using the BTM.

This study provides a reevaluation of previous studies. Its advantages are that it combines data from two 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 those described in the summaries of the Calabrese et al. (1989), Davis et al. (1990), and Calabrese et al. (1990) studies.

5.2.8. Thompson and Burmaster, 1991

Thompson and Burmaster (1991) developed parameterized distributions of soil ingestion rates for children on the basis of a reanalysis of the key study data collected by Binder et al. (1986). In the Binder et al. study, an assumed fecal weight of 15 g/day was used. Thompson and Burmaster reestimated the soil ingestion rates from the Binder et al. study using the actual rather than the assumed stool weights of the study participants. 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 5-11 presents the distribution of estimated soil ingestion rates calculated by Thompson and Burmaster (1991) based on the three tracers elements (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 1004 mg/day for titanium. The 90th percentile estimates were 197 mg/day for aluminum, 166 mg/day for silicon, and 2105 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.

The investigators 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. 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 5-11 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.

5.2.9. Sedman and Mahmood, 1994

Sedman and Mahmood (1994) used the results of two of the key children's tracer studies (Calabrese et al. 1989; Davis et al. 1990) to determine estimates of average daily and lifetime soil ingestion in young children. In the two key studies, the intake and excretion of a variety of tracers were monitored, and concentrations of tracers in soil adjacent to the children's 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 (the 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 tracer (Y) from both studies to reflect that of a 2-year-old child using the following equation:

$$Y_i = xe^{(-0.112*yr)} \tag{5-3}$$

where:

Y_i = adjusted mean soil ingestion (mg/day)
x = a constant
yr = average age (2 years)

The average ages of the children in the two key 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 2-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, the authors 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 estimates were derived using the equation presented above that describes changes in soil ingestion with age.

5.2.10. Calabrese and Stanek, 1995

Calabrese and Stanek (1995) explored the sources and magnitude of positive and negative errors in soil ingestion estimates for children on a subject-week and trace element basis. They identified possible sources of positive errors to be

- ingestion of high levels of tracers before the study starts and low ingestion during study period, resulting in over estimation of soil ingestion; and

- ingestion of element tracers from a nonfood or nonsoil source during the study period.

Possible sources of negative bias were identified as

- tracers in ingested food not being captured in the fecal sample due either to slow lag time or to not having a fecal sample available on the final study day, and

- sample measurement errors that result in diminished detection of fecal tracers but not in soil tracer levels.

The authors developed an approach that 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-hour day a fecal sample was obtained, (3) the median tracer-based soil ingestion rate for each subject-day was determined, and (4) negative errors due to missing fecal samples at the end of the study period were also determined. Also, upper- and lower-bound estimates were determined, based on criteria formed using an assumption of the magnitude of the relative standard deviation presented in 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.

Table 5-12 presents the estimated magnitude of positive and negative error for six tracer elements in the children's study (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 5-12). 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 5-12). 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 study is valuable for 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 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 much values for that tracer differed 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.

5.2.11. Calabrese et al., 1997

Calabrese et al. (1997) estimated soil ingestion rates for children residing on a Superfund site using a mass-balance methodology in which eight tracer elements (aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium) were analyzed. The methodology used in this study is very similar to the one used by in Calabrese et al. (1989). As in the Calabrese et al. (1989) study, 64 children ages 1–4 years were selected for this study and were predominantly from two-parent households. This stratified simple random sample of children was selected from the Anoconda, MT area. Thirty-six of the 64 children were male, and the children ranged in age from 1 to 4 years, with approximately an equal number of children in each age group. The study was conducted for 7 consecutive days during a 2-week period in September. Duplicate samples of meals, beverages, and over- the-counter medicines and vitamins were collected over the 7-day period, along with fecal samples. In addition, soil and dust samples were collected from the children's homes and play areas. Toothpaste containing nondetectable levels of the tracer elements, with the exception of silica, was provided to all of the children. Infants were provided with baby cornstarch, diaper rash cream, and soap, which were found to contain low levels of tracer elements.

As in Calabrese et al. (1989), an additional study was conducted in which the identical mass-balance methodology used to estimate soil ingestion rates among children was used on adults in order to validate that soil ingestion could be detected. Known amounts of soil were administered to 10 adults (5 males, 5 females) from western Massachusetts over a period of 28 days. Each adult ingested for 7 consecutive days (1) no soil during week 1, (2) 20 mg of sterilized soil during week 2, (3) 100 mg of sterilized soil during week 3, and (4) 500 mg of sterilized soil during week 4. Soil samples were previously characterized and were of sufficient concentration to be detected in the analysis of fecal samples. Duplicate food and fecal samples were collected every day during each study week and analyzed for eight tracer elements (aluminum, silicon, titanium, cerium, lanthanum, neodymium, yttrium, and zirconium). It was found that ingestion of soil from 20 to 500 mg/day could be detected in a reliable manner.

The investigators estimated soil ingestion by each tracer element using BTM, which allows for the selection of the most recoverable tracer for a particular group of subjects (Stanek and Calabrese, 1995b). In this case, barium, manganese, and vanadium were dropped, as they were found to be poor performing tracers. The median soil ingestion estimates for the four best trace elements, based on F/S ratios for the 64 children using aluminum, silicon, titanium, yttrium, and zirconium are presented (Table 5-13). The best estimate was calculated by taking the median of the best four trace elements. Based on the soil ingestion estimate for the best tracer, the mean soil ingestion rate was 66 mg/day, and the median was 20 mg/day. The 95th percentile value was 282 mg/day. Using the median of the four best tracers, the mean was 7 mg/day and the 95th percentile was 160 mg/day. These results are lower than the soil ingestion estimates obtained by Stanek and Calabrese (1995a). Calabrese et al. (1997) believe that this may be due to the fact that the families of the children who participated in this study were aware that they lived on an EPA Superfund site and thus may have limited their children's exposure to soil. There was no statistically significant difference found in soil ingestion estimates by gender or age. There was also no significant difference in soil ingestion by housing or yard characteristics (i.e., porch, deck, door mat, etc.) or between children with or without pets.

The median dust ingestion estimates for the four best tracer elements using aluminum, silicon, titanium, yttrium, and zirconium are also presented (Table 5-14). The estimate is based on food/dust ratios for the 64 Anaconda children. The mean dust ingestion rate, based on the best tracer, was 127 mg/day, and the 95th percentile rate was 614 mg/day.

The advantages of this study were the use of a consecutive 7-day study period rather than two periods of 3 and 4 days as in Stanek and Calabrese (1995a), the use of the BTM, the use of an expanded adult validation study that used 10 volunteers rather than 6 as in Calabrese et al. (1989), and the use of a dietary education program to reduce food tracer input and variability. However, the data presented in this study are from a single 7-day period during September, which may not reflect soil ingestion rates for other months or time periods. In addition, the study displayed a net residual negative error, which may have resulted in underestimated soil ingestion rates. The authors believe that this error did not likely affect the median by more than 40 mg/day.

5.3. SOIL PICA

5.3.1. Prevalence

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 published articles have reported on the incidence of pica among various populations. However, most of these articles describe pica for substances other than soil, including sand, clay, paint, plaster, hair, string, cloth, glass, matches, paper, feces, and various other items. These articles 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 among different subpopulations. The incidence rate appears to be higher for black children than for white children. Approximately 30% of black children aged 1 to 6 years are reported to have deliberate ingestion behavior, compared with 10 to 18% of white children in the same age group (Danford, 1982). There does not appear to be any 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 (50 to 60%) than in higher income families (about 30%). 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, earth eating, was about 16% among children from a rural black community in Mississippi. However, geophagia was described as a cultural practice in 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” among 91 nonblack, low-income families of migrant agricultural workers in California to be 19% in children, 14% in pregnant women, and 3% in nonpregnant women. However, “dirt” was not clearly defined. On the basis of data from the five key tracer studies (Binder et al., 1986; Clausing et al., 1987; Van Wïjnen 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 data for 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. However, it is incumbent upon users to select the appropriate value for their specific study population.

5.3.2. Pica 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.

5.3.2.1. *Calabrese et al., 1991*

Calabrese et al. (1991) estimated that upper range soil ingestion values may range from approximately 5 to 7 g/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 1 of the 2 weeks of observation. Intake ranged from 74 mg/day to 2.2 g/day during the first week of observation and from 10.1 to 13.6 g/day during the second week of observation (Table 5-15). These results are based on mass-balance analyses for seven tracer elements (aluminum, barium, manganese, silicon, titanium, vanadium, and yttrium) of the eight used. Intake rates based on zirconium werr significantly lower, but the authors indicated that this may have "resulted from a limitation in the analytical protocol."

5.3.2.2. *Calabrese and Stanek, 1992*

Using a methodology that compared differential element ratios, Calabrese and Stanek (1992) quantitatively distinguished outdoor soil ingestion from indoor dust ingestion in a soil pica child. This study was based on a previous mass-balance study (Calabrese et al., 1991) in which a 3.5-year-old child ingested 10–13 g/day of soil over the second week of a 2-week soil ingestion study. Also, the previous study used a soil tracer methodology with eight tracers (aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium). The reader is referred to Calabrese et al. (1989) for a detailed description and results of the soil ingestion study.

Table 5-16 presents tracer ratios of soil, dust, and residual fecal samples in the soil pica child. The authors 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 5-16. Of these 19 pairs, nine fecal tracer ratios fell within the boundaries for soil and dust (Table 5-16). For these nine 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% of the fecal tracer ratios from soil origin. Also, the nine residual fecal samples within the boundaries revealed that a high percentage (71–99%) of the residual fecal tracers were estimated to be of soil origin. Therefore, the authors 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 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (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).

5.3.2.3. *Calabrese and Stanek, 1993*

Calabrese and Stanek (1993) reviewed a study by Wong (1988) that attempted to estimate the amount of soil ingested by two groups of children. Wong studied a total of 52 children in two government institutions in Jamaica. The younger group (from the Glenhope Place of Safety) contained 24 children with an average age of 3.1 years (ranging from 0.3 to 7.6 years). The older group (from the Reddies Place of Safety) contained 28 children with an average age of 7.2 years (ranging from 1.8 to 14 years). Fecal samples were obtained from the subject children, and the amount of silicon in dry feces was measured in order to quantify soil ingestion.

An unspecified number of daily fecal samples were collected from a hospital control group of 30 children with an average age of 4.8 years (ranging from 0.3 to 12 years). Dry feces were observed to contain 1.45% silicon, or 14.5 mg of silicon per 1 g of dry feces. This amount of silicon in dry feces was assumed to be representative of the typical background amount of silicon from dietary sources only. Observed quantities of silicon greater than 1.45% were then assumed to be from soil ingestion.

The amount of soil ingested was calculated by using the standard soil ingestion estimation formula (Binder et al. 1986). One fecal sample was collected from each subject per month over the 4-month study period.

For the 28 children in the older group, soil ingestion was estimated to be 58 mg/day, based on the mean minus one outlier, and 1520 mg/day, based on the mean of all the children. The outlier was a child with an estimated average soil ingestion rate of 41 g/day over the 4 months. Of the 28 children in the group, 7 had an average soil ingestion of > 100 mg/day, 4 of > 200 mg/day, and 1 of > 300 mg/day; 8 showed no indication of soil ingestion for any month.

Estimated average soil ingestion in the younger group of children was higher. The mean soil ingestion of all the children was 470 ± 370 mg/day. Due to some sample losses, of the 24 children studied, only 15 subjects had samples for each of the 4 months. Of the 24 children, 14 had an average soil ingestion of < 100 mg/day, 10 of > 100 mg/day, 5 of > 600 mg/day, and 4 of > 1000 mg/day; 5 showed no indication of soil ingestion for any month.

Over the entire 4-month study period, 9 of 84 total samples (or 10.5%) showed soil ingestion estimates of > 1 g/day (pica behavior). Of the 52 children studied, 6 displayed soil pica behavior. The estimated soil ingestion for each of these subjects is shown in Table 5-17. For the younger group of children, 5 of 24 (or 20.8%) displayed soil pica behavior on at least one occasion. A high degree of daily variability in soil ingestion was observed among the six children who exhibited pica behavior. As shown in Table 5-17, three of six children (#11, 12, and 22) showed soil pica on only 1 of 4 days. The other three (#14, 18, and 27) ingested ≥ 1.0 g/day on 2 of 4, on 3 of 4, and on 4 of 4 days, respectively. Subject #27 displayed a high degree of soil pica, ranging from 3.7 to 60.6 g/day of soil ingestion; however, it was indicated that this child was mentally retarded, whereas the other pica children were considered to have normal mental capabilities.

Sources of uncertainty or error in this study include differences between the hospital study group (the background control) and the two study groups, lack of information on the dietary intake of silicon for the studied children, use of a single fecal sample, and loss of fecal samples. The use of a single soil tracer may also introduce error, because there may be other sources from which the tracer could originate. For example, some toothpastes have extremely high concentrations of silicon, and children could ingest significant quantities of toothpaste. Additionally, tracers could be found in indoor dust that children may ingest. However, despite these uncertainties, the results are important in that they indicate that soil pica is not a rare occurrence in younger children.

5.4. RECOMMENDATIONS

The studies described in this section were used to recommend values for soil intake among children. Estimates of the amount of soil ingested by children are summarized in Table 5-18, and the recommended values are presented in Table 5-19. The mean values range from 39 mg/day to 271 mg/day, with an average of 138 mg/day for soil ingestion and 193 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 is the best estimate of the mean for children under 6 years of age. However, because the children were studied for short periods 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 1432 mg/day, with an average of 358 mg/day for soil ingestion and 790 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, because the period of study was short, these values are not estimates of usual intake.

Data on soil ingestion rates for children who deliberately ingest soil are also limited. An ingestion rate of 10 g/day is a reasonable value 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, where the intake ranged from 10 to 14 g/day during the second week of observation. In addition, a statistical designation is not assigned to this value.

It should be noted that these recommendations are based on studies that used different survey designs and populations. For example, some of the studies considered food and nonfood sources of trace elements, whereas others 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 5-20. It is important, however, to understand the various uncertainties associated with these values.

First, individuals were not studied for sufficient periods of time to obtain 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 parents' 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 that 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.

Table 5-1. Estimated daily soil ingestion based on aluminum, silicon, and titanium concentrations

Estimation method	Soil ingestion (mg/day)				
	Mean ± SD	Median	Range	95th percentile	Geometric mean
Aluminum	181 ± 203	121	25–1324	584	128
Silicon	184 ± 175	136	31–799	578	130
Titanium	1834 ± 3091	618	4–17,076	9590	401
Minimum	108 ± 121	88	4–708	386	65

Source: Binder et al., 1986

Table 5-2. Calculated soil ingestion by nursery school children

Child	N	Soil ingestion (mg/day)			
		Calculated from Ti	Calculated from Al	Calculated from AIR	Limiting Tracer
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

Ti =titanium
Al = aluminum
AIR = acid-insoluble residue

Source: Adapted from Clausing et al., 1987

Table 5-3. Calculated soil ingestion by hospitalized, bedridden children

Child	Sample	Soil ingestion (mg/day)		Limiting Tracer (mg/day)
		Calculated from Ti	Calculated from Al	
1	G5 G6	3290 4790	57 71	57 71
2	G1	28	26	26
3	G2 G8	6570 2480	94 57	84 57
4	G3	28	77	28
5	G4	1100	30	30
6	G7	58	38	38
Arithmetic Mean		2293	56	49

Ti = titanium
Al = aluminum

Source: Adapted from Clausing et al., 1987

Table 5-4. Mean and standard deviation percentage recovery of eight tracer elements

Tracer Element	Percentage recovered	
	300 mg soil ingested Mean ± SD	1500 mg soil ingested Mean ± SD
Aluminum	152.8 ±107.5	93.5 ± 15.5
Barium	2304.3 ± 4533.0	149.8 ± 69.5
Manganese	1177.2 ± 1341.0	248.3 ± 183.6
Silicon	139.3 ± 149.6	91.8 ± 16.6
Titanium	251.5 ± 316.0	286.3 ± 380.0
Vanadium	345.0 ± 247.0	147.6 ± 66.8
Yttrium	120.5 ± 42.4	87.5 ± 12.6
Zirconium	80.6 ± 43.7	54.6 ± 33.4

Source: Adapted from Calabrese et al., 1989

Table 5-5. Soil and dust ingestion estimates for children ages 1–4 years[a] (mg/day)

Tracer Element	N	Intake (mg/day)[a]			
		Mean ± SD	Median	95th percentile	Maximum
Aluminum					
Soil	64	153 ± 852	29	223	6837
Dust	64	317 ± 1,272	31	506	8462
Soil/dust combined	64	154 ± 629	30	478	4929
Silicon					
Soil	64	154 ±693	40	276	5,549
Dust	64	964 ±6848	49	692	54,870
Soil/dust combined	64	483 ±3105	49	653	24,900
Yttrium					
Soil	62	85 ±890	9	106	6,736
Dust	64	62 ±687	15	169	5,096
Soil/dust combined	62	65 ±717	11	159	5,269
Titanium					
Soil	64	218 ±1150	55	1432	6,707
Dust	64	163 ±659	28	1266	3,354
Soil/dust combined	64	170 ±691	30	1059	3,597

[a] Corrected for Tracer Concentrations in Foods

Source: Adapted from Calabrese et al. (1989)

Table 5-6. Average daily soil ingestion values based on aluminum, silicon, and titanium as tracer elements[a]

Element	Soil ingestion (mg/day)		
	Mean ± SE	Median	Range[b]
Aluminum	38.9 ± 14.4	25.3	279.0–904.5
Silicon	82.4 ± 12.2	59.4	–404.0–534.6
Titanium	245.5 ± 119.7	81.3	–5820.8–6182.2
Minimum	38.9 ± 12.2	25.3	–5820.8
Maximum	245.5 ± 119.7	81.3	6182.2

[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

Table 5-7. Geometric mean (GM) and standard deviation (GSD) LTM values for children at daycare centers and campgrounds (mg/day)

Age (years)	Sex	Daycare Centers			Campgrounds		
		N	GM LTM	GSD LTM	N	GM LTM	GSD LTM
< 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 5-8. Estimated geometric mean (GM) LTM values of children attending daycare centers according to weather category, age, and sampling period (mg/day)

Weather Category	Age (years)	First sampling period		Second sampling period	
		n	Estimated GM LTM Value	n	Estimated GM LTM Value
Bad (> 4 days/wk precipitation)	< 1	3	94	3	67
	1–< 2	18	103	33	80
	2–< 3	33	109	48	91
	4–< 5	5	124	6	109
Reasonable (2–3 days/wk precipitation)	< 1			1	61
	1–< 2			10	96
	2–< 3			13	99
	3–< 4			19	94
	4–< 5			1	61
Good (< 2 days/wk precipitation)	< 1	4	102		
	1–< 2	42	229		
	2–< 3	65	166		
	3–< 4	67	138		
	4–< 5	10	132		

Source: Van Wijnen et al. (1990)

Table 5-9. Per child distribution of average (mean) daily soil ingestion estimates by trace for 64 children[a]

Category	Soil ingestion (mg/day)								
	Overall (N = 64)	A1 (N = 64)	Ba (N = 33)	Mn (N = 19)	Si (N = 63)	Ti (N = 56)	V (N = 52)	Y (N = 61)	Zr (N = 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 "overall" column 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.

Al = aluminum
Ba = barium
Mn = manganese
Si = silicon
Ti = titanium
V = vanadium
Y = yttrium
Zr = zirconium

Source: Stanek and Calabrese, 1995a

Table 5-10. Estimated distribution of individual mean daily soil ingestion based on data for 64 subjects projected over 365 days[a]

Category	Soil ingestion (mg/day)
Range	1–2268[b]
50th percentile (median)	75
90th percentile	1190
95th percentile	1751

[a] Based on fitting a lognormal distribution to model daily soil ingestion values.
[b] Subject with pica excluded.

Source: Stanek and Calabrese, 1995a

Table 5-11. Summary statistics and parameters for distributions of estimated soil ingestion by tracer element[a]

	Soil ingestion (mg/day)			
	Aluminum	**Silicon**	**Titanium**	**Mean[b]**
Mean	97	85	1,004	91
Minimum	11	10	1	13
10th percentile	21	19	3	22
20th percentile	33	23	22	34
30th percentile	39	36	47	43
40th percentile	43	52	172	49
Median	45	60	293	59
60th percentile	55	65	475	69
70th percentile	73	79	724	92
80th percentile	104	106	1,071	100
90th percentile	197	166	2,105	143
Maximum	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] Using Binder et al. (1986) data with actual fecal weights.
[b] Arithmetic average of soil ingestion based on aluminum and silicon.

Source: Thompson and Burmaster, 1991

Table 5-12. Positive/negative error (bias) in soil ingestion estimates in the Calabrese et al. (1989) mass-balance study—effect on mean soil ingestion estimate (mg/day)[a]

Tracer element	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

Table 5-13. Soil ingestion estimates for the median of best four tracer elements based on food/soil ratios for 64 Anaconda children using aluminum, silicon, titanium, yttrium, and zirconium

Category	Soil ingestion (mg/day)										
	Min	P5	P10	SP25	P50	SP75	P90	P95	Max	Mean	SD
Median of best four	–101.3	–91.0	–53.8	–38.0	–2.4	26.8	73.1	159.8	380.2	6.8	74.5
Best tracer	–53.4	–24.4	–14.4	2.2	20.1	68.9	223.6	282.4	609.9	65.5	120.3
Second best	–115.9	–62.1	–48.6	–26.6	1.5	38.4	119.5	262.3	928.5	33.2	144.8
Third best	–170.5	–88.9	–67.0	–52.0	–18.8	25.6	154.7	376.1	1293.5	31.2	199.6
Fourth best	–298.3	–171.0	–131.9	–74.7	–29.3	0.2	74.8	116.8	139.1	–34.6	79.7

Source: Calabrese et al., 1997

Table 5-14. Dust ingestion estimates for the median of best four trace elements based on food/dust ratios for 64 Anaconda children using aluminum, silicon, titanium, yttrium, and zirconium

Category	Soil ingestion (mg/day)										
	Min	P5	P10	SP25	P50	SP75	P90	P95	Max	Mean	SD
Median of best four	–261.5	–186.2	–152.7	–69.5	–5.5	62.8	209.2	353.0	683.9	16.5	160.9
Best tracer	–377.0	–193.8	–91.0	–20.8	26.8	198.1	558.6	613.6	1499.4	127.2	299.1
Second best	–239.8	–147.2	–137.1	–59.1	7.6	153.1	356.4	409.5	1685.1	82.7	283.6
Third best	–375.7	–247.5	–203.1	–81.7	–14.4	49.4	406.5	500.5	913.2	25.5	235.9
Fourth best	–542.7	–365.6	–277.7	–161.5	–55.1	52.4	277.3	248.8	6120.5	81.8	840.3

Source: Calabrese et al., 1997

Table 5-15. Daily soil ingestion estimation in a soil-pica child by tracer and by week

Tracer element	Estimated soil ingestion (mg/day)	
	Week 1	Week 2
Aluminum	74	13,600
Barium	458	12,088
Manganese	2,221	12,341
Silicon	142	10,955
Titanium	1,543	11,870
Vanadium	1,269	10,071
Yttrium	147	13,325
Zirconium	86	2,695

Source: Calabrese et al., 1991

Table 5-16. Ratios of soil, residual fecal, and dust samples in the soil pica child

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

Source: Calabrese and Stanek, 1992

Table 5-17. Daily variation of soil ingestion by children displaying soil pica in Wong (1988)

Child subject number	Month	Estimated soil ingestion (mg/day)
Glenhope Place of Study		
11	1	55
	2	1,447
	3	22
	4	40
12	1	0
	2	0
	3	7,924
	4	192
14	1	1,016
	2	464
	3	2,690
	4	898
18	1	30
	2	10,343
	3	4,222
	4	1,404
22	1	0
	2	—
	3	5,341
	4	0
Reddles Place of Study		
27	1	48,314
	2	60,692
	3	51,422
	4	3,782

Source: Calabrese and Stanek, 1993

Table 5-18. Summary of estimates of soil ingestion by children

Soil ingestion (mg/day)									References
Mean					Upper percentile				
Al	Si	AIR	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[a]	160[a]		268.4[a]						
153	154		218.0	85	223	276	1,432	106	Calabrese et al., 1989
154[a]	483[a]		170.0[b]	65[a]	478[a]	653[a]	1,059[a]	159[a]	
122	139		271.0	165	254	224	279	144	Stanek and Calabrese, 1995a
133[c]					217[b]				Stanek and Calabrese, 1995b
69–120[c]									Van Wijnen et al., 1990
66[b]					280[b]				Calabrese et al., 1997
196[a]					994[a]				
Average: 138 (soil) 193 (soil and dust combined)					358 (soil) 790 (soil and dust combined)				

[a] Soil and dust combined
[b] Best tracer method
[c] Limited tracer method; corrected value

Al = aluminum
Si = silicon
AIR = acid-insoluble residue
Ti = titanium
Y = yttrium

Table 5-19. Summary of recommended values for soil ingestion

Population	Soil ingestion	
	Mean	Upper Percentile
Children (age 1–6 years)	100 mg/day[a]	400 mg/day[b]
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).

Table 5-20. Confidence in soil intake recommendation

Considerations	Rationale	Rating
Study Elements		
Level of peer review	All key studies are from peer-reviewed 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	All 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 absorption 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 a few adults have been studied.	Medium (for children) Low (for adults)
Representativeness of the population	The study population may not be representative of the U.S. in terms of race, socioeconomics, 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 seven 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)

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6. OTHER NONDIETARY INGESTION FACTORS

6.1. INTRODUCTION

Young children (i.e., ages 6 months through approximately 4 years) have the potential for exposure to toxic substances through nondietary ingestion pathways other than soil ingestion (e.g., ingesting pesticide residues that have been transferred from treated surfaces to the hands or objects that are mouthed). These children have an urge to mouth objects or their fingers in exploring their environment, as a sucking reflex and as a habit (Groot et al., 1998). Exposure via this route may exceed that of other routes of ingestion (i.e., food, pica, drinking water, breast milk) and dermal exposure, because nondietary ingestion may result in higher ingestion rates of contaminated material (Weaver et al., 1998). This exposure route is also difficult to model, because there is little literature or research on mouthing behavior (Reed et al., 1999) and little information on the susceptibility of children to toxic substances (Weaver et al., 1998).

Mouthing behavior includes all activities in which objects, including fingers, are touched by the mouth or put into the mouth except for eating and drinking and includes licking, sucking, chewing, and biting (Groot et al., 1998). Children's contact with surfaces is intermittent and nonuniform over different parts of the body and the nature of the mouthing itself is intermittent and nonuniform, also making this pathway difficult to model (Zartarian et al., 1997).

Children exhibit large differences in mouthing behavior (Groot et al., 1998). Infants are born with a sucking reflex for breast-feeding, and within a few months, they begin to use sucking or mouthing as a means to explore their surroundings. Children will use both sucking and licking to explore their environment. Sucking also becomes a means of comfort when a child is tired or upset. In addition, teething normally causes substantial mouthing behavior—sucking or chewing—to alleviate discomfort in the gums. Each child is different, and large differences occur even between children in the same family.

Where mouthing becomes critical in exposure to potentially toxic substances is the small child's proximity to and behavior around potentially contaminated sources. Children play close to the ground and are constantly licking their fingers or mouthing toys or objects. As a result, mouthing becomes a potentially significant exposure route. Children can ingest more toxic constituents through this behavior than from dietary ingestion or inhalation because they may place wet, sticky fingers on potentially contaminated surfaces, and more toxic constituents may adhere than if the fingers were dry (Gurunathan et al., 1998).

Gurunathan et al. (1998) estimated that young children spend as much as 90% of their days inside, so exposure to contaminants that may infiltrate the home through the vapor phase (e.g., volatile organic compounds [VOCs] and semi-vocs [SVOCs]) may be of concern. This may be a significant pathway of exposure to SVOCs, because these compounds can be deposited on surfaces in the home or become absorbed onto plastic toys or settle onto stuffed animals, where they can serve as reservoirs for toxic constituents (Gurunathan et al., 1998).

Few studies have investigated this potential exposure route. The shortage of research and data may be due to the difficulty in observing very young children and the labor-intensive effort in gathering the data (Hubal et al., 2000). The applicable research efforts use two general approaches to gather data: real-time hand recording, in which trained persons observe a child and manually record information on a survey sheet or score sheet, and videotaping, in which trained videographers tape a child's activities and subsequently extract the pertinent data manually or with computer software (Hubel et al., 2000).

Some researchers express mouthing behavior in terms of frequency of occurrence (e.g., contacts per hour, contacts per minute). Others express mouthing behavior as a rate in units of minutes per hour of mouthing time. Both approaches have their use in exposure assessments. The former approach is more appropriate when studying children's behavior during various microactivities. The latter, however, is more useful when studying children's behavior during macroactivities. Macroactivities can be described by a child's general activities, such as sleeping, watching television, playing, and eating. Microactivities refer to the specific behavior a child is engaged in, such as hand-to-surface contacts and hand-to-mouth behavior (Hubel et al., 2000). Time spent in various macroactivities in several microenvironments (e.g., indoors at home) is presented in Chapter 9.

6.2. STUDIES RELATED TO NONDIETARY INGESTION

6.2.1. Davis, 1995

In 1992, the Fred Hutchinson Cancer Research Center, under a Cooperative Agreement with EPA, conducted a study to estimate children's soil intake rates and collect mouthing behavior data. Originally, the study was designed with two primary purposes: (1) to describe and quantify the distribution of soil ingestion values in a group of children under the age of 5 who exhibit behaviors that would be likely to result in the ingestion of larger than normal amounts of soil, and (2) to assess and quantify the degree to which soil ingestion varies among children according to season of the year (summer vs. winter). The study was conducted during the first 4 months of 1992 and included 92 children from the Tri-Cities area in Washington State.

The children were volunteers among a group selected through random digit dialing and their ages ranged between 0 and 48 months. The study was conducted during a 7-day period.

Because there was no standard methodology to study mouthing behavior, a pretest and a series of pilot studies were conducted to examine various aspects of the methodology. As a result of the pilot studies, it was determined that although parents could be taught to conduct observations using the instrument, the resulting ranking of children according to degree of mouthing behavior did not correspond very well to the rankings based on observations of the same children by trained staff observers. Therefore, using parents' observations to select a group with high mouthing activity was not deemed appropriate. Funding constraints made it impractical to continue with the original design of screening a large number of children and conducting field work during two different times of the year.

The Davis (1995) research recognizes that mouthing behavior is intermittent. Therefore, a method called "interval method" of observation was used. This method measures both frequency and duration of the behavior. Under this method, children were observed during 15 second intervals, during which the mouthing behavior was recorded. Based on the types of behaviors observed in the testing of the instrument, two mouthing behaviors were selected for the full study: (1) tongue contacts object, and (2) object in mouth. In addition, four other behaviors were included in an attempt to better describe the types of behaviors that would likely result in soil ingestion: (1) hand touches ground, (2) child is repulsed by object in mouth and tries to get it out, (3) other person stops child's contact with object, and (4) child is out of sight or view. To further characterize potential exposures to soil associated with the two types of mouthing behaviors, six object categories were included to be used along with the behaviors: (1) hand, finger, or thumb; (2) other body parts, including toes, feet, arms; (3) natural materials, including dirt, sand, rocks, leaves; (4) toys and other objects, including books, utensils, keys; (5) surfaces, including, window sills, floor, furniture, carpet; and (6) food or drink. An additional code was added to indicate whether an object was swallowed by the child. The type of activity the child was engaged in during the observation period was also recorded. In addition to mouthing behavior data, information on how long the child spent indoors and outdoors each day and the general types of outdoor settings in which the child played was collected.

Mouthing behavior data were collected during a 4-day period. Both trained observers and one parent observed the children to record mouthing behavior data. Trained observers recorded mouthing behavior data for 1 hour during active play time, and the parent recorded mouthing behavior data for the first 15 minutes of that hour.

The basic measure of each type of mouthing activity derived from the observation form was the percent of time spent in that activity. This measure was defined as the percentage of the total number of intervals observed that indicate such an activity took place. If there was no activity in an interval, that interval was excluded. For tabulating the object categories, multiple instances of the same object in a single interval were counted only once in that interval. Multiple instances of different objects in a single interval were counted separately under each object category.

Based on the mouthing behavior data collected in this study, EPA calculated that during the period of observation (assumed to be 1 hour) the average mouthing activity was 6.2 minutes and the average tongue activity was 0.70 minutes. It is important to note that these values are based on 1 hour of observation. In order to estimate the overall mouthing activity in a day, one would have to make some assumptions about the amount of time a child is involved in active play time in a day. These values may also be underestimates, because they assume that all the children in the study were observed for 1 hour on each of the 4 days. If this were true, each child would have a total of 960 intervals of observations (i.e., 3600 seconds x intervals/15 seconds x 4 days). The data show that the number of intervals of observation ranged from 80 to 840. It can be concluded that some children were either observed for less than 1 hour or less than 4 days.

In order to compare the values estimated by Groot et al. (1998), whose work also used time as a basis for measuring mouthing activity, it is necessary to multiply the Davis (1995) hourly estimate by an estimate of how long the children were awake during the day. According to Davis (1995) children ages 0 to 48 months are awake approximately 8.9 hours per day. Based upon this estimate, the Davis (1995) findings translate into about 55 min/day of mouthing activity and 6 min/day of tongue activity. The 55 minutes compares favorably to the 37 minutes and 44 minutes estimated by Groot et al. (1998) for 3- to 6-month and 6- to 12-month-old children, respectively, but it is significantly above the 16.4 minutes and 9.3 minutes estimated for the 12- to 18-month and 18- to 36-month-old children, respectively.

EPA also analyzed the mouthing behavior data for 86 children (43 males and 43 females) from the Davis (1995) study. Six children from the original sample size of 92 were excluded from the analysis because no age information was provided. Total mouthing behavior included both mouth and tongue contacts with hands, other body parts, surfaces, natural objects, and toys. Eating events were excluded from the analysis. Statistical analysis was undertaken to determine whether significant differences existed between age and gender. Model results showed that there were no associations between mouthing frequency and gender. However, a clear relationship was observed between mouthing frequency and age. Two distinct groups could be identified: children younger than 24 months and children older than 24 months. Children than 24 months exhibited the highest frequency of mouthing behavior, with 81 ± 7 contacts/hr (28 subjects, 69 observations). On the other hand, children older than 24 months exhibited a lower frequency of mouthing behavior, with 42 ± 4 contacts/hr (44 subjects, 117 observations). These results suggest that as children grow older, they are less likely to put objects into their mouths.

This study has both strengths and weaknesses. The strengths are that it incorporates more children (92) in the sample population than any of the other studies in the reviewed literature. In addition, the research is very detailed in defining the parameters and variables associated with mouthing behavior. The research also gathered information over 4 days, whereas most of the other studies involved only 1 or 2 days of observation.

Although the research included the largest sample population of the reviewed literature, 92 sample points is still a small number, considering the wide variability associated with mouthing in children. The random nature in which the population was selected probably provides a representative population of the northwest U.S. but not the national population in general. The interval time of 15 seconds would also appear to be small and potentially easily skewed for those children observed less than an hour. In addition, most other studies used observation times of 15 minutes to continuous observation throughout waking hours.

6.2.2. Groot et al., 1998

In this study, Groot et al. (1998) examined the mouthing behavior of infants and young children between the ages of 3 and 36 months in the Netherlands. The study was actually part of a larger effort to determine whether PVC toys softened with phthalate could pose health risks to children from mouthing. As part of the effort, the investigators asked parents to observe their children and gather information that could be used to estimate how often children engage in mouthing and the duration spent mouthing during a day. Parents were asked to observe their children 10 times per day for 15-minute intervals (i.e., 150 minutes total per day) for 2 days and measure mouthing with a stopwatch. In total, 36 parents participated in the study and 42 children were observed by their parents. For the study, a distinction was made to differentiate between toys meant for mouthing (e.g., pacifiers, teething rings) and those not meant for mouthing. The time a child spent mouthing a dummy (e.g., pacifier) was not included in the time recorded.

Although the sample size was relatively small, the results provide a first-order estimate on mouthing times during a day. Table 6-1 compiles the mouthing times from the study. The results show wide variation. The standard deviation in all four age categories, except the 3- to 6-month old children, exceeds the mean time estimated for mouthing during a day. The large standard deviations is not unexpected, given the vast behavioral differences from child to child and the small sample size of the study. The overall trend of the data, however, may be accurate in that it shows that as the children age, the time spent mouthing decreases. The 3- to 6-month-old children were estimated to mouth 37 min/day and the 6- to 12-month-old 44 min/day. After 12 months, the estimated mouthing time dropped quickly to 16 min/day for the 12- to 18-month-old and 9 min/day for the 18- to 36-month-old children.

The study has several limitations that have an impact on the usability of the data. The initial drawback concerns the small size of the study. The authors acknowledged this shortcoming and recommended further study using a larger sample population. In addition, the area where the study was performed consisted primarily of people with higher education and most of the parents in the study were in this category. The study attempted to recruit persons of lower education and socioeconomic levels, but these persons chose not to participate in the study after recruitment. Therefore, the results do not reflect data from the full spectrum of the population. The study also recorded only the time spent mouthing and not the number of times that mouthing occurred, and it did not differentiate the types of objects mouthed. In addition, children were observed for a period of 2 consecutive days, which may not reflect long-term behavior. The study may not be representative of the U.S. population.

6.2.3. Reed et al., 1999

In this study, Reed et al. (1999) used videotaping to quantify the frequency and type of contacts children have during the course of an hour. The contacts included numerous categories: hand to clothing, hand to dirt, hand to hand, hand to mouth, hand to object, object to mouth, hand to smooth surface (e.g., counter tops, table tops), hand to textured surface (e.g., stuffed animal). A total of 30 children were observed in this study. Children were observed in both day care (20 children 3–6 years old) and residential (10 children 2–5 years old) settings. Parents and day care providers were also asked to complete questionnaires describing the behavior of the children. In addition, the study also differentiated between the usage of right and left hands.

Over the course of the research, the investigators found that the behavior of children in day care residential settings was similar except for the contact rate of hand to smooth surfaces. Children in residential settings had higher contact rates with smooth surfaces than did children in day care centers. The results of the study are compiled in Table 6-2. The highest contacts were with objects (123 contacts/hr), smooth surfaces (84 contacts/hr), and other (83 contacts/hr). The two lowest contact rates were hand to mouth (9.5 contacts/hr) and object to mouth (16.3 contacts/hr). Because the contact rates of hand to objects and smooth surfaces are high, these results indicate that the fingers would appear to provide a continual dose per hand-to-mouth contact because of constant touching of potentially contaminated surfaces. Pesticides and other SVOCs are partitioned between the vapor and deposited phases (e.g., on dust or absorbed on a plastic toy or stuffed animal) such that a child's fingers, especially if wet from mouthing, will continually be acquiring doses of these types of constituents (Gurunathan et al., 1998).

The investigators also noted that children acted equally on their environment with both hands with the exception of object-to-mouth behavior. Therefore, the compiled data are reported as combined right-hand and left-hand data. The object-to-mouth behavior showed a strong preference for the right hand over the left hand for nearly all children. The preference ratio for the right hand over the left hand for this category was 6.8 to 1.

The advantage of this study is that it incorporates a wide variety of contacts that small children have—not just the hand to mouth or object to mouth. This information allows assessors to identify areas or surfaces that may serve as sources for toxic constituent transfer. This is especially important for exposure to SVOCs such as pesticides (e.g., chlorpyrifos) that have an affinity for absorption onto dust particles and plastic toys and into the polyurethane foam that is used in many stuffed animals (Gurunathan et al., 1998). Another strength of this study is the agreement it shows with earlier work by Zartarian et al. (1998) for the hand-to-mouth contacts. Some of the shortcomings are the small sample size study and the lack of comment as to the representativeness of the sample population to the U.S. population. The authors acknowledged the weakness in regard to the sample size and recommended further work with a larger population. The study makes no mention of the representativeness of the sample population nor does it address the need for a representative population for any additional study.

6.2.4. Zartarian et al., 1997

Zartarian et al. (1997) conducted a pilot study of four children of farm workers to investigate the applicability of using videotaping for gathering information related to children's interaction with their environment. The evaluation of the videotaping included observation of the children's contact frequency and duration with objects in their environment, duration spent in different locations, activity levels, and frequency distributions. As such, the research was not specifically intended to gather data for nondietary ingestion; however, the activities used to evaluate the use of videotaping provide data were for dermal and nondietary exposure.

Four Mexican-American farm worker children—two girls and two boys between the ages of 2.5 and 4.2 years—were videotaped for 33 hours using hand-held cameras over the course of a single day in 1993. The videotaping gathered information on detailed micro-activity patterns of children to be used to evaluate software for videotaped activities and translation training methods. The data were also reported by type of object/surface and by left or right hand.

The investigators presented the data for their observations on a per-child and per-hand basis. The data suggest that the U.S. EPA (1997) estimate of hand-to-mouth contact of 1.56 contacts/hr may significantly underestimate the number of contacts per hour for young children. None of the children had average contact frequencies for either hand individually lower than 3 contacts/hr for hand-to-mouth contact, and the investigators estimated the average as 9 contacts/hr. As also reported by Reed et al. (1999), the most frequently contacted objects were toys and hard (i.e., smooth) surfaces. The average contact time with objects was only 2 to 3 seconds; therefore questionnaires and diaries would be insufficient for gathering that level of activity, according to the authors.

This study has several weaknesses. The sample population is very small, only four children; however, the work was reported as a pilot study, completely acknowledging that further work was necessary. The effort was intended to evaluate only the methodology of collecting observations; thus, the data are not presented in a format that can be used to support other research or supply recommended estimates for contact frequency. This study may not reflect long-term behavior. In addition, the sample population is not representative of the U.S. population in general.

6.2.5. Stanek et al., 1998

Stanek et al. (1998) presented a methodology that links mouthing behavior among children to the prevalence of ingestion of nonfat items. Soil ingestion data were collected via face-to-face interviews over a period of 3 months from parents or guardians of 533 children ages 1 to 6 years who attended well-visits in western Massachusetts. Three clinics participated in this study during the months of August, September, and October, 1992: Kaiser Permanente's clinic in Amherst, a private clinic associated with the Cooley Dickinson Hospital in Northampton, and the BayState Medical Center clinic in Springfield. Participants were questioned about the frequency of 28 mouthing behaviors of the children over the past month in addition to exposure time (e.g., time outdoors, play in sand or dirt) and children's characteristics (e.g., teething). Response categories of the clinic questionnaire corresponded to daily, at least weekly, at least monthly, and never.

The authors expressed the mouthing rate for each child as the sum of rates for responses to four questions on mouthing specific outdoor objects. Regression models with variables in a stepwise manner identified factors related to high outdoor mouthing rates. The authors first considered variables that indicated opportunity for exposure, then subjects' characteristics (e.g., teething) and environmental factors, and finally, concurrent reported behaviors.

Table 6-3 presents the prevalence of nonfood ingestion/mouthing behaviors by age as the percentage of children whose parents reported the behavior in the past month. Outdoor soil mouthing behavior prevalence was found to be higher than indoor dust mouthing prevalence, but both behaviors had highest prevalence among 1-year-old children and dropped quickly among children 2 years old and older. The investigators conducted principal component analyses on the responses to four questions relating to ingestion of outdoor objects (Table 6-3) in an attempt to characterize variability. Responses were converted to mouthing rates per week using values of 0, 0.25, 1, and 7 for responses of never, monthly, weekly, and daily ingestion. Outdoor ingestion/mouthing rates were 4.73 per week for children 1 year of age and 0.44 per week for children 2–6 years of age. The frequency with which children played in sand/dirt was estimated as a measure of potential exposure; 71% of the children were reported to play in sand or dirt at least weekly and 45% were reported as playing in the sand or dirt daily. Children who played in the sand or dirt were found to have higher outdoor object ingestion/mouthing rates. Thus, children with higher direct exposure to sand or dirt were more likely to ingest or mouth on outdoor objects. The authors found similar results when comparing the time spent outdoors to reported outdoor ingestion and mouthing rates. Sixty-five percent of 1 year-old children were reported to spend less than 3 hour per day outdoors, whereas 42 percent of children 2–6 years old spend less than 3 hours per day outdoors.

Table 6-4 presents average outdoor mouthing rates by age and sand/dirt play frequency. The authors presented the data for children by quartiles according to their general mouthing rates and applied linear regression models fit to general mouthing rates. They found a significant slope for all groups but one and thus demonstrated that outdoor mouthing behavior increased with higher quartiles and that rates of increase depended on age and sand/soil play exposure.

A strength of this study is that it focuses on the prevalence of specific behaviors to quantify soil mouthing or ingestion among healthy children. The results might have important health implications, as they show that 1 year-old children with high general levels of mouthing behavior have the potential for high-risk soil ingestion.

A limitation associated with this study is that the data are based on recall behavior from the summer previous to the interview. Extrapolation to other seasons may be difficult. In addition, data were collected for children in western Massachusetts and they were available only for the healthy children who were present for well-visits.

6.3. RECOMMENDATIONS

Due to the paucity of available research data, mouthing frequency data should be used with caution. Table 6-5 summarizes the studies on mouthing behavior that were described in this chapter. Table 6-6 summarizes the results of these studies. Table 6-7 summarizes the recommended values for mouthing frequency. As mentioned earlier, the studies presented used different units for reporting mouthing behavior. If the assessor is interested in estimating exposures during macroactivities, then the total amount of time engaged in mouthing behavior may be the unit of interest. Groot et al. (1998) is the only published study that presents data for infants. These data, as well as those of the Davis (1995) study, show that mouthing behavior decreases as children age. Data from both Groot et al. (1998) and Davis (1995) for children between 3 to 60 months ranged from 9 min/day to 55 min/day, with a weighted average of 46 min/day.

If the assessor is interested in estimating exposures to various microactivities, then the number of contacts with hands or objects per unit of time may be the unit of interest. Both Reed et al. (1999) and Zartarian et al. (1997) studied hand-to-mouth behavior. Although there are uncertainties with the results of these two studies due to sample size, they are fairly consistent. Based on these two studies, a value of 9 contacts/hr seems to be a reasonable average estimate of hand-to-mouth behavior for ages 24–72 months. Reed et al. (1999) estimated a 90th percentile hand-to-mouth behavior of 20.1 contacts/hr. In the same study Reed et al. examined object-to-mouth frequency. On the basis of Reed et al. (1999) and the analysis of the Davis (1995) data, mean total mouthing behavior, including hand-to-mouth as well as objects, ranged from 26 contacts/hr (i.e., 9.5 (hand-to-mouth) + 16.3 (object-to-mouth)) to 76 contacts/hr, with a weighted average of 49 contacts/hour for ages 10–72 months.

The frequency of finger-to-mouth contact (9.5 contacts/hr) greatly exceeds the 1.56 contacts/hr for fingers to mouth suggested by EPA in its guidance for calculating exposure to pesticides (U.S. EPA, 1997). The estimate of 9.5 contacts/hr is close to the 9 contacts/hr estimated by Zartarian et al. (1997) in a study conducted using video taping, as reported by Reed et al. (1999). The agreement of the two studies suggests that EPA's value of 1.56 contacts/hr may significantly underestimate the nondietary exposure route. Table 6-8 presents the confidence ratings for the recommended values.

Table 6-1. Extrapolated total mouthing times minutes per day[a]

Age (months)	No. Children	Mouthing time (min/day)[b]		
		Mean ± SD	Minimum	Maximum
3–6	5	36.9 ± 19.1	14.5	67.0
6–12	14	44 ± 44.7	2.4	171.5
12–18	12	16.4 ± 18.2	0.0	53.2
18–36	11	9.3 ± 9.8	0.0	30.9

[a] The object most mouthed in all age groups was the fingers except for the 6–12 month group, which mostly mouthed on toys.
[b] Time awake.

Source: Groot et al., 1998

Table 6-2. Frequency of contacts

Variable	Contacts per hour				
	Mean	Medium	Minimum	Maximum	90th Percentile
Clothing	66.6	65.0	22.8	129.2	103.3
Dirt	11.4	0.3	0.0	146.3	56.4
Hand	21.1	14.2	6.3	116.4	43.5
Hand to mouth	9.5	8.5	0.4	25.7	20.1
Object	122.9	118.7	56.2	312.0	175.8
Object to mouth	16.3	3.6	0.0	86.2	77.1
Other	82.9	64.3	8.3	243.6	199.6
Smooth surface	83.7	80.2	13.6	190.4	136.9
Textured surface	22.1	16.3	0.2	68.7	52.2

Source: Reed et al., 1999

Table 6-3. Prevalence of non-food ingestion/mouthing behaviors by age[a]

Non-food ingestion/mouthing	Prevalence	Age (years) 1 N = 171	2 N = 70	3 N = 93	4 N = 82	5 N = 90	6 N = 22	All N = 528
Outdoor "soil" mouthing/ingestion								
Sand, stones	% > Monthly	54	26	19	9	7	9	27
	% > Weekly	36	10	6	2	4	5	16
	% Daily	17	0	2	1	1	5	6
Grass, leaves, flowers	% > Monthly	48	16	24	13	9	5	26
	% > Weekly	34	7	14	4	6	0	16
	% Daily	16	0	2	1	1	0	6
Twigs, sticks, woodchips	% > Monthly	42	23	13	13	11	5	23
	% > Weekly	29	7	9	5	7	0	14
	% Daily	12	0	0	1	0	0	4
Soil, dirt	% > Monthly	38	21	5	7	3	9	18
	% > Weekly	24	7	3	2	1	9	10
	% Daily	11	0	1	0	1	0	4
Dust, lint, dustballs	% > Monthly	14	4	2	0	0	5	6
	% > Weekly	7	1	1	0	0	0	3
	% Daily	2	0	0	0	0	0	1
Plaster, chalk	% > Monthly	8	10	3	2	3	5	5
	% > Weekly	5	3	0	1	0	0	2
	% Daily	2	0	0	1	0	0	1
Paintchips, splinters	% > Monthly	6	0	0	4	1	0	3
	% > Weekly	2	0	0	1	0	0	1
	% Daily	0	0	0	0	0	0	0
General mouthing of objects								
Other toys	% > Monthly	88	53	64	44	42	23	62
	% > Weekly	82	44	42	26	28	9	49
	% Daily	63	27	20	9	7	5	30
Paper, cardboard, tissues	% > Monthly	71	37	32	23	18	14	41
	% > Weekly	54	23	20	12	7	9	28
	% Daily	28	9	8	5	2	5	13
Teething toys	% > Monthly	65	29	15	4	3	9	29
	% > Weekly	55	16	9	1	1	9	22

Table 6-3. Prevalence of non-food ingestion/mouthing behaviors by age[a] (continued)

Non-food ingestion/mouthing	Prevalence	Age (years) 1 N = 171	2 N = 70	3 N = 93	4 N = 82	5 N = 90	6 N = 22	All N = 528
Teething toys (continued)	% Daily	44	6	6	0	0	9	17
Crayons, pencils, erasers	% > Monthly	56	54	46	50	41	36	50
	% > Weekly	41	37	25	27	26	27	32
	% Daily	19	17	4	6	4	18	12
Blankets, cloth	% > Monthly	51	21	26	22	22	14	32
	% > Weekly	42	17	17	18	14	14	25
	% Daily	29	11	9	13	7	5	16
Shoes, Footware	% > Monthly	50	23	8	7	2	5	22
	% > Weekly	42	10	3	2	1	5	16
	% Daily	20	1	0	0	0	0	7
Clothing	% > Monthly	49	34	37	43	26	27	39
	% > Weekly	39	24	23	28	16	14	27
	% Daily	25	7	11	9	6	14	14
Other items	% > Monthly	41	30	30	23	21	27	31
	% > Weekly	35	26	24	15	10	14	23
	% Daily	22	11	15	7	6	5	14
Crib, chairs, furniture	% > Monthly	37	11	8	10	4	5	17
	% > Weekly	26	9	3	5	2	0	11
	% Daily	13	3	1	1	0	0	5
Sucking of fingers, etc.								
Suck fingers/thumb	% > Monthly	67	41	43	57	39	41	52
	% > Weekly	60	27	31	43	31	18	41
	% Daily	44	21	22	26	24	14	30
Suck feet or toes	% > Monthly	37	14	12	11	3	0	18
	% > Weekly	23	4	3	2	1	0	9
	% Daily	8	1	0	1	0	0	3
Use pacifier	% > Monthly	24	9	6	2	2	5	11
	% > Weekly	22	9	5	2	2	0	10
	% Daily	20	6	5	1	1	0	9
Suck hair	% > Monthly	1	3	8	9	10	5	5
	% > Weekly	1	3	2	2	4	5	2

Table 6-3. Prevalence of non-food ingestion/mouthing behaviors by age[a] (continued)

Non-food ingestion/mouthing	Prevalence	Age (years) 1 N = 171	2 N = 70	3 N = 93	4 N = 82	5 N = 90	6 N = 22	All N = 528
Suck hair (continued)	% Daily	1	1	1	0	2	0	1
"Disgusting" object mouthing/ingestion								
Soap, detergent, shampoo	% > Monthly	48	34	24	17	9	9	29
	% > Weekly	37	27	14	11	6	9	21
	% Daily	15	14	3	2	0	0	8
Plastic, plastic wrap	% > Monthly	32	19	8	7	9	0	17
	% > Weekly	22	11	3	4	4	0	10
	% Daily	7	4	1	0	1	0	3
Cigarette butts, tobacco	% > Monthly	16	6	5	4	3	5	8
	% > Weekly	10	4	4	1	2	5	5
	% Daily	4	0	1	1	1	0	2
Matches	% > Monthly	6	4	1	4	1	0	4
	% > Weekly	2	3	1	1	1	0	2
	% Daily	1	0	0	0	0	0	0
Insect	% > Monthly	5	1	2	4	2	0	3
	% > Weekly	2	0	1	4	2	0	2
	% Daily	0	0	1	2	2	0	1
Other ingestion and behaviors								
Toothpaste	% > Monthly	63	97	92	94	93	86	84
	% > Weekly	60	94	91	93	92	86	82
	% Daily	52	87	86	93	89	82	77
Chew gum	% > Monthly	18	56	76	76	91	100	58
	% > Weekly	10	40	60	60	69	68	43
	% Daily	3	17	18	13	21	36	14
Bite nails	% > Monthly	8	26	31	29	33	59	24
	% > Weekly	5	23	24	20	26	45	18
	% Daily	2	7	12	9	10	14	7
Play in sand/dirt	% > Monthly	62	76	85	96	88	73	78
	% > Weekly	57	64	77	88	81	68	71
	% Daily	42	39	43	55	52	45	45

[a] Parents reported the behavior in the past month.

Source: Stanek et al., 1998

Table 6-4. Average outdoor object mouthing scores for children by age, frequency of sand/dirt play, and general mouthing quartiles

General mouthing score quartiles (mean)	Score							
	1-year-olds Frequency of sand/dirt play				2- to 6-year-olds Frequency of sand/dirt play			
	> Daily		Daily		> Daily		Daily	
	Mean	N	Mean	N	Mean	N	Mean	N
1st quartile (1.5)	0.1	19	2.8	16	0.1	139	0.5	117
2nd quartile (9.7)	0.7	14	3.9	11	0.3	27	0.8	28
3rd quartile (19.6)	1.3	33	10.5	22	0.2	19	1.8	21
4th quartile (35.6)	3.6	35	14.0	23	0.5	2	1.5	4
Slope based on general mouthing quartile score	0.110		0.340		0.007		0.054	
SE	0.052		0.060		0.021		0.019	

Source: Stanek et al., 1998

Table 6-5. Summary of studies on mouthing behavior

Study	Population Size	Population and time studied
Groot et al., 1998	42	3–36 months in Netherlands children from well educated parents
Reed et al., 1999	30	20 children 3–6 years 10 children 2–5 years Day care and residential settings
Zartarian et al, 1997	4	2.5–4.2 years children of farm workers
Davis, 1995	92	10–60 months Washington State
Stanek et al., 1998	355	1–6 years Private medical clinic in Springfield, MA

Table 6-6. Summary of mouthing frequency data

Age (months)	Mouthing frequency	Population size	Reference
3–6 6–12 12–18 18–36	37 min/day 44 min/day 16 min/day 9 min/day	5 14 12 11	Groot et al., 1998
2–6 years	9.5 contacts/hr (hand to mouth) 16.3 contacts/hr (object to mouth)	30	Reed et al., 1999
2.5–4.2 years	9 contacts/hr	4	Zartarian, 1997
10–60 < 24 > 24	55 min/day 81 ± 7 contacts/hr 42 ± 4 contacts/hr	92 28 44	EPA analysis of Davis, 1995

Table 6-7. Summary of recommended values for mouthing behavior

Age (months)	Mean Mouthing Frequency/Time	Reference
3–60	46 min/day	Weighted average from Groot et al., 1998 and Davis, 1995
24–72	Hand-to-Mouth 9 contacts/hr	Hand-to-mouth is the weighted average from Zartarian et al., 1997 and Reed et al., 1999
	20 contact/hr	90th percentile, Reed et al., 1999
	Object-to-Mouth 16.3 contacts/hr	Object-to-mouth based on Reed et al., 1999
10–72	49 contacts/hr (total mouthing)	Weighted average from Reed et al., 1999 and EPA analysis of Davis, 1995

Table 6-8. Confidence in mouthing behavior recommendations

Considerations	Rationale	Rating
Study Elements		
Peer Review	Three of the studies are from peer-reviewed journals, one is from a contractor's report to EPA.	Medium
Accessibility	Studies in journals have wide circulation. Contractor's report available only through EPA.	Medium
Reproducibility	Cannot reproduce the data unless raw data are provided.	Medium
Focus on factor of Interest	Studies focused on mouthing behavior as well as other hand contacts.	High
Data pertinent to U.S.	Studies were conducted in the U.S.	High
Primary data	Analyses were done on primary data. EPA did the analysis of the raw data from Davis, (1995).	High
Currency	Recent studies were evaluated.	HIgh
Adequacy of data collection period	Data were collected for a period of several days, not enough to represent seasonal variations.	Medium
Validity of Approach	Measurements were made by observation methods. Both surveys and videotaping were used. Videotaping techniques may be more reliable but resource intensive.	Medium
Representativeness of the population	An effort was made to consider age and gender (in the Davis study), but sample size was too small.	Low
Characterization of variability	An effort was made to consider age and gender; data for infants are fairly limited.	Low
Lack of bias in study design	Subjects were selected from volunteers.	Medium
Measurement error	Measuring children's behavior is difficult and somewhat subjective and depends on the experience of the observer.	Medium
Other Elements		
Number of studies	Four studies were evaluated	Medium
Agreement between researchers	There is general agreement among the researchers.	High
Overall Rating	Although there are four studies, they have very small sample sizes; variability in the population cannot be assessed. Variation in behavior due to seasons cannot be evaluated. Measuring children's behavior is difficult.	**Low**

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7. INHALATION ROUTE

7.1. INTRODUCTION

This chapter presents data and recommendations for inhalation rates that can be used to assess children's exposure to contaminants in air. Children may be more highly exposed to environmental toxicants through inhalation routes than are adults. Infants and young children have a higher resting metabolic rate and rate of oxygen consumption per unit body weight than do adults because they have a larger cooling surface per unit body weight and because they are growing rapidly. The oxygen consumption of a resting infant aged between 1 week and 1 year is 7 mL/kg body weight per minute. The rate for an adult under the same conditions is 3–5 mL/kg per minute (WHO, 1986). Thus, on a body-weight basis, the volume of air passing through the lungs of a resting infant is twice that of a resting adult under the same conditions and, therefore, twice as much of any chemical in the atmosphere could reach the lungs of an infant. The recommended inhalation rates for children are summarized in section 7.3.

7.2. INHALATION RATE STUDIES

7.2.1. Linn et al., 1992

Linn et al. (1992) conducted a study that estimated the inhalation rates for "high-risk" subpopulation groups exposed to ozone in their daily activities in the Los Angeles area. The population surveyed consisted of several panels of both adults and children. The panels consisting of children included *Panel 2*: 17 healthy elementary school students (5 males and 12 females, ages 10–12 years); *Panel 3*: 19 healthy high school students (7 males and 12 females, ages 13–17 years); *Panel 6*: 13 young asthmatics (7 males and 6 females, ages 11–16 years).

An initial calibration test was conducted, followed by a training session. Finally, a field study that involved the subjects collecting their own heart rate and diary data was conducted. During the calibration tests, ventilation rate (VR), breathing rate, and heart rate (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.

In the field study, each subject 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. Asthmatic subjects recorded their diary information once every hour using a Heart Watch. 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 7-1 presents the calibration and field protocols for self-monitoring of activities for each subject panel.

Table 7-2 presents the mean VR, the 99th percentile VR, and the mean VR at each subjective activity level (slow, medium, fast). The mean VR and the 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. The authors reported that the diary data showed that most individuals spent most of their time (in a typical day) indoors at slow activity level. During slow activity, asthmatic subjects had higher VRs than did healthy subjects, (Table 7-2). The authors also 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. The wide variety of exercises in everyday activities may result in greater variation of the VR-HR relationship than was calibrated. Another limitation 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 that are useful in exposure assessments. Another advantage is that inhalation rates were presented for both healthy and asthmatic children.

7.2.2. Spier et al., 1992

Spier et al. (1992) investigated the 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 each of rest, slow walking, jogging, and fast walking. HR and 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 his or her daily activities, change in location, and breathing rates in diaries 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 once per minute during the 3 days with 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 7-3 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 number of hours spent indoors was higher for high school students (21.2 hours) 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 7-4). Based on the data presented in Tables 7-3 and 7-4, the average activity-specific inhalation rates for elementary school students (10–12 years old) and high school students (13–17 years old) were calculated and are presented in Table 7-5. For elementary school students, the average daily inhalation rates (based on indoor and outdoor locations) 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. For high school students, the daily inhalation rates for light, moderate, and heavy activities are estimated to be 16.4 m^3/day, 3.1 m^3/day, and 0.54 m^3/day, respectively (Table 7-5).

A limitation of this study is the small sample size. The results may not be representative of all children in these age groups. Another limitation is that the accuracy of the self-estimated breathing rates reported by younger age groups is uncertain, which 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.

7.2.3. Adams, 1993

Adams (1993) conducted research to accomplish two main objectives: (1) identification of mean and ranges of inhalation rates for various age/gender cohorts and specific activities, and (2) derivation of simple linear and multiple regression equations that could be used to predict inhalation rates through other measured variables: breathing frequency and oxygen consumption. A total of 160 subjects participated in the primary study. For children, there were two age-dependent groups: children 6 to 12.9 years old, and adolescents 13 to 18.9 years old. An additional 40 children from 6 to 12 years old and 12 young children from 3 to 5 years old were identified as subjects for pilot testing purposes.

Resting protocols conducted in the laboratory for all age groups consisted of three phases (25 minutes each) of lying, sitting, and standing. The phases were categorized as resting and sedentary activities. Two active protocols—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 three speeds, ranging from slow to moderately fast. All protocols involved measuring VR, HR, breathing frequency, and oxygen consumption. Measurements were taken in the last 5 minutes of each phase of the resting protocol and the last 3 minutes of the 6-minute intervals at each speed designated in the active protocols.

In the field, all children completed spontaneous play protocols; the older adolescent population (16–18 years) completed car driving and riding, car maintenance (males), and housework (females) protocols.

During all activities in either the laboratory or the field protocols, IR for the children's group revealed no significant gender differences. Therefore, the inhalation rate data presented in Appendix Tables 7A-1 and 7A-2 were categorized by activity type (lying, sitting, standing, walking, and running) for young children and children (no gender). These categorized data from the appendix tables are summarized as inhalation rates in Tables 7-6 and 7-7. The laboratory protocols are shown in Table 7-6. Table 7-7 presents the mean inhalation rates by group and for moderate activity levels in field protocols. Data were not provided for the light and sedentary activities because the group did not perform for this protocol or the number of subjects was too small for appropriate comparisons. Accurate predictions of inhalation rates across all population groups and activity types were obtained by including body surface area (BSA), HR, and breathing frequency in multiple regression analysis. The authors calculated BSA from measured height and weight using the equation:

$$\text{BSA} = \text{Height}^{(0.425)} \times \text{Weight}^{(0.425)} \times 71.84 \qquad (7\text{-}1)$$

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.

7.2.4. Layton, 1993

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. However, in this study, breathing rates were calculated on the basis of 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:

$$V_E = E \times H \times VQ \qquad (7\text{-}2)$$

where:

V_E = ventilation rate (L/min or m^3/hr);

E = energy expenditure rate; (kilojoules [KJ]/min or megajoules [MJ]/hr;

H = volume of oxygen (at standard temperature and pressure, dry air consumed in the production of 1 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.

Layton used two alternative approaches to estimate daily chronic (long-term) inhalation rates for different age/gender cohorts of the U.S. population using this methodology.

7.2.4.1. *First Approach*

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. The average food energy intake data (Table 7-8) were based on approximately 30,000 individuals and 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. This factor compensated for a consistent bias in the USDA-NFCS that was attributed to under reporting of the foods consumed or the methods used to ascertain dietary intakes. Layton 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 survey sample for NHANES II was approximately 20,000 participants. A VQ of 27 used was calculated as the geometric mean of VQ data that were obtained from several studies.

The inhalation rate estimation techniques are shown in footnote (a) of Table 7-9. Table 7-9 presents the daily inhalation rate for each age/gender cohort. The highest daily inhalation rates were 10 m^3/day for children between the ages of 6 and 8 years, 17 m^3/day for males between 15-18 years, and 13 m^3/day for females between 9 and 11 years. 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 H times VQ. BMR was defined as “the minimum 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 7-9. The data for active and inactive inhalation rates are also presented in Table 7-9. For children, inactive and active inhalation rates ranged between 2.35 and 5.95 m^3/day and 6.35 and 13.09 m^3/day, respectively.

7.2.4.2. *Second Approach*

Inhalation rates were calculated by multiplying the BMR of the population cohorts times the ratio of total daily energy expenditure to daily BMR times H times VQ. The BMR data obtained from the literature were statistically analyzed, and regression equations were developed to predict BMR from body weights of various age/gender cohorts. The statistical data used to develop the regression equations are presented in Appendix Table 7A-3. The data obtained from the second approach are presented in Table 7-10. Inhalation rates for children (6 months to 10 years) ranged from 7.3-9.3 m^3/day for male and 5.6 to 8.6 m^3/day for female children; for older children (10–18 years), the rates were 15 m^3/day for males and 12 m^3/day for females. 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.

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 the metabolic equivalent times H times VQ. The data obtained for short-term exposures are presented in Table 7-11.

The major strengths of this study are that it obtains similar results using two different approaches to estimate inhalation rates in different age groups and that the populations are large and consist 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 (1) the estimated activity pattern levels are somewhat subjective, (2) the explanation that activity pattern differences are responsible for the lower level obtained with the metabolic approach (25%) compared with the activity pattern approach is not well supported by the data, and (3) different populations were used in each approach, which may have introduced error.

7.2.5. Rusconi et al., 1994

Rusconi et al. (1994) examined a large number of infants and children in order to determine the reference values for respiratory rate in children aged 15 days to 3 years. Previous discrepancies in methodologies and results and lack of age-related reference values for the first years of life prompted the investigators to obtain normal reference values for respiratory rate from a sufficient number of subjects. They assessed 618 infants and children (336 males and 282 females) ages 15 days to 3 years old who did not have respiratory infections or any severe disease. Of the 618, a total of 309 were in good health and in daycare centers; while the other 309 were seen in hospitals or outpatients.

Respiratory rates were recorded twice, 30 to 60 minutes apart, listening to breath sounds for 60 seconds with a stethoscope, when the child was awake and calm and when the child was sleeping quietly (sleep not associated with any spontaneous movement, including eye movements or vocalizations) (Table 7-12). The children were assessed for 1 year in order to determine the repeatability of the recordings, to compare respiratory rate counts obtained by stethoscope and by observation, and to construct reference percentile curves by age in a large number of subjects.

The authors plotted the differences between respiratory rate counts determined by stethoscope at 30- to 60-minute intervals against the mean count in awake and asleep subjects. The standard deviation of the differences between the two counts was 2.5 and 1.7 breaths/min, respectively, when the infants and children were awake and when they were asleep. This standard deviation yielded 95% repeatability coefficients of 4.9 breaths when the infants and children were awake and 3.3 breaths when they were asleep.

In both awake and asleep states, the respiratory rate counts determined by stethoscope were found to be higher than those obtained by observation. The mean difference was 2.6 and 1.8 breaths per minute, respectively, in awake and asleep states. The mean respiratory rate counts were significantly higher in infants and children at all ages when awake and calm than when asleep. A decrease in respiratory rate with increasing age was seen in awake and asleep infants and children. A scatter diagram of respiratory rate counts by age in awake subjects and during sleep showed that the pattern of respiratory rate decline with age was similar in both states, but it was much faster in the first few months of life. The authors constructed centile curves by first log-transforming the data and then applying a second-degree polynormal curve, which allowed excellent fitting to observed data. Figures 7-1 and 7-2 show smoothed percentiles by age in awake and asleep subjects, respectively.

The authors suggested that the differences between the reported respiratory rates in healthy infants and children might be due to various factors, including the number of infants studied, the period of time of counting, the method of counting, and the state of the infant. The variability of respiratory rate among subjects was higher in the first few months of life, which may be attributable to biological events that occur during these months, such as maturation of the neurologic control of breathing and changes in lung and chest wall compliance and lung volumes.

An advantage of this study is that it provides distribution data for respiratory rate for children ages < 2 months to 36 months old. These data are not for the U.S.; however, U.S. distributions were not available.

7.3. RECOMMENDATIONS

The recommended inhalation rates for children are based on the studies described in this chapter. Different survey designs and populations were used in these studies. Excluding the Layton (1993) and Rusconi et al., (1994) studies, the population surveyed in all of the 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, these studies were selected as the basis for recommended inhalation rates, based on other aspects of the study design.

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 confidence ratings and recommended inhalation rates are presented in Tables 7-13 and 7-14, respectively. Based on the results from Layton (1993), the recommended daily inhalation rate for infants (children less than 1 year old), during long-term dose assessments is 4.5 m^3/day. For children 1–2 years old, 3–5 years old, and 6–8 years old, the recommended daily inhalation rates are 6.8 m^3/day, 8.3 m^3/day, and 10 m^3/day, respectively. Recommended values for children ages 9–11 years are 14 m^3/day for males and 13 m^3/day for females. The recommended values for children aged 12–14 years and 15–18 years are also shown in Table 7-14.

Recommended short-term inhalation rates for children ages 18 years and under are summarized in Table 7-14. The short-term inhalation rates were calculated by averaging the inhalation rates for each activity level from the various key studies (Table 7-15). The recommended average hourly inhalation rates are 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 include infants (under 1 year).

Table 7-1. Calibration and field protocols for self-monitoring of activities, grouped by subject panels

Panel	Calibration Protocol	Field Protocol
Panel 2: Healthy elementary school students; 5 males, 12 females, ages 10–12 years	20-minute outdoor calibration study including rest, slow walking, jogging, and fast walking	Saturday, Sunday, and Monday (school day) in early autumn; heart rate recordings and activity diary during waking hours and during sleep.
Panel 3: Healthy high school students; 7 males, 12 females, ages 13–17 years	20-minute outdoor calibration study including rest, slow walking, jogging, and fast walking	Same as Panel 2; however, no heart rate recordings during sleep for most subjects.
Panel 6: Young asthmatics; 7 males, 6 females, ages 11–16 years	Laboratory exercise tests on bicycles and treadmills	Summer monitoring for 2 successive weeks, including two controlled exposure studies with few or no observable respiratory effects.

Source: Linn et al., 1992

Table 7-2. Subject panel inhalation rates by mean ventilation rate, upper percentiles, and self-estimated breathing rates

		Inhalation Rate (m^3/hr)				
				Mean VR at Activity Levels (m^3/hr)[b]		
Panel	N[a]	Mean VR (m^3/hr)	99th Percentile VR	Slow	Medium	Fast
Healthy						
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
Asthmatics						
6 - Elementary and high school Students	13	1.20	2.40	1.20	1.20	1.50

[a] Number of individuals in each survey panel.
[b] 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).

Source: Linn et al., 1992

Table 7-3. Distribution of predicted inhalation rates by location and activity levels for elementary and high school students who participated in the survey

Age years	Student	Location	Activity level	% Recorded time[a]	Inhalation Rates (m^3/hr) Mean ± SD	Percentile Rankings[b] 1st	50th	99.9th
10–12	Elementary school (N=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	High school (N=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 hours per elementary school student and 33 hours per high school student, over 72-hour periods.
[b] Geometric means closely approximated 50th percentiles; geometric standard deviations were 1.2–1.3 for heart rate and 1.5–1.8 for ventilation rate.
[c] Highest single value.

Source: Spier et al., 1992

Table 7-4. Average hours spent per day in a given location and activity level for elementary and high school students

Students	Location	Activity Level Slow	Medium	Fast	Total time spent (hrs/day)
Elementary school, ages 10–12 years (N = 17)	Indoors	16.3	2.9	0.4	19.6
	Outdoors	2.2	1.7	0.5	4.4
High school, ages 13–17 years (N = 19)	Indoors	19.5	1.5	0.2	21.2
	Outdoors	1.2	1.3	0.2	2.7

Source: Spier et al., 1992

Table 7-5. Distribution patterns of daily inhalation rates for elementary and high school students grouped by activity level[a]

Students	Location	Activity type[b]	Mean inhalation rate[c] (m^3/day)	Percentile Rankings		
				1st	50th	99.9th
Elementary school, ages 10–12 years (N = 17)	Indoors	Light	13.70	2.930	12.71	38.14
		Moderate	2.80	0.700	2.44	7.48
		Heavy	0.40	0.096	0.34	1.37
	Outdoors	Light	2.10	0.790	1.72	9.50
		Moderate	1.84	0.410	1.63	5.71
		Heavy	0.57	0.240	0.48	1.80
High school, ages 13–17 years (N = 19)	Indoors	Light	15.20	5.850	14.04	63.18
		Moderate	1.40	0.630	1.26	6.03
		Heavy	0.25	0.110	0.22	1.37
	Outdoors	Light	1.15	0.500	1.08	6.34
		Moderate	1.64	0.620	1.40	7.41
		Heavy	0.29	0.096	0.20	1.19

[a] Generated using data from Tables 7-3 and 7-4

[b] For this report, activity type presented in Table 7-2 was redefined as light activity for slow, moderate activity for medium, and heavy activity for fast.

[c] Daily inhalation rate was calculated by multiplying the hours spent at each activity level (Table 7-4) by the corresponding inhalation rate (Table 7-3).

Source: Adapted from Spier et al., 1992

Table 7-6. Summary of average inhalation rates by age group and activity levels for laboratory protocols

Age Group	Activity Level				
	Resting[a]	Sedentary[b]	Light[c]	Moderate[d]	Heavy[e]
Young children (3–5.9 years) Average inhalation rate (m^3/hr)	0.37	0.40	0.65	DNP[f]	DNP[f]
Children (6–12.9 years) average inhalation rate (m^3/hr)	0.45	0.47	0.95	1.74	2.23

[a] Resting defined as lying (see Appendix Table 7A-1 for original data).
[b] Sedentary defined as sitting and standing (see Appendix Table 7A-1 for original data).
[c] Light defined as walking at speed level 1.5–3.0 mph (see Appendix Table 7A-1 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 7A-1 for original data).
[e] Heavy defined as fast running (4.5 - 6.0 mph) (see Appendix Table 7A-1 for original data).
[f] Group did not perform this protocol or N was too small for appropriate mean comparisons. All young children did not run.

Source: Adapted from Adams, 1993

Table 7-7. Summary of average inhalation rates by age group and activity levels in field protocols

Age Group	Moderate activity [a]
Young children (3–5.9 years) average inhalation rate (m^3/hr)	0.68
Children (6–12.9 years) average inhalation rate (m^3/hr)	1.07

[a] Moderate activity was defined as mowing (males); wood working (males); yard work (males); and play (children) (see Appendix Table 7A-2 for original data).

Source: Adams, 1993

Table 7-8. Comparisons of estimated basal metabolic rates (BMR) with average food-energy intakes for individuals sampled in the 1977–1978 NFCS

Cohort/Age (years)	Body weight (kg)	BMR[a]		EFD		Ratio EFD/BMR
		MJ d^{-1}	kcal d^{-1}	MJ d^{-1}	kcal d^{-1}	
Children						
> 1	7.6	1.74	416	3.32	793	1.90
1–2	13.0	3.08	734	5.07	1209	1.65
3–5	18.0	3.69	881	6.14	1466	1.66
6–8	26.0	4.41	1053	7.43	1774	1.68
Males						
9–11	36.0	5.42	1293	8.55	2040	1.58
12–14	50.0	6.45	1540	9.54	2276	1.48
15–18	66.0	7.64	1823	10.80	2568	1.41
Females						
9–11	36.0	4.91	1173	7.75	1849	1.58
12–14	49.0	5.64	1347	7.72	1842	1.37
15–18	56.0	6.03	1440	7.32	1748	1.21

[a] Calculated from the appropriate age and gender-based BMR equations given in Appendix Table 7A-3.
MJ d^{-1} = - mega joules/day.
kcal d^{-1} = kilo calories/day.

Source: Layton, 1993

Table 7-9. Daily inhalation rates calculated from food-energy intakes

Cohort/Age (years)	L	Daily Inhalation Rate[a] (m^3/day)	Sleep (hours)	MET value		Inhalation Rates	
				A[b]	F[c]	Inactive[d] (m^3/day)	Active[d] (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	10.0	10	1.7	2.2	5.95	13.09
Males							
9–11	3	14.0	9	1.9	2.5	7.32	18.30
12–14	3	15.0	9	1.8	2.2	8.71	19.16
15–18	4	17.0	8	1.7	2.1	10.31	21.65
Females							
9–11	3	13.0	9	1.9	2.5	6.63	16.58
12–14	3	12.0	9	1.6	2.0	7.61	15.20
15–18	4	12.0	8	1.5	1.7	8.14	13.84

[a] Daily inhalation rate was calculated by multiplying the EFD values (see Table 7-10) by H x VQ x (m^3 1,000 L^{-1}) for subjects under 9 years of age and by 1.2 x H x VQ x (m^3 1,000 L^{-1}) (for subjects 9 years of age and older (see text for explanation), where EFD = food energy intake (Kcal/day) or (MJ/day), H = oxygen uptake = 0.05 LO_2/KJ or 0.21 LO_2/Kcal, and VQ = ventilation equivalent = 27 = geometric mean of VQs (unitless).

[b] For individuals 9 years of age and older, A was calculated by multiplying the ratio for EFD/BMR (unitless) (Table 7-10) by the factor 1.2 (see text for explanation).

[c] 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.

[d] Inhalation rate for inactive periods was calculated as BMR x H x VQ x (d 1,440 min^{-1}) and for active periods by multiplying inactive inhalation rate by F (See footnote f); BMR values are from Table 7-10, where BMR = basal metabolic rate (MJ/day) or (kg/hr).

L = number of years for each age cohort.

MET = metabolic equivalent.

Source: Layton, 1993

Table 7-10. Daily inhalation rates obtained from the ratios of total energy expenditure to basal metabolic rate (BMR)

Gender/Age (years)	Body weight[a] (kg)	BMR[b] (MJ/day)	VQ	A[c]	H (m^3O_2/MJ)	Inhalation Rate, V_E (m^3/day)[d]
Males						
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	15.0
Females						
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	12.0

[a] Body weight was based on the average weights for age/gender cohorts in the U.S. population.

[b] BMRs were calculated using the respective body weights and BMR equations (see Appendix Table 7A-3).

[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 7-11 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, where VQ = ventilation equivalent and H = oxygen uptake.

Source: Layton, 1993

Table 7-11. Inhalation rates for short-term exposures

MET (BMR Multiplier)			Inhalation Rate (m^3/hr)[f,g] by activity level				
			1	1.2	2[c]	4[d]	10[e]
Gender/age (years)	Weight (kg)[a]	BMR[b] (MJ/day)	Rest	Sedentary	Light	Moderate	Heavy
Males							
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
Females							
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

[a] Body weights were based on average weights for age/gender cohorts of the U.S. population.
[b] The BMRs for the age/gender cohorts were calculated using the respective body weights and the BMR equations (Appendix Table 7A-3).
[c] Range = 1.5–2.5.
[d] Range = 3–5.
[e] Range = >5–20.
[f] The inhalation rate was calculated by multiplying BMR (MJ/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 7-12. Mean, median, and SD of respiratory rate according to waking or sleeping in 618 infants and children grouped in classes of age (breaths/minute)

Age (months)	N	Respiratory rate (breaths/min)			
		Awake		Asleep	
		Mean ± SD	Median	Mean ± SD	Median
< 2	104	48.0 ± 9.1	47	39.8 ± 8.7	39
2 – <6	106	44.1 ± 9.9	42	33.4 ± 7.0	32
6 – <12	126	39.1 ± 8.5	38	29.6 ± 7.0	28
12 – <18	77	34.5 ± 5.8	34	27.2 ± 5.6	26
18 – <24	65	32.0 ± 4.8	32	25.3 ± 4.6	24
24 – <30	79	30.0 ± 6.2	30	23.1 ± 4.6	23
30 – 36	61	27.1 ± 4.1	28	21.5 ± 3.7	21

Source: Rusconi et al., 1994

Table 7-13. Confidence in inhalation rate recommendations

Considerations	Rationale	Rating
Study Elements Peer Review	Studies are from peer-reviewed journal articles and an EPA peer-reviewed report.	High
Accessibility	Studies in journals have wide circulation. EPA reports are available from the National Technical Information Service.	High
Reproducibility	Information on questionnaires and interviews were not provided.	Medium
Focus on factor of interest	Studies focused on ventilation rates and factors influencing them.	High
Data pertinent to U.S.	Studies conducted in the U.S. Distribution data are foreign data.	High
Primary data	Both data collection and reanalysis 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 were made by indirect methods.	Medium
Representativeness of the population	An effort has been made to consider age and gender, but not systematically. Sample size was too small.	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 were 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 seven relevant studies were evaluated.	
Agreement between researchers	There is 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.	**Medium**

Table 7-14. Summary of recommended values for inhalation[a]

Population (years)	Mean
Long-term exposures	
Infants	
< 1	4.5 m^3/day
Children	
1–2	6.8 m^3/day
3–5	8.3 m^3/day
6–8	10 m^3/day
9–11	
Males	14 m^3/day
Females	13 m^3/day
12–14	
Males	15 m^3/day
Females	12 m^3/day
15–18	
Males	17 m^3/day
Females	12 m^3/day
Short-term exposures	
Children (18 and under)	
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 Activities	1.9 m^3/hr

[a] No data were available for the upper percentile.

Table 7-15. Summary of arithmetic mean (m^3/hr) of children's inhalation rates by activity level for short-term exposure studies

Rest	Sedentary	Light	Moderate	High	
0.4	0.4	0.8	—	—	Adams, 1993 (lab protocols)
—	—	—	0.9	—	Adams, 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	11.0	Linn et al., 1992 (10–12 yrs)

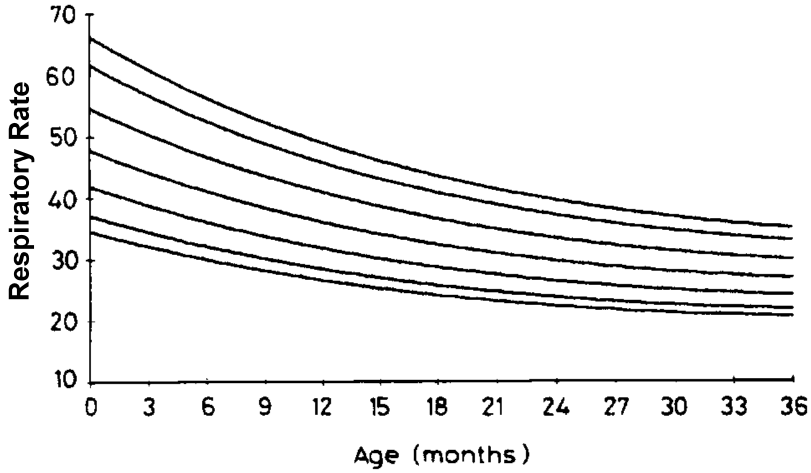

Figure 7-1. 5th, 10th, 25th, 50th, 75th, 90th, and 95th smoothed centiles by age in awake subjects.

Figure 7-2. 5th, 10th, 25th, 50th, 75th, 90th, and 95th smoothed centiles by age in asleep subjects.

Appendix A for Chapter 7: Ventilation Rates

Table 7A-1. Mean minute ventilation (V_e, L/min) by group and activity for laboratory protocols

Activity		Young Children[a]	Children
Lying		6.19	7.51
Sitting		6.48	7.28
Standing		6.76	8.49
Walking	1.500 mph	10.25	DNP[b]
	1.875 mph	10.53	DNP
	2.000 mph	DNP[b]	14.13
	2.250 mph	11.68	DNP
	2.500 mph	DNP	15.58
	3.000 mph	DNP	17.79
	3.300 mph	DNP	DNP
	4.000 mph	DNP	DNP
Running	3.500 mph	DNP	26.77
	4.000 mph	DNP	31.35
	4.500 mph	DNP	37.22
	5.000 mph	DNP	DNP
	6.000 mph	DNP	DNP

[a] Young Children, males and females, 3–5.9 years old; Children, males and females, 6–12.9 years old; Adult Females, adolescent, young to middle-aged, and older adult females; Adult Males, adolescent, young to middle-aged, and older adult males.
[b] Group did not perform this protocol or N was too small for appropriate mean comparisons.

Source: Adams, 1993

Table 7A-2. Mean minute ventilation (V_e, L/min) by group and activity for field protocols

Activity[a]	Young Children[b]	Children
Play	11.31	17.89

[a] Activities for which groups did not perform the protocol or N was too small for appropriate mean comparisons were car driving, car riding, yardwork, housework, car maintenance, mowing, and woodworking.
[b] Young children, males and females, 3–5.9 years old; Children, males and females, 6–12.9 years old.

Source: Adams, 1993

Table 7A-3. Statistics of the age/gender cohorts used To develop regression equations for predicting basal metabolic rates (BMR)

Gender/Age (years)	BMR			Body weight (kg)	N	BMR equation[a]	r
	MJ d^{-1}	± SD	CV				
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	21.0	338	0.095 bw + 2.110	0.83
0 to < 18	5.86	1.171	0.20	42.0	734	0.074 bw + 2.754	0.93
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	21.0	413	0.085 bw + 2.033	0.81
10 to < 18	5.04	0.780	0.15	38.0	575	0.056 bw + 2.898	0.80

[a] Body weight (bw) in kg
CV = Coefficient of variation (SD/mean)
r = coefficient of correlation

Source: Layton, 1993

REFERENCES FOR CHAPTER 7

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8. DERMAL ROUTE

8.1. INTRODUCTION

Children may be more highly exposed to environmental toxicants through dermal routes than are adults. For instance, children often play and crawl on contaminated surfaces and are more likely to wear less clothing than do adults. These factors result in higher dermal contact with contaminated media. In addition, children have a higher body surface area relative to body weight. In fact, the surface area-to-body weight (SA/BW) ratio for newborn infants is more than two times greater than that for adults (Cohen-Hubal et al., 1999).

Dermal exposure can occur during a variety of activities in different environmental media and microenvironments (U.S. EPA, 1992a, b). 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., touching carpets, floors, countertops).

The major factors that must be considered when estimating dermal exposure are the chemical concentration in contact with the skin, the extent of skin surface area exposed, the duration of exposure, the absorption of the chemical through the skin, the internal dose, and the amount of chemical that can be delivered to a target organ (i.e., biologically effective dose) (see Figure 8-1). A detailed discussion of these factors can be found in *Guidelines for Exposure Assessment* (U.S. EPA, 1992a).

This chapter focuses on measurements of body surface areas and dermal adherence of soil to the skin. *Dermal Exposure Assessment: Principles and Applications* (U.S. EPA, 1992b), provides detailed information concerning dermal exposure assessment using a stepwise guide in the exposure assessment process.

8.2. SURFACE AREA

8.2.1. 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, estimates 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.

8.2.2. 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 are 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 that parts of the body resemble geometric solids. More recently, Popendorf and Leffingwell (1976) and Haycock et al. (1978) have developed similar geometric methods that assume that 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 the appendix to Chapter 8.

8.2.3. Body Surface Area Studies

8.2.3.1. *Costeff, 1966*

Costeff (1996) developed an empirical formula for calculating the surface area of children. Earlier formulae encompassed derivation for a regular solid and then changing exponents and coefficients or using empirical formulae that bear no relation to the geometric problem. Costeff's empirical formula is the following:

$$SA = \frac{4W + 7}{W + 90} \tag{8-1}$$

where:

SA	=	surface area (m^2);
Constants	=	4, 7, and 90; and
W	=	weight (kg).

This simple formula applies to the weight range between 1.5 and 100 kg. According to the author, this formula is recommended for calculating basal metabolic rate and other physiological indices.

8.2.3.2. *U.S. EPA, 1985*

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). For their analysis, Gehan and George (1970) selected 401 measurements made by Boyd (1935) that were complete for surface area, height, weight, and age. Boyd (1935) had reported surface area estimates for 1114 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 (1970) 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.

Regression equations were developed for specific body parts using the Dubois and Dubois (1916) formula and using the surface area of various body pars provided by Boyd (1935) and Van Graan (1969) in conjunction with SPS. Equations to estimate the body part surface area of children were not developed because of insufficient data.

The percentile estimates for total surface area of male and female children presented in Tables 8-1 and 8-2 were calculated using the total surface area regression equation and 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, because it cannot be assumed that the errors associated with the exogenous variables (height and weight) are independent of those 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 8-3. 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 proportion of total body surface area contributed by the head decreases from childhood to adulthood, whereas the proportion contributed by the leg increases.

8.2.3.3. *Phillips et al., 1993*

Phillips et al. (1993) observed a strong correlation (0.986) between body surface area and body weight and studied the effect of using these factors as independent variables in the lifetime average daily dose (LADD) equation. The authors concluded that, because of the correlation between these two variables, the use of 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 SA/BW ratios for two age groups of children (infants ages 0 to 2 years and children ages 2.1 to 17.9 years). 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 the two age groups and the combined data set.

Summary statistics for the two children's age groups are presented in Table 8-4. 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. The 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.

8.2.3.4. *Wong et al., 2000*

Wong et al. (2000) conducted telephone surveys to gather information on children's activity patterns as related to dermal contact with soil during outdoor play on bare dirt or mixed grass and dirt surfaces. This second Soil Contact Survey (SCS-II) was a follow-up to an initial Soil Contact Survey (SCS-I) conducted in 1996, which primarily focused on assessing adult behavior related to dermal contact with soil and dust (Garlock et al., 1999). As part of SCS-I, information was gathered on the behavior of children under the age of 18 years; however, the questions were limited to clothing choices and the length of time after soil contact to hand washing. Results obtained for children from SCS-I were not reported in Garlock et al. (1999), but some of the collected information is summarized in Wong et al. (2000).

For SCS-I, the population size of children sampled was 211. Older children (those between the ages of 5 and 17 years) were questioned regarding participation in "gardening and yardwork," "outdoor sports," and "outdoor play activities." For children less than 5 years old, "outdoor play activities" occurring on a playground or yard with "bare dirt or mixed grass and dirt" surfaces were noted. An effort was also made to determine the clothing worn during these play activities during warm weather months (April though October). For both groups of children, information was gathered concerning hand washing, bathing, and clothes changing habits after soil contact activities, but these results are not reported in Wong et al. (2000).

The results of SCS-I indicated that most children wore short pants, a dress or skirt, short sleeve shirts, no socks, and leather or canvas shoes during the outdoor play activities of interest. Using data from Anderson et al. (1985), percentages of total body surface area associated with specific body parts were estimated (Table 8-5). Then exposed skin surface areas for children under age 5 were estimated per clothing item as well as for all clothing items worn together during warm weather outdoor play (Table 8-6). Faces and hands were assumed to be exposed under all conditions, with the face having a constant surface area fraction of 5% and the hands 6%.

8.2.4. Application of Body Surface Area Data

For swimming and bathing scenarios, past exposure assessments have assumed that 75% to 100% of the skin surface is exposed (U.S. EPA, 1992b). Central and upper-percentile values for children should be derived from Table 8-1 or Table 8-2.

Unlike in exposure to liquids, clothing may or may not be effective in limiting the extent of exposure to soil. The children clothing scenarios are presented below.

- Central tendency mid-range: Child wears long-sleeved shirt, pants, and shoes. The exposed skin surface is limited to the head and hands. Table 8-3 can be used to determine the skin surface area, depending on the age group of interest.

- Upper percentile: Child wears short-sleeved shirt, shorts, and shoes. The exposed skin surface is limited to the head, hands, forearms, and lower legs. Table 8-3 can be used to determine the skin surface, area depending on the age group of interest.

The clothing scenarios presented above suggest that roughly 10% to 25% of the skin area may be exposed to soil. Because 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, 1992b) for deriving defaults. Default values for children can be derived by multiplying the 50th and 95th percentiles of the total surface area 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% of the skin is exposed during the winter, 10% during the spring and fall, and 25% during the summer.

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.

8.3. SOIL ADHERENCE TO SKIN

This section presents soil adherence data 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 8-3 to estimate surface areas of specific body parts.

8.3.1. Background

Soil adherence to the surface of the skin is a required parameter for calculating 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 (1992b). This section summarizes recent studies that estimate soil adherence to skin for use as exposure factors.

8.3.2. Soil Adherence to Skin Studies

8.3.2.1. *Kissel et al., 1996a*

Kissel et al. (1996a) conducted soil adherence experiments using five soil types (descriptors) obtained locally in the Seattle, WA, 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 content ranged from 0.5 to 7.0%. Organic carbon content, determined by combustion, ranged from 0.7 to 4.6%. 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, and inversely correlated with particle size and was independent of clay content or organic carbon content.

8.3.2.2. *Kissel et al., 1996b*

Further experiments were conducted by Kissel et al. to estimate 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 (Kissel et al., 1996b). Several of the activities studied by involved children, as shown in Table 8-7.

A summary of field studies by activity, gender, age, field conditions, and clothing worn is presented in Table 8-7. The subjects' body surfaces (forearms, hands, lower legs for all sample groups; faces, and/or feet pairs in some sample groups) were washed before and after the monitored activities. Paired samples were pooled into single ones. Mass recovered was converted to loading using allometric models of surface area. Geometric means for soil adherence by activity and body region are presented in Table 8-8. The results presented are based on direct measurement of soil loading on the surfaces of skin before and after activities that may be expected to have soil contact (Kissel et al., 1996b). The results indicate that the rate of soil adherence to the hands is higher than for other parts of the body.

8.3.2.3. *Holmes et al.,1999*

Holmes et al. (1999) collected pre- and post-activity soil loadings on various body parts of individuals within groups engaged in various occupational and recreational activities. These groups included children at a daycare center (Daycare kids) and playing indoors in a residential setting (Indoor kids). This study was conducted as a follow-up to previous field sampling of soil adherence on individuals participating in various activities (Kissel et al., 1996b). For this round of sampling, soil loading data were collected using the same methods used and described in Kissel et al. (1996b). Information regarding the groups of children studied and their observed activities is presented in Table 8-9.

The daycare children studied were all at one location, and measurements were taken on 3 different days. The children freely played both indoors in the house and outdoors in the backyard. The backyard was described as having a grass lawn, shed, sand box, and wood chip box. In this setting, the children engaged in typical activities, including playing with toys and with each other, wrestling, sleeping, and eating. The number of children within each day's group and the clothing worn are described in Table 8-10.

The five children measured on the first day were washed first thing in the morning to establish a preactivity level. They were next washed at noon to determine the postactivity soil loading for the morning (Daycare kids No. 1a). The same children were washed once again at the close of the day for measurement of soil adherence from the afternoon play activities (Daycare kids No. 1b).

For the second observation day (Daycare kids No. 2), postactivity data were collected for five children. All the activities on this day occurred indoors. For the third daycare group (Daycare kids No. 3), four children were studied.

On two separate days, children playing indoors in a home environment were monitored. The first group (Indoor kids No. 1) had four children and the second group (Indoor kids No. 2) had six children. The play area was described by the authors as being primarily carpeted. The clothing worn by the children within each day's group is described in Table 8-10.

The geometric means and standard deviations of the postactivity soil adherence for each group of children and for each body part are summarized in Table 8-11. According to the authors, variations in the soil loading data from the daycare participants reflect differences in the weather and access to the outdoors.

An advantage of this study is that it provides a supplement to the soil loading data collected in a previous round of studies (Kissel et al., 1996b). Also, the data support the assumption that hand loading can be used as a conservative estimate of soil loading on other body surfaces for the same activity. The activities studied represent normal child play both indoors and outdoors, as well as for different combinations of clothing. The small number of participants is a disadvantage of this study. Also, the children studied and the activity setting may not be representative of the U.S. population.

8.3.2.4. *Kissel et al., 1998*

In this study, Kissel et al. (1998) measured dermal exposure to soil from staged activities conducted in a greenhouse. A fluorescent marker was mixed in soil so that soil contact for a particular skin surface area could be identified. The subjects, which included a group of children, were video-imaged under a long-wave ultraviolet (UV) light before and after soil contact. In this manner, soil contact on hands, forearms, lower legs, and faces was assessed by the presence of fluorescence. In addition to fluorometric data, gravimetric measurements for preactivity and postactivity were obtained from the different body parts examined.

The studied group of children played for 20 minutes in a soil bed of varying moisture content that represented wet and dry soils. For wet soils, combinations of both long sleeves and long pants and short sleeves and short pants were tested. Children only wore short sleeves and short pants during play in the dry soil. Clothing was laundered after each trail. Thus, a total of three trials with children were conducted. The parameters describing each of these trials are summarized in Table 8-12.

Before each trial, each child was washed in order to obtain a preactivity or background gravimetric measurement. Preactivity data are shown in Table 8-13. Body part surface areas were calculated using Anderson et al. (1985) for the range of heights and weights of the study participants.

For wet soil, postactivity fluorescence results indicated that the hand had a much higher fractional coverage than other body surfaces (see Figure 8-2). No fluorescence was detected on the forearms or lower legs of the children dressed in long sleeves and pants.

As shown in Figure 8-3, postactivity gravimetric measurements showed higher soil loading on hands and much lower amounts on other body surfaces, as was observed with the fluorescence data. According to the authors, the relatively low loadings observed on nonhand body parts may have been a result of the limited area of contact rather than lower localized loadings. A geometric mean dermal loading of 0.7 mg/cm^2 was found on the children's hands following play in wet soil. Mean loadings were lower on hands in the dry soil trial and on lower legs, forearms, and faces in both the wet and dry soil trials. Higher loadings were observed for all body surfaces with the higher moisture content soils.

This report is valuable in showing soil loadings from soils of different moisture content and providing evidence that dermal exposure to soil is not uniform for various body surfaces. There is also some evidence from this study demonstrating the protective effect of clothing. Disadvantages of the study include a small number of study participants and a short activity duration. Also, no information is provided on the ages of the children involved in the study.

8.4. RECOMMENDATIONS

8.4.1. 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 widely accepted. The representativeness of these data to the general population is somewhat limited, because variability due to race or gender have not been systematically addressed.

The recommendations for body surface area for children are summarized in Table 8-14. These recommendations are based on U.S. EPA (1985) and Phillips et al. (1993). Table 8-15 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, it summarizes and compares previous reports in the literature, it provides statistical distributions for adults, and it provides data for total body surface area and body parts by gender for children. The results are based on selected measurements from the original data collected by Boyd (1935). The Phillips et al. (1993) analyses are based on direct-measurement data that provide distributions of body surface area to calculate LADD. The results are consistent with previous efforts to estimate body surface area. Analyses are also based on measurements selected from the original measurements made by Boyd (1935), and data were not analyzed for specific body parts.

8.4.2. Soil Adherence to Skin

Recommendations for the rate of soil adherence to the skin are based on data collected by Kissel et al. (1996a, b) for specific activities. The experimental design and measurement methods used by Kissel et al. are straightforward and reproducible, but it should be noted that the controlled experiments and field studies are based on a limited number of measurements, and specific situations were selected to assess soil adherence to skin. Consequently, variation due to individuals, protective clothing, temporal, or seasonal factors remains to be studied in more detail. Therefore, caution is required in the interpretation and application of these results for exposure assessments.

In consideration of these general observations and the recent data from Kissel et al. (1996a, b), changes are needed to past EPA recommendations, which used one adherence value to represent all soils, body parts, and activities. One approach would be to select the activity from Table 8-7 that best represents the exposure scenario of concern and use the corresponding adherence value from Table 8-8. Although this approach represents an improvement, it still has shortcomings. For example, it is difficult to decide which activity in Table 8-8 is most representative of a typical residential setting involving a variety of activities. It may be useful to combine these activities into general classes of low, moderate, and high contact. In the future, it may be possible to combine activity-specific soil adherence estimates with survey-specific soil adherence estimates with survey-derived data on activity frequency and duration to develop overall average soil contact rates. EPA is sponsoring research to develop such an approach. As this information becomes available, updated recommendations will be issued.

Table 8-8 provides the best estimates available on activity-specific adherence values, but they are based on limited data. Therefore, they have a high degree of uncertainty, so considerable judgment must be used when selecting them for an assessment. The confidence ratings for various aspects of this recommendation are summarized in Table 8-16. 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 it 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, there has been increased acceptance that soil and dust particles can get under clothing and be deposited on skin. Second, recent studies of soil adherence 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 the 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 the 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, 1992b). 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, 1992b).

Table 8-1. Total body surface area of male children in m^2 [a]

Age (years)[b]	Percentile								
	5th	10th	15th	25th	50th	75th	85th	90th	95th
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	1.010	1.060
7 < 8	0.794	0.832	0.848	0.877	0.936	0.993	1.010	1.060	1.110
8 < 9	0.836	0.897	0.914	0.932	1.000	1.060	1.120	1.170	1.240
9 < 10	0.932	0.966	0.988	1.000	1.070	1.130	1.160	1.250	1.290
10 < 11	1.010	1.040	1.060	1.100	1.180	1.280	1.350	1.400	1.480
11 < 12	1.000	1.060	1.120	1.160	1.230	1.400	1.470	1.530	1.600
12 < 13	1.110	1.130	1.200	1.250	1.340	1.470	1.520	1.620	1.760
13 < 14	1.200	1.240	1.270	1.300	1.470	1.620	1.670	1.750	1.810
14 < 15	1.330	1.390	1.450	1.510	1.610	1.730	1.780	1.840	1.910
15 < 16	1.450	1.490	1.520	1.600	1.700	1.790	1.840	1.900	2.020
16 < 17	1.550	1.590	1.610	1.660	1.760	1.870	1.980	2.030	2.160
17 < 18	1.540	1.560	1.620	1.690	1.800	1.910	1.960	2.030	2.090
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	1.010	1.050	1.090	1.140
9 < 12	0.972	1.000	1.020	1.070	1.160	1.280	1.360	1.420	1.520
12 < 15	1.190	1.240	1.270	1.320	1.490	1.640	1.730	1.770	1.850
15 < 18	1.500	1.550	1.590	1.650	1.750	1.860	1.940	2.010	2.110

[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 8-2. Total body surface area of female children m^2 [a]

Age (year)[b]	Percentile								
	5th	10th	15th	25th	50th	75th	85th	90th	95th
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	1.030
7 < 8	0.792	0.808	0.819	0.854	0.917	0.977	1.020	1.060	1.130
8 < 9	0.863	0.888	0.913	0.932	1.000	1.050	1.080	1.110	1.180
9 < 10	0.897	0.948	0.969	1.010	1.060	1.140	1.220	1.310	1.410
10 < 11	0.981	1.01	1.050	1.100	1.170	1.290	1.340	1.370	1.430
11 < 12	1.060	1.09	1.120	1.160	1.300	1.400	1.500	1.560	1.620
12 < 13	1.130	1.19	1.240	1.270	1.400	1.510	1.620	1.640	1.700
13 < 14	1.210	1.28	1.320	1.380	1.480	1.590	1.670	1.750	1.860
14 < 15	1.310	1.34	1.390	1.450	1.550	1.660	1.740	1.760	1.880
15 < 16	1.380	1.49	1.430	1.470	1.570	1.670	1.720	1.760	1.830
16 < 17	1.400	1.46	1.480	1.530	1.600	1.690	1.790	1.840	1.910
17 < 18	1.420	1.49	1.510	1.560	1.630	1.730	1.800	1.840	1.940
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	1.000	1.040	1.070	1.130
9 < 12	0.957	0.990	1.030	1.060	1.160	1.310	1.380	1.430	1.560
12 < 15	1.210	1.27	1.300	1.370	1.480	1.610	1.680	1.740	1.820
15 < 18	1.400	1.44	1.470	1.510	1.600	1.700	1.760	1.820	1.920

[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 8-3. Percentage of total body surface area by body part for children

Age (years)	N[a] M:F	Percent of Total: Head Mean	Head Min-Max	Trunk Mean	Trunk Min-Max	Arms Mean	Arms Min-Max	Hands Mean	Hands Min-Max	Legs Mean	Legs Min-Max	Feet Mean	Feet Min-Max
< 1	2:0	18.20	18.2–18.3	35.70	34.8–36.6	13.70	12.4–15.1	5.300	5.21–5.39	20.60	18.2–22.9	6.540	6.49–6.59
1 < 2	1:1	16.50	16.5–16.5	35.50	34.5–36.6	13.00	12.8–13.1	5.680	5.57–5.78	23.10	22.1–24.0	6.270	5.84–6.70
2 < 3	1:0	14.20		38.50		11.80		5.300		23.20		7.070	
3 < 4	0:5	13.60	13.3–14.0	31.90	29.9–32.8	14.40	14.2–14.7	6.070	5.83–6.32	26.80	26.0–28.6	7.210	6.80–7.88
4 < 5	1:3	13.80	12.1–15.3	31.50	30.5–32.4	14.00	13.0–15.5	5.700	5.15–6.62	27.80	26.0–29.3	7.290	6.91–8.10
5 < 6													
6 < 7	1:0	13.10		35.10		13.10		4.710		27.10		6.900	
7 < 8													
8 < 9													
9 < 10	0:2	12.00	11.6–12.5	34.20	33.4–34.9	12.30	11.7–12.8	5.300	5.15–5.44	28.70	28.5–28.8	7.580	7.38–7.77
10 < 11													
11 < 12													
12 < 13	1:0	8.74		34.70		13.70		5.390		30.50		7.030	
13 <14	1:0	9.97		32.70		12.10		5.110		32.00		8.020	
14 < 15													
15 < 16													
16 < 17	1:0	7.96		32.70		13.10		5.680		33.60		6.930	
17 < 18	1:0	7.58		31.70		17.50		5.130		30.80		7.280	

[a] N = number of subjects; M:F = male-to-female ratios.

Source: U.S. EPA, 1985

Table 8-4. Descriptive statistics for surface area/body weight (SA/BW) ratios (m^2/kg)

Age (years)	Mean	Range (min–max)	SD[a]	SE[b]	Percentiles						
					5th	10th	25th	50th	75th	90th	95th
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

Source: Phillips et al., 1993

Table 8-5. Clothing choices and assumed body surface areas exposed

Clothing	Area assumed exposed	% of total body surface area	
		M	F
Long pants		0	0
Short pants	Lower ½ of thigh and upper ½ of lower leg	13	13
Long sleeves		0	0
Short sleeves	Forearms	6	6
No shirt (males)	3/4 trunk and arms	38	n/a
Halter (females)	1/2 trunk and arms	n/a	30
High socks		0	0
Low socks	1/4 lower leg	3	3
No socks	bottom half lower leg	6	6
Shoes		0	0
No shoes or sandals	feet	7	7
Gloves		0	0
No gloves	hands	6	6
Hat or no hat	1/3 head for face	5	5
Maximum exposure		75	67

Source: Wong et al., 2000

Table 8-6. Estimated skin surface exposed during warm weather outdoor play for children under age 5 (based on SCS-I data)

	Skin area exposed (% of total) based on expressed choice of clothing					
	Pants	Shirt sleeves	Socks	Shoes	Hat[a]	All clothing
N	41.0	43.0	42.0	43.0	43.0	41.0
Mean	12.8	6.6	4.4	3.0	5.0	32.0
Median	13.0	6.0	5.3	3.5	5.0	30.5
S.D.	1.0	2.7	1.7	3.2	0.0	6.0

[a] Face was assumed to always be exposed.

Source: Wong et al., 2000

Table 8-7. Summary of field studies

Activity	Month	Event duration (hours)	M/F	N[b]	Age (years)	Conditions	Clothing
Indoor							
Tae kwon do	Feb	1.50	6/1	7	8–42	Carpeted floor	All in long sleeved, long pants martial arts uniform, sleeves rolled back, barefoot
Indoor kids No. 1	Jan	2.00	3/1	4	6–13	Playing on carpeted floor	3 of 4 short pants, 2 of 4 short sleeves, socks, no shoes
Indoor kids No. 2	Feb	2.00	4/2	6	3–13	Playing on carpeted floor	5 of 6 long pants, 5 of 6 long sleeves, socks, no shoes
Daycare kids No. 1a	Aug	3.50	5/1	6	1–6.5	Indoors: linoleum surface; outdoors: grass, bare earth, barked area	4 of 6 long pants, 4 of 6 short sleeves, shoes
Daycare kids No. 1b	Aug	4.00	5/1	6	1–6.5	Indoors: linoleum surface; outdoors: grass, bare earth, barked area	4 of 6 long pants, 4 of 6 short sleeves, no shoes
Daycare kids No.2[b]	Sept	8.00	4/1	5	1–4	Indoors, low napped carpeting, linoleum surfaces	4 of 5 long pants, 3 of 5 long sleeves, all barefoot for part of the day
Daycare kids No. 3	Nov	8.00	3/1	4	1–4.5	Indoors: linoleum surface, outside: grass, bare earth, barked area	All long pants, 3 of 4 long sleeves, socks and shoes
Outdoor							
Soccer No. 1	Nov	0.67	8/0	8	13–15	Half grass-half bare earth	6 of 8 long sleeves, 4 of 8 long pants, 3 of 4 short pants and shin guards
Gardeners No. 1	Aug	4.00	1/7	8	16–35	Weeding, pruning, digging a trench	6 of 8 long pants, 7 of 8 short sleeves, 1 sleeveless, socks, shoes, intermittent use of gloves
Archeologists	July	11.50	3/4	7	16–35	Digging with trowel, screening dirt, sorting	6 of 7 short pants,all short sleeves, 3 no shoes or socks, 2 sandals
Kids in mud No. 1	Sept	0.17	5/1	6	9–14	Lake shoreline	All in short sleeve T-shirts, shorts, barefoot
Kids in mud No. 2	Sept	0.33	5/1	6	9–14	Lake shoreline	All in short sleeve T-shirts, shorts, barefoot

[b] Activities were confined to the house

Sources: Kissel et al., 1996b; Holmes et al., 1996

Table 8-8. Geometric mean (Geometric Standard Deviation) of soil adherence by activity and body region

Activity	N	Postactivity dermal soil loadings (mg/cm²)				
		Hands	Arms	Legs	Faces	Feet
Indoor						
Tae kwon do	7	0.0063 (1.9)	0.0019 (4.1)	0.0020 (2.0)		0.0022 (2.1)
Indoor kids No. 1	4	0.0073 (1.9)	0.0042 (1.9)	0.0041 (2.3)		0.0120 (1.4)
Indoor kids No. 2	6	0.0140 (1.5)	0.0041 (2.0)	0.0031 (1.5)		0.0091 (1.7)
Daycare kids No. 1a	6	0.1100 (1.9)	0.0260 (1.9)	0.0300 (1.7)		0.0790 (2.4)
Daycare kids No. 1b	6	0.1500 (2.1)	0.0310 (1.8)	0.0230 (1.2)		0.1300 (1.4)
Daycare kids No. 2	5	0.0730 (1.6)	0.0230 (1.4)	0.0110 (1.4)		0.0440 (1.3)
Daycare kids No. 3	4	0.0360 (1.3)	0.0120 (1.2)	0.0140 (3.0)		0.0053 (5.1)
Outdoor						
Soccer No. 1	8	0.1100 (1.8)	0.0110 (2.0)	0.0310 (3.8)	0.012 (1.5)	
Gardeners No. 1	8	0.2000 (1.9)	0.0500 (2.1)	0.0720 —	0.058 (1.6)	0.1700 —
Archeologists	7	0.1400 (1.3)	0.0410 (1.9)	0.0280 (4.1)	0.050 (1.8)	0.2400 (1.4)
Kids in mud No. 1	6	35.0000 (2.3)	11.0000 (6.1)	36.0000 (2.0)		24.0000 (3.6)
Kids in mud No. 2	6	58.0000 (2.3)	11.0000 (3.8)	9.5000 (2.3)		6.7000 (12.4)

Sources: Kissel et al., 1996b; Holmes et al., 1996

Table 8-9. Summary of groups assayed in round 2 of field measurements

Activity	Month	Event duration (hours)	M/F	N	Ages
Daycare kids No. 1a	Aug	3.5	5/1	6	1–6.5
Daycare kids No. 1b	Aug	4.0	5/1	6	1–6.5
Daycare kids No. 2	Sept	8.0	4/1	5	1–4
Daycare kids No. 3	Nov	8.0	3/1	4	1–4.5
Indoor kids No. 1	Jan	2.0	3/1	4	6–13
Indoor kids No. 2	Feb	2.0	4/2	6	3–13

Source: Holmes et al., 1999

Table 8-10. Attire for individuals within children's groups studied

Activity	N	Pants		Sleeves		Socks		Shoes
		Long	Short	Long	Short	High	Low	
Daycare kids No. 1a	6	4	2	1	5	1	5	Low leather or canvas shoes: 6
Daycare kids No. 1b	6	4	2	1	5	1	5	Barefoot: 3 Low leather or canvas shoes: 3
Daycare kids No. 2	5	4	1	2	3	NA	NA	Barefoot: 2 Shoes/socks ½ day and barefoot ½ day: 3
Daycare kids No. 3[a]	4	4	0	3	1	0	4	Low shoes: 4
Indoor kids No. 1	4	1	3	2	2	0	4	No shoes (socks only): 4
Indoor kids No. 2	6	5	1	5	1	0	6	No shoes (socks only): 6

[a] All children wore jackets when engaged in outdoor activities.
NA = Not Available: 3 children wore socks for ½ day in the morning but no specific information is provided on the type of socks worn.

Source: Holmes et al., 1999

Table 8-11. Geometric mean (geometric standard deviation) of round 2 post-activity loadings

Activity	N[a]	Postactivity Dermal Soil Loadings (mg/cm2)			
		Hands	Forearms	Lower legs	Feet[b]
Daycare kids No. 1a	4	0.1100 (1.9)	0.0260 (1.9)	0.0300 (1.7)	0.0790 (2.4)
Daycare kids No. 1b	6	0.1500 (2.1)	0.0310 (1.8)	0.0230 (1.2)	0.1300 (1.4)
Daycare kids No. 2	6	0.0730 (1.6)	0.0230 (1.4)	0.0110 (1.4)	0.0440 (1.3)
Daycare kids No. 3	6	0.0360 (1.3)	0.0120 (1.2)	0.0140 (3.0)	0.0053 (5.1)
Indoor kids No. 1	5	0.0073 (1.9)	0.0042 (1.9)	0.0041 (2.3)	0.0120 (1.4)
Indoor kids No. 2	4	0.0140 (1.5)	0.0041 (2.0)	0.0031 (1.5)	0.0091 (1.7)

[a] Number of data points for specific non-hand body parts may deviate slightly.
[b] Children's feet rather than faces were washed in order to reduce the chance of a child's refusal to participate.

Source: Holmes et al., 1999

Table 8-12. Summary of controlled greenhouse trials, children playing

Activity	Age (years)	Duration (min)	Soil moisture (%)	Clothing	N	M/F
Playing	8–12	20	17–18	L	4	3/1
			16–18	S	9	5/4
			3–4	S	5	3/2

L = long sleeves and long pants.
S = short sleeves and short pants.

Source: Kissel et al., 1998

Table 8-13. Preactivity loadings recovered from greenhouse trial children volunteers

Area	N	Body part surface area (cm^2)	Geometric mean ($\mu g/cm^2$) (95% CI)
Hands	12	420–798	9.4 (5.4–15.8)
Forearms	12	584–932	3.4 (2.3–5.2)
Lower legs	12	1206–2166	1.0 (0.7–1.5)
Face	12	388–602	0.8 (0.5–1.5)

Source: Kissel et al., 1998

Table 8-14. Summary of recommended values for skin surface area

Surface Area	Central Tendency	Upper Percentile	Multiple Percentiles
Whole body	See Table 8-1 and 8-4 for 50^{th} percentile	See Tables 8-1, 8-2, and 8-4	See Tables 8-1, 8-2, and 8-4
Body parts	See Table 8-3	See Table 8-3	See Table 8-3

Table 8-15. Confidence in body surface area measurement recommendations

Considerations	Rationale	Rating
Study Elements		
Level of peer review	Studies were from peer-reviewed journal articles. EPA report was peer-reviewed before distribution.	High
Accessibility	The journals used have wide circulation. EPA report available from the National Technical Information Service.	High
Reproducibility	Experimental methods are 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	One 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. Influences of age, race, or gender have not been detailed adequately in these studies.	**Medium**

Table 8-16. Confidence in soil adherence to skin recommendations

Considerations	Rationale	Rating
Study Elements		
Level of peer review	Studies were from peer-reviewed journal articles.	High
Accessibility	Articles were published in widely circulated journals.	High
Reproducibility	Reports clearly describe experimental method.	High
Focus on factor of interest	The goal of the studies was to determine soil adherence to skin.	High
Data pertinent to U.S.	Experiments were conducted in the U.S.	High
Primary data	Experiments directly measured soil adherence to skin; exposure and dose of chemicals in soil were measured indirectly or estimated from soil contact.	High
Currency	New studies were presented.	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 were limited to Washington State and 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	The studies attempted to measure soil adherence in selected activities and conditions to identify important activities and groups.	High
Measurement error	The experimental error is low and well controlled.	High
Other Elements		
Number of studies	The experiments were controlled as they were conducted by a few laboratories; activity patterns were studied by only one laboratory.	Medium
Agreement among researchers	Results from key study were consistent with earlier estimates from relevant studies and assumptions but are limited to hand data.	Medium
Overall Rating	Data are limited; therefore it is difficult to extrapolate from experiments and field observations to general conditions. Application of results to other similar activities may be subject to variation.	**Medium**

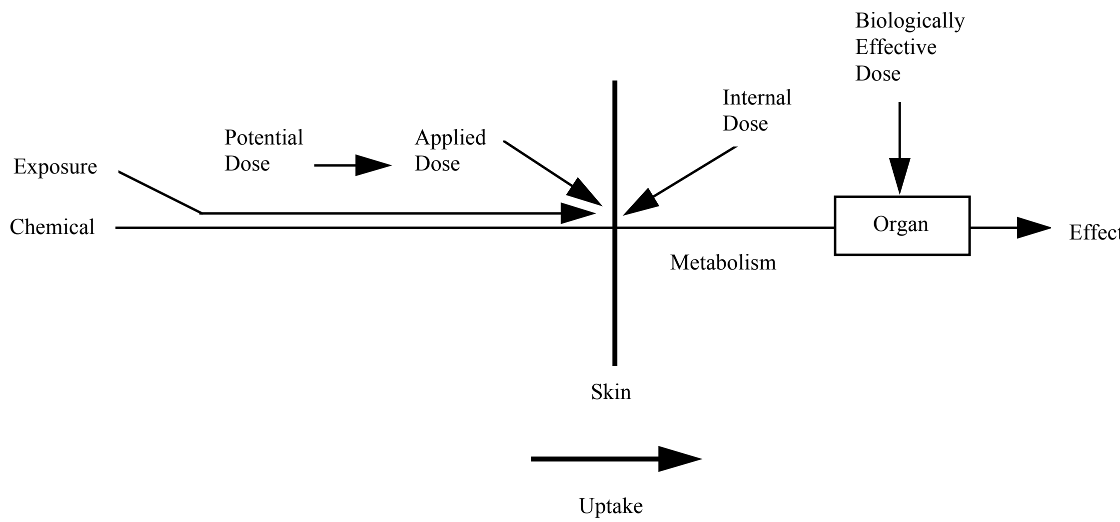


Figure 8-1. Schematic of dose and exposure: dermal route.

Source: U.S. EPA, 1992a

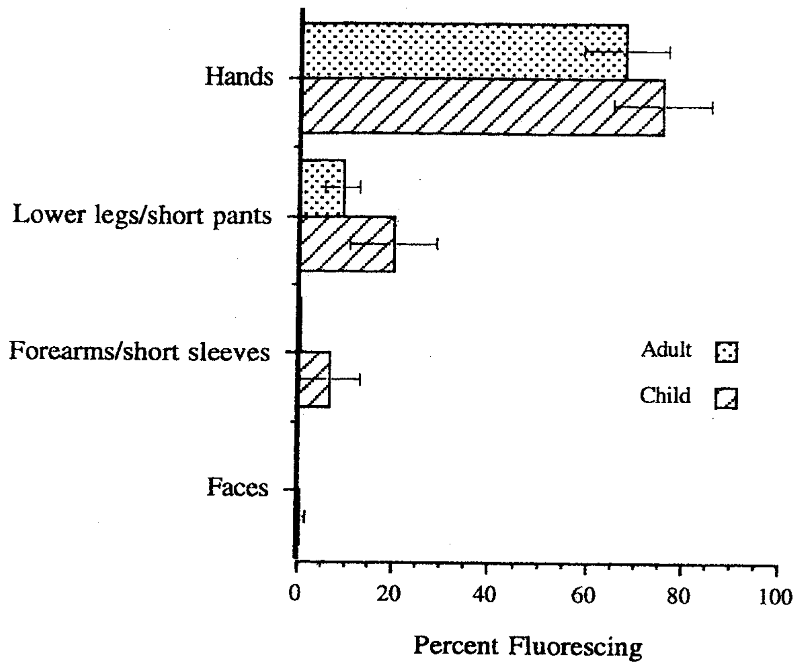
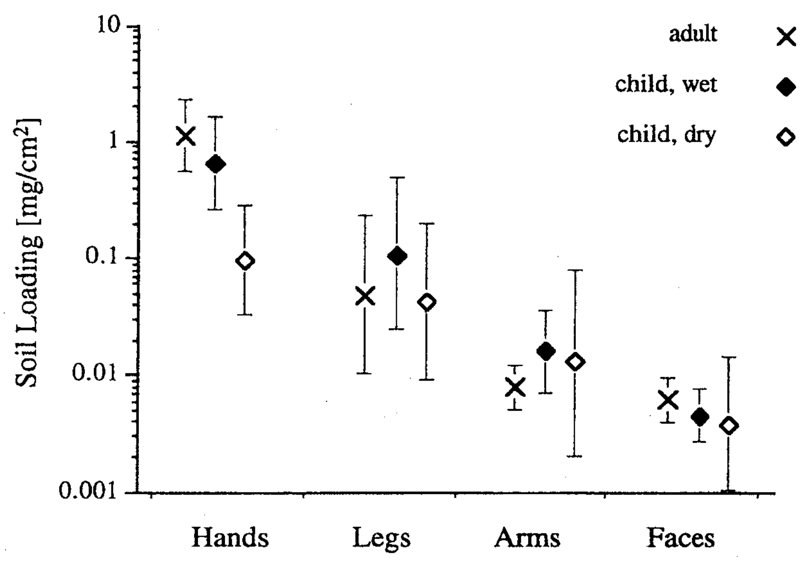


Figure 8-2. Skin coverage as determined by fluorescence versus body part for adults transplanting plants and for children playing in wet soils.

Source: Kissel, 1998

Figure 8-3. Gravimetric loading versus body part for adult transplanting plants in wet soil



and for children playing in wet and dry soils.

Source: Kissel, 1998

Appendix A for Chapter 8: 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):

$$SA = KW^{2/3} \qquad (8A\text{-}1)$$

where:

SA = surface area in m^2;
W = weight in kg; and
K = constant.

Although 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.

$$SA = a_0 \, H^{a1} W^{a2} \qquad (8A\text{-}2)$$

A formula published in 1916 that still finds wide acceptance and use is that of Dubois and Dubois. Their model can be written:

where:

SA = surface area in m^2;
H = height in cm; 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 and 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 (Lentner, 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 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 m^2 depends on the surface area of the individual. Gehan and George 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 SA is:

$$SA = 0.02350\ H^{0.42246} W^{0.51456} \qquad (8A\text{-}3)$$

or in logarithmic form:

$$1nSA = -3.75080 + 0.422461nH + 0.514561nW \qquad (8A\text{-}4)$$

where:

SA = surface area in m^2;
H = height in cm; and
W = weight in kg.

This prediction explains more than 99% of the variations in surface area among the 401 individuals measured (Gehan and George, 1970).

The equation proposed by Gehan and George was determined by EPA as the best choice for estimating total body surface area (U.S. EPA, 1985). 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 software package to obtain the standard error.

The Dubois and Dubois (1916) formula uses weight and height as independent variables to predict total body SA, and can be written as:

or in logarithmic form:

where:

Sa_i	=	surface area of the i-th individual (m^2);
H_i	=	height of the i-th individual (cm);
W_i	=	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:

$$SA_i = a_0 H_i^{a1} W_i^{a2} e_i \qquad (8A\text{-}5)$$

$$SA = 0.0239\ H^{0.417} W^{0.517} \qquad (8A\text{-}7)$$

$$1n(SA)_i = 1na_0 + a_1 1nH_i + a_2 1nW_i + 1ne_i \qquad (8A\text{-}6)$$

or in logarithmic form:

$$1nSA = 3.73 + 0.4171nH + 0.5171nW \quad (8A\text{-}8)$$

with a standard error about the regression of 0.00374. This model explains more than 99% 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% 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%. 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. Because the same observer measured surface area for these four 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 in Table 8A-1.

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 m^2, 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), working 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. 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 two hospitals (19 cases). The subjects all had grossly normal body structure, but the sample

Table 8A-1. Estimated Parameter Values for Different Age Intervals

Age group	N	Values		
		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 old	30	0.01545	0.54468	0.46336

included subjects of widely varying physique, ranging from thin to obese. Black, Hispanic, and white children were included in the 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:

$$SA = 0.024265H^{0.3964}W^{0.5378} \quad (8A\text{-}9)$$

expressed logarithmically as:

$$1nSA = 1n0.024265 + 0.39641nH + 0.53781nW \quad (8A\text{-}10)$$

The coefficients for this equation agree remarkably well with those obtained by Gehan and George (1970) for 401 measurements.

George et al. (1979) agreed 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 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:

$$1nSA = 1na_0 + a_1 lnH + a_2 lnW \quad (8A\text{-}11)$$

The values for a_0, a_1, and a_2 obtained by the various authors discussed in this section are shown in Table 8A-2.

Table 8A-2. Summary of surface area parameter values for the Dubois and Dubois model

Author	N	Values		
		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. were unaware of the previous work. Haycock et al. 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 because it is based on the largest number of direct measurements.

Sendroy and Cecchini (1954) proposed a graphical method for creating a nomogram whereby surface area could be read from a diagram relating height and weight to surface area. However, they did 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.

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9. ACTIVITY FACTORS

9.1. INTRODUCTION

As a consequence of a child's immaturity and small stature, certain activities and behaviors specific to children place them at higher risk to certain environmental agents (Chance and Harmsen, 1998). Individual or group activities are important determinants of potential exposure, because toxic chemicals introduced into the environment may not cause harm to a child until an activity is performed that subjects the child to contact with those contaminants. An activity or time spent will vary on the basis of, for example, culture, hobbies, location, gender, age, and personal preferences. It is difficult to accurately collect/record data for a child's activity patterns (Hubal et al., 2000). Children engage in more contact activities than do adults: therefore, a much wider distribution of activities need to be considered when assessing children's exposure (Hubal et al., 2000). Behavioral patterns, preferred activities, and developmental stages result in different exposures for children than for adults (Chance and Harmsen, 1998).

This section summarizes data on how much time children spend participating in various activities in various microenvironments and on the frequency of performing various activities. These data cover a wide scope of activities and populations, which are arranged by age group when such data are available.

9.2. ACTIVITY PATTERNS

This section briefly describes published time-use studies that provide information on time-activity patterns of children in the U.S. For a detailed description of the studies, the reader is referred to *Exposure Factors Handbook* (U.S. EPA, 1997).

9.2.1. Timmer et al., 1985

Timmer et al. (1985) conducted a study using the data obtained on children's time use from a 1981–1982 panel study. A total of 922 children between the ages of 3 and 17 years participated in the survey, which used a time diary and a standardized interview. The time diary involved the children's 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 was administered to the children 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.

The mean time spent performing major activities on weekdays and weekends by age and sex and type of day is presented in Table 9-1. On weekdays, the children spent about 40% of their time sleeping, 20% in school, and 10% eating, washing, dressing, and performing other personal activities (Timmer et al., 1985). The data in Table 9-1 indicate that girls spent more time than boys performing household work and personal care activities and less time playing sports. Also, the children spent most of their free time watching television.

Table 9-2 presents the mean time children spent during weekdays and weekends performing major activities by five different age groups. The significant effects of each variable (i.e., age and sex) are also shown. Older children spent more time performing household and market work, studying, and watching television and less time eating, sleeping, and playing. The authors estimated that, on average, boys spent 19.4 hours a week and girls spent 17.8 hours per week watching television.

A limitation associated with this study is that it was conducted in 1981, and there is the potential that activity patterns in children may have changed significantly from 1981 to the present. Thus, application of these data for current exposure assessment may bias results. Another limitation is that the data do not provide overall annual estimates of children's time use, because data were collected only during the time of the year when children attended school and not during school vacation.

EPA estimated the total time indoors and outdoors using the Timmer et al. data. Activities performed indoors were assumed to include household work, personal care, eating, sleeping, attending school, studying, attending church, watching television, and engaging in household conversations. The average times spent in these indoor activities and half the time spent in each activity that could have occurred either indoors or outdoors (e.g., market work, sports, hobbies, art activities, playing, reading, and other passive leisure) were summed. Table 9-3 shows the results of this analysis by age groups and time of the week.

9.2.2. Robinson and Thomas, 1991

Robinson and Thomas (1991) reviewed and compared data from the 1987–88 California Air Resources Board (CARB) time-activity study for California residents and from a similar 1985 national study, *American's Use of Time*. Both studies used the diary approach data. Time-use patterns were collected for individuals 12 years and older. Telephone interviews based on the random-digit-dialing procedure were conducted for 1762 and 2762 respondents for the CARB study and the national study, respectively. Data categorized for children (18 years and younger) were not provided in Robinson and Thomas (1991).

In addition, Robinson and Thomas (1991) defined a set of 16 microenvironments on the basis of the activity and location codes employed in the two studies. The mean duration of time spent in three location categories is presented in Table 9-4. Respondents spent most of their time indoors: 1255 and 1279 min/day in the CARB study and the national study, respectively.

Table 9-5 presents the mean duration of time and standard mean error for 16 microenvironments, grouped by total sample population and gender. Also included is the mean time spent by respondents who reported participating in each activity ("doers"). Table 9-5 shows that in both studies males spent more time in work locations, in automobiles and other vehicles, and in autoplaces (garages) and engaging in physical activities at outdoor sites. In contrast, females spent more time cooking, engaging in other kitchen activities, performing other chores, and shopping. The same trends also occurred on a per-participant basis.

Table 9-6 shows the mean time spent in various microenvironments by time of week (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 9-7.

One of the limitations associated with the Robinson and Thomas (1991) study is that the CARB survey was performed in California only. Therefore, if applied to other populations, the data set may be biased. In addition, the studies were conducted in 1980s and may bias exposure assessment results when used for current exposure assessments. Another limitation is that time distribution patterns were not provided for both studies, and the data are based on short-term studies.

9.2.3. Wiley et al., 1991

The California children's activity pattern survey design (Wiley et al., 1991) provided estimates of the time children spent in various activities and locations (microenvironments) on a typical day. A total of 1200 children under the age of 12 years were included in the study. The average times spent participating in the 10 activity categories are presented in Table 9-8. 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 activity category with the highest time expenditure was personal care (794 mins/day, 13.2 hrs/day), with night sleep being the detailed activity with the highest average minutes. The activity category "don't know" had a duration of about 2 min/day, and only 4% of the respondents reported missing activity time.

Table 9-9 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 9-10 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 9-11 presents the distribution of time across six location categories. The participation rates (percent) of respondents; the mean, median, and maximum time for "doers"; and the detailed location with the highest average time expenditure are shown. The largest amount of time spent was at home (1078 min/day); 99% of respondents spent time at home (1086 min/participant/day). Tables 9-12 and 9-13 show the average time spent in the six locations grouped by age and gender and by season and region, respectively. There are age differences in time expenditure in educational settings (Table 9-12). There are no differences in time expenditure at the six locations by regions, and time spent in school decreased in the summer months as compared to other seasons (Table 9-13).

Table 9-14 shows the average potential exposure time children spent in proximity to tobacco smoke, gasoline fumes, and gas oven fumes. The sampled children spent more time closer to tobacco smoke (77 min/day) than to gas oven fumes (11 min/day) or to gasoline fumes (2 min/day).

EPA estimated the total time indoors and outdoors using the data from the Wiley et al. (1991) study. Activities performed indoors were assumed to include household work, child care, personal needs and care, education, and communication and passive leisure. The average times spent in these indoor activities and half the time spent in each activity that could have occurred either indoors or outdoors (i.e., work-related, goods/services, organizational activities, entertainment/social, don't know/not coded) were summed. Table 9-15 summarizes the results of this analysis by age groups.

9.2.4. U.S. EPA, 1992

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 for soil- and water-related activities. The suggested values that can be used for dermal exposure are presented in Table 9-16. Limitations of this study are that the values are based on small data sets and a limited number of studies.

These data are not representative for children in specific age group categories. An advantage is that it presents default values for frequency and duration for use in exposure assessments when specific data are not available.

9.2.5. Tsang and Klepeis, 1996

The National Human Activity Pattern Survey (NHAPS) conducted by EPA is the largest and most current human activity pattern survey available (Tsang and Klepeis, 1996). A total of 9386 individuals of all ages participated in the study. Data were collected 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 (e.g., gender, age, race, employment status, census region, season). 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.

Tables 9-17 through 9-47 provide data from the NHAPS study. Tables 9-17 through 9-31 present data on the amount of time spent in selected activities and/or the corresponding distribution data, when available. The data are for age groups 1–17 years old only, where data are available.

- Table 9-17 presents number of showers per day by age of respondents. The data show that the majority of respondents took a shower one or two times a day.

- Table 9-18 shows time spent taking a shower and time spent in the shower room immediately after showering. Most of the respondents spent 10–20 minutes taking a shower and in the shower room after showering.

- Table 9-19 shows the percentile data for the same activity shown in Table 9-16. The 50th percentile value is 10 minutes for showering and 5 minutes for time spent after showering was complete. The 90th percentile values vary across age groups and range from 30–35 minutes and 10–15 minutes for time spent showering and in the bathroom after showering, respectively.

- Table 9-20 presents total time (minutes) spent in the shower or bathtub and in the bathroom immediately after a shower or bath. The majority of respondents spent 10–20 minutes in the shower or bathtub and approximately 10 minutes in the bathroom afterwards.

- Table 9-21 presents the percentile data for the same activity shown in Table 9-18. The 50th percentile values range from 15 to 20 minutes and from 2 to 5 minutes for taking a shower or bath and time spent in the bathroom after the bath, respectively.

- Table 9-22 provides a range of the number of times the respondents washed their hands in a day. Most washed their hands 3–5 times a day.

- Table 9-23 presents statistics data for the number of minutes per day spent working or being near excessive dust in the air. For age groups 1–11 years old, the 50th percentile data indicate that approximately 75 min/day was spent in air with excessive dust.

- Table 9-24 provides data for the frequency of starting a motor vehicle in a garage or carport and starting with the garage door closed.

- Table 9-25 provides data for the range of min/day spent playing on sand, gravel, dirt, or grass and playing when fill dirt was present.

- Table 9-26 provides the percentile data for the same activity shown in Table 9-25.

- Table 9-27 presents data for time (min/day) spent playing on the grass by number of respondents. The majority of respondents spent more than 120 min/day in this activity.

- Table 9-28 presents percentile data for the same activity shown in Table 9-27. The 50th percentile rate is 60 min/day for all age groups.

- Table 9-29 provides number of times/month respondents swam in a freshwater swimming pool. The majority of respondents did so 1 or 2 times/month.

- Table 9-30 provides percentile data for the same activity shown in Table 9-29. The 50th percentile values are 42.5 min/month for age group 1–4 years and 60 min/month for age groups 5–11 and 12–17 years.

- Table 9-31 presents the range of the average amount of time (min/month) actually spent in the water by swimmers. The majority of swimmers spent an average of 50 to 60 min/month in the water.

Tables 9-32 through 9-45 provide statistics for 24-hour cumulative time (minimum, mean, maximum) spent in or in the presence of selected activities. The minimum is the minimum number of minutes spent in the activity. The mean is the mean 24-hour cumulative number of minutes spent by doers. The maximum is the maximum number of minutes spent in the activity. The percentiles are the percentage of doers below or equal to the given number of minutes.

- Table 9-32 provides number of minutes spent playing indoors and playing outdoors.
- Table 9-33 provides number of minutes spent sleeping/napping in a day.
- Table 9-34 presents data for time spent attending full-time school.
- Table 9-35 provides data for time spent in active sports and for time spent in sports/exercise.
- Table 9-36 presents data for time spent in outdoor recreation and walking.
- Table 9-37 provides data for time spent bathing.
- Table 9-38 presents statistics for minutes eating or drinking.
- Table 9-39 provides data for time spent indoors at school and in a restaurant.
- Table 9-40 provides information for time spent outdoors on school grounds/playgrounds and at a pool/river/lake.
- Table 9-41 provides information on time spent at home in the kitchen, bathroom, and bedroom, and indoors in a residence (all rooms).
- Table 9-42 presents data for time spent traveling inside a vehicle.
- Table 9-43 provides data for time spent outdoors (outside the residence) and outdoors at locations other than near a residence, such as parks, golf courses, or farms.
- Table 9-44 provides information for time spent in malls, grocery stores, and other stores.
- Table 9-45 presents data for minutes spent with smokers present.

Advantages of the NHAPS data set 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 of all ages and gender, and it is race specific. A disadvantage of the study is that for ages 1–17, the N is small for most activities. In addition, means cannot be calculated for time spent over 60, 120, and 181 minutes in selected activities. Therefore, actual time spent at the high end of the distribution for these activities cannot be captured.

9.2.6. Funk et al., 1998

Funk et al. (1998) used the data from the California Air Resources Board (CARB) study to determine distributions of exposure time by tracking the time spent participating in daily at-home and at-school activities for male and female children and adolescents. CARB performed two studies from 1987 to 1990; the first was focused on adults and adolescents (12–17 years old), and the second focused on children (6–11 years old) (Funk et al., 1998). The targeted groups were noninstitutionalized, English-speaking Californians who had a telephone in their residence. Individuals were contacted by telephone and asked to account for every minute within the previous 24 hours, including the amount of time spent on an activity and the location of the activity. The surveys were conducted on different days of the week as well as different seasons of the year.

Using the location descriptors provided in the CARB study, Funk et al. (1998) assigned the activities into two groups, "at home" (any activity at principal residence) and "away." Each activity was assigned to one of three ventilation levels: low, moderate, or high. Resting activities were placed in the low-ventilation-level group; moderate-exertion activities were assigned to the moderate group; activities requiring high levels of physical exertion were placed in the high group. Ambiguous activities were assigned to moderate-ventilation levels. Among the adolescents and children studied, means were determined for the aggregate age groups, as shown in Table 9-46.

Funk et al. used several statistical methods, such as chi-square, Kolmogorov-Smirnov, and Anderson-Darling, to determine whether the time spent in an activity group had a known distribution. All the activities identified in the CARB study were assigned to the three ventilation levels. Most of the activities performed by children were in the low- to moderate-ventilation-level groups, as shown in Table 9-47.

The aggregate time periods spent at home in each activity are shown in Table 9-48. Aggregate time spent at home performing different activities was compared between genders. No significant differences were found between adolescent male and females in any of the activity groups (Table 9-49). In children ages 6–11 years differences were found between gender and age at the low-ventilation levels. In the moderate-ventilation level there were significant differences between two age groups (6–8 years and 9–11 years) and gender (Table 9-50).

Large proportions of the respondents in the study did not participate in high-ventilation-level activities; discrete distributions were used to characterize high-ventilation-activity groups (Funk et al., 1998). Lognormal distribution best described the time spent by children at high ventilation levels.

9.2.7. Hubal et al., 2000

Hubal et al. (2000) reviewed available data, including activity patterns data, to characterize and assess environmental exposures for children. The EPA National Exposure Research Laboratory's Consolidated Human Activity Database (CHAD), which contains data from several studies on human activities, was reviewed. CHAD contains 4300 person-days of information and 3009 person-days of microactivity data for 2640 children under 12 years (Table 9-51). Specific examples of the type of microactivity data available for children are shown in Tables 9-52 and 9-53. The number of hours spent in various microenvironments are shown in Table 9-52 and time spent in various activities indoors at home in Table 9-53.

CHAD contains approximately

> "...140 activity codes and 110 location codes, but the data generally are not available for all activity locations for any single respondent. In fact, not all of the codes were used for most of the studies. Even though many codes are used in macroactivity studies, many of the activity codes do not adequately capture the richness of what children actually do. They are much too broadly defined and ignore many child-oriented behaviors. Thus, there is a need for more and better-focused research into children's activities."(Hubal et al., 2000).

9.2.8. Wong et al., 2000

Wong et al. (2000) conducted telephone surveys to gather information on children's activity patterns as related to dermal contact with soil during outdoor play on bare dirt or mixed grass and dirt surfaces. This study, the second Soil Contact Survey (SCS-II), was a follow-up to the initial Soil Contact Survey (SCS-I) conducted in 1996, which focused primarily on assessing adult behavior related to dermal contact with soil and dust (Garlock et al., 1999). As part of SCS-I, information was gathered on the behavior of children under the age of 18 years; however, the questions were limited to clothing choices and the length of time between soil contact and hand washing. For SCS-II, questions were posed to further define children's outdoor activities and hand washing and bathing frequency. For both soil contact surveys, households were randomly phoned in order to obtain nationally representative results. The adult respondents were questioned as surrogates for one randomly chosen child under the age of 18 residing within the household.

In SCS-II, of 680 total adult respondents with a child in their household, 500 (73.5%) reported that their child played outdoors on bare dirt or mixed grass and dirt surfaces (identified as "players"). Those children that reportedly did not play outdoors ("nonplayers") were typically very young ($\leq$1 year) or relatively older ($\geq$14 years). Of the 500 children that played outdoors, 497 played outdoors in warm weather months (April through October), and 390 were reported to play outdoors during cold weather months (November through March). These results are presented in Table 9-54. The frequency (days/wk), duration (hrs/day), and total hours per week spent playing outdoors were determined for those children identified as "players" (Table 9-55). The responses indicated that children spend a relatively high percentage of time outdoors during the warmer months and a lesser amount of time in cold weather. The median play frequency reported was 7 days/wk in warm weather and 3 days/wk in cold weather. Median play duration was 3 hrs/day in warm weather and 1 hr/day during cold weather months.

Adult respondents were then questioned as to how many times per day their child washed his/her hands and how many times the child bathed or showered per week during both warm and cold weather months. This information provided an estimate of the time between skin contact with soil and removal of soil by washing (i.e., exposure time). Hand washing and bathing frequencies for child players are reported in Table 9-56. Hand washing was found to occur a median of four times per day during both warm and cold weather months. The median frequency for baths and showers was estimated to be seven times per week for both warm and cold weather.

Based on reported household incomes, the respondents sampled in SCS-II tended to have higher incomes than the general population. This may be explained by the fact that phone surveys cannot sample households that do not have telephones. Additional uncertainty or error in the study results may have occurred due to the use of surrogate respondents. Adult respondents were questioned regarding children's activities that may have occurred in prior seasons, introducing the chance of recall error. In some instances, a respondent did not know the answer to a question or refused to answer. The information in Tables 9-57 and 9-58 was extracted from the National Human Activity Pattern Survey (NHAPS) (Tsang and Klepeis, 1996). Table 9-57 compares mean play duration data from SCS-II to similar activities identified in NHAPS. The number of times per day a child washed his or her hands was presented in both SCS-II and NHAPS follow-up survey B and is shown in Table 9-57. Corresponding information for bathing frequency data collected from SCS-II was not collected in NHAPS. As indicated in

Tables 9-57 and 9-58, where comparison is possible, NHAPS and SCS-II results showed similarities in observed behaviors.

9.3. 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. The confidence in the recommendations for activity patterns is presented in Table 9-59.

9.3.1. Recommendations for Activity Patterns

This chapter presents several studies that provide data on activity patterns. Table 9-60 summarizes information on the various studies. Recommendations for selected activities commonly used in exposure assessments and known to increase exposure to certain chemicals are provided below. These activities are time spent indoors versus outdoors, showering, swimming, residential time spent indoors and outdoors, and time spent playing on sand or gravel and on grass.

9.3.1.1. *Time Spent Indoors Versus Outdoors*

Assessors often require knowledge of the amount of time individuals spend indoors versus outdoors. Ideally, this issue would be addressed on a site-specific basis because the times are likely to vary considerably, depending on climate, residential setting (i.e., rural vs. urban), personal traits (e.g., age, health), and personal habits.

Activities can vary significantly with differences in age. Table 9-61 summarizes the studies that present information on time spent indoors and outdoors. Of these studies, Timmer et al. (1985), in addition to being a national study, presents the data for a more comprehensive set of age groupings for children. This study presented data on time spent in various activities for boys and girls ages 3–17 years and focused on activities performed indoors, such as household work, personal care, eating, sleeping, attending school, studying, attending church, watching television, and engaging in household conversations. The average times spent in each activity and half the times spent in each activity that could have occurred indoors or outdoors were summed. The results are presented in Table 9-62 for various age groups. Although there is good agreement between Robinson and Thomas (1991) and Timmer et al. (1985), the recommendations are based on the Timmer study (Table 9-61), because it provides data for younger children.

9.3.1.2. *Showering*

The recommended showering frequency of one shower per day is based on the NHAPS data summarized in Table 9-17. This table shows that 341 of the 451 total participants indicated taking at least one shower the previous day.

Recommendations for showering duration are based on Tsang and Klepeis (1996). A recommended value for average showering time is 10 minutes (Table 9-18), based on professional judgment.

9.3.1.3. *Swimming*

Data for swimming frequency is taken from the NHAPS Study (Tsang and Klepeis, 1996). A total of 241 of the 653 participants who answered “yes” to the question “in the past month, did you swim in a freshwater pool?”, were ages 1–17 years (see Table 9-29). The recorded number of times respondents swam in the past month ranged from 1 to 60, with the greatest number of respondents reporting that they swam one time per month. Thus, the recommended swimming frequency is one event per month. The recommended swimming duration, 60 minutes per swimming event, is based on the NHAPS distribution shown on Table 9-30. Sixty minutes is based on an average of the 50th percentile values. The 90th percentile value is 180 minutes per swimming event (based on one event per month) and the 99th percentile value is 181 minutes. The 99th percentile value indicates that more than 180 minutes were spent. This number refers to time swimming at a swimming pool, not necessarily at a lake, river, etc.

9.3.1.4. *Residential Time Spent Indoors and Outdoors*

The recommendations for average and 95th percentile time spent indoors at one’s residence for children 1–17 years old is 18 hrs/day and 24 hrs/day, respectively. These numbers are based on the NHAPS data summarized in Table 9-41 for number of minutes spent indoors in a residence (all rooms). Table 9-41 presents the distributions of time spent indoors at one’s residence for age groups 1–4, 5–11, and 12–17 years. The total average time spent indoors at one’s residence and elsewhere for children 3–17 years old is 19 hrs/day, based on Timmer et al. (1985). These data are summarized in Table 9-3. Table 9-3 presents mean values for time spent indoors by weekday and weekend for age groups 3–5, 6–8, 9–11, 12–14, and 15–17 years.

The average and 95th percentile time spent outdoors at one's residence for children 1–17 years old is 3 hrs/day and 8 hrs/day, respectively, based on the NHAPS data shown on Table 9-43. Table 9-43 presents distributions of time spent outdoors at one's residence for age groups 1–4, 5–11, and 12–17 years. The total average time spent outdoors for children 3–17 years old is 2 hours, based on the data from Timmer et al. (1985) (Table 9-3).

9.3.1.5. *Playing on Sand or Gravel and on Grass*

The recommended value for time spent playing on sand or gravel is 60 min/day. This value is based on the NHAPS data shown in Table 9-25. This recommendation is based on professional judgement. The data in Table 9-25 show that the majority of respondents are captured in the 0–0 min/day category. For the remaining time categories, the majority of respondents are captured in the 50–60 min/day category.

The recommended average value for time spent playing on grass is 60 min/day, based on the 50th percentile data shown in Table 9-28 and the 50–60 min/day category data in Table 9-27.

9.3.2. Summary of Recommended Activity Factors

Table 9-62 summarizes the recommended activity pattern factors presented in this section and the studies that provided data on the specific activities. The type of activities include indoor activities, outdoor activities, taking a shower, swimming, time spent playing on sand or gravel, and time spent playing on grass.

Table 9-1. Mean time spent performing major activities grouped by age, sex and type of day

Activity	Age (3–11 years) Time (mins/day)				Age (12–17 years) 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
Time accounted for by activities above (%)	**94**	**92**	**93**	**89**	**93**	**92**	**88**	**89**

[a] NA = Unknown
Source: Timmer et al., 1985

Table 9-2. Mean time spent in major activities grouped by type of day for five different age groups

Activity	Weekday time (mins/day)					Weekend time (mins/day)					Significant effects[a]
	Age (years)					Age (years)					
	3–5	6–8	9–11	12–14	15–17	3–5	6–8	9–11	12–14	15–17	
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 9-3. Mean time spent indoors and outdoors grouped by age and time of the week

Age (years)	Time indoors		Time outdoors	
	Weekday (hrs/day)	Weekend (hrs/day)	Weekday (hrs/day)	Weekend (hrs/day)
3–5	19.4	18.9	2.5	3.1
6–8	20.7	18.6	1.8	2.5
9–11	20.8	18.6	1.3	2.3
12–14	20.7	18.5	1.6	1.9
15–17	19.9	17.9	1.4	2.3

Source: Adapted from Timmer et al., 1985

Table 9-4. Mean time spent at three locations for both CARB and national studies (ages 12 years and older)

Location	Time (mins/day)			
	CARB (N = 1762)[a]	SE	National (N = 2762)[a]	SE
Indoors	1255[b]	28	1279[b]	21
Outdoors	86[c]	5	74[c]	4
In vehicle	98[c]	4	87[c]	2
Total time spent	**1440**		**1440**	

[a] Weighted number; national sample population was weighted to obtain a ratio of 46.5 males and 53.5 females in equal proportion for each day of the week and for each quarter of the year.
[b] Difference between the mean values for the CARB and national studies is not statistically significant.
[c] Difference between the mean values for the CARB and national studies is statistically significant at the 0.05 level.

Source: Robinson and Thomas, 1991

Table 9-5. Mean time spent in various microenvironments grouped by total population and gender (12 years and over) in the national and CARB data

Microenvironment	National data Time (mins/day) (SE)						CARB data Mean duration (mins/day) (SE)					
	N = 1284[a] Male	"Doer"[b] Male	N = 1478[a] Female	"Doer" Female	N = 2762[a] Total	"Doer" Total	N = 867[a] Male	"Doer"[b] Male	N = 895[a] Female	"Doer" Female	N = 1762[a] Total	"Doer" Total
Auto places	5 (1)	90	1 (0)	35	3 (0)	66	31 (8)	142	9 (2)	50	20 (4)	108
Restaurant/bar	22 (2)	73	20 (2)	79	21 (1)	77	45 (4)	106	28 (3)	86	36 (3)	102
In vehicle	92 (3)	99	82 (3)	94	87 (2)	97	105 (7)	119	85 (4)	100	95 (4)	111
In vehicle/other	1 (1)	166	1 (0)	69	1 (0)	91	4 (1)	79	3 (2)	106	3 (1)	94
Physical/outdoors	24 (3)	139	11 (2)	101	17 (2)	135	25 (3)	131	8 (1)	86	17 (2)	107
Physical/indoors	11 (1)	84	6 (1)	57	8 (1)	74	8 (1)	63	5 (1)	70	7 (1)	68
Work/study-residence	17 (2)	153	15 (2)	150	16 (1)	142	14 (3)	126	11 (2)	120	13 (2)	131
Work/study-other	221 (10)	429	142 (7)	384	179 (6)	390	213 (14)	398	156 (11)	383	184 (9)	450
Cooking	14 (1)	35	52 (2)	67	34 (1)	57	12 (1)	43	42 (2)	65	27 (1)	55
Other activities/kitchen	54 (3)	69	90 (4)	102	73 (2)	88	38 (3)	65	60 (4)	82	49 (2)	74
Chores/child	88 (3)	89	153 (5)	154	123 (3)	124	66 (4)	75	134 (6)	140	100 (4)	109
Shop/errand	23 (2)	56	38 (2)	74	31 (1)	67	21 (3)	61	41 (3)	78	31 (2)	70
Other/outdoors	70 (6)	131	43 (4)	97	56 (4)	120	95 (9)	153	44 (4)	82	69 (5)	117
Social/cultural	71 (4)	118	75 (4)	110	73 (3)	118	47 (4)	112	59 (5)	114	53 (3)	112
Leisure-eat/indoors	235 (8)	241	215 (7)	224	224 (5)	232	223 (10)	240	251 (10)	263	237 (7)	250
Sleep/indoors	491 (14)	492	496 (11)	497	494 (9)	495	492 (17)	499	504 (15)	506	498 (12)	501

[a] Weighted number.
[b] Doer = Respondents who reported participating in each activity/location or spent time in microenvironments.

Source: Robinson and Thomas, 1991

Table 9-6. Mean time spent in various microenvironments by type of day for the CARB and national surveys (sample population ages 12 years and older)

Microenvironment	Weekday				Weekend			
	Time (SE) (mins/day)		Time for "Doer"[a] (mins/day)		Time (SE) (mins/day)		Time for "Doer"[a] (mins/day)	
	CARB (N=1259)[b]	National (N=1973)[c]	CARB	National	CARB (N=503)[b]	National (N=789)[b]	CARB	National
Auto places	21 (5)	3 (1)	108	73	19 (4)	3 (1)	82	62
Restaurant/bar	29 (3)	20 (2)	83	73	55 (6)	23 (2)	127	84
In vehicle/internal combustion	90 (5)	85 (2)	104	95	108 (8)	91 (6)	125	100
In vehicle/other	3 (1)	1 (0)	71	116	5 (3)	0 (0)	130	30
Physical/outdoors	14 (2)	15 (2)	106	118	23 (3)	23 (4)	134	132
Physical/indoors	7 (1)	8 (1)	64	68	7 (1)	9 (2)	72	80
Work/study-residence	14 (2)	16 (2)	116	147	10 (2)	15 (3)	155	165
Work/study-other	228 (11)	225 (8)	401	415	74 (11)	64 (6)	328	361
Cooking	27 (2)	35 (2)	58	57	27 (2)	34 (2)	60	55
Other activities/kitchen	51 (3)	73 (3)	76	87	44 (3)	73 (4)	71	90
Chores/child	99 (5)	124 (4)	108	125	103 (7)	120 (5)	114	121
Shop/errand	30 (2)	30 (2)	67	63	35 (4)	35 (3)	81	75
Other/outdoors	67 (6)	51 (4)	117	107	74 (7)	67 (7)	126	132
Social/cultural	42 (3)	62 (3)	99	101	79 (7)	99 (6)	140	141
Leisure-eat/indoors	230 (9)	211 (6)	244	218	256 (12)	257 (11)	273	268
Sleep/indoors	490 (14)	481 (10)	495	483	520 (20)	525 (17)	521	525

[a] Doer = Respondent who reported participating in each activity/location or spent time in microenvironments.
[b] Weighted number

Source: Robinson and Thomas, 1991

Table 9-7. Mean time spent in various microenvironments by age groups for the national and CARB surveys

Microenvironment	National Data Time (mins/day) (SE) Age 12–17 years N=340 [a]	National Data "Doer"[b]	National Data Age 18–24 years N=340	National Data "Doer"	CARB Data Time (mins/day) (SE) Age 12–17 years N=183 [a]	CARB Data "Doer"[b]	CARB Data Age 18–24 years N=250	CARB Data "Doer"
Auto places	2 (1)	73	7 (2)	137	16 (8)	124	16 (4)	71
Restaurant/bar	9 (2)	60	28 (3)	70	16 (4)	44	40 (8)	98
Invehicle/internal combustion	79 (7)	88	103 (8)	109	78 (11)	89	111 (13)	122
Invehicle/other	0 (0)	12	1 (1)	160	1 (0)	19	3 (1)	60
Physical/outdoors	32 (8)	130	17 (4)	110	32 (7)	110	13 (3)	88
Physical/indoors	15 (3)	87	8 (2)	76	20 (4)	65	5 (2)	77
Work/study-residence	22 (4)	82	19 (6)	185	25 (5)	76	30 (11)	161
Work/study-other	159 (14)	354	207 (20)	391	196 (30)	339	201 (24)	344
Cooking	11 (3)	40	18 (2)	39	3 (1)	19	14 (2)	40
Other activities/kitchen	53 (4)	64	42 (3)	55	31 (4)	51	31 (5)	55
Chores/child	91 (7)	92	124 (9)	125	72 (11)	77	79 (8)	85
Shop/errands	26 (4)	68	31 (4)	65	14 (3)	50	35 (7)	71
Other/outdoors	70 (13)	129	34 (4)	84	58 (8)	78	80 (15)	130
Social/cultural	87 (10)	120	100 (12)	141	63 (14)	109	65 (10)	110
Leisure-eat/indoors	237 (16)	242	181 (11)	189	260 (27)	270	211 (19)	234
Sleep/indoors	548 (31)	551	511 (26)	512	557 (44)	560	506 (30)	510

[a] All Ns are weighted numbers.
[b] Doer = Respondents who reported participating in each activity/location or spent time in microenvironments.

Source: Robinson and Thomas, 1991

Table 9-8. Mean time children ages 12 years and under spent in 10 major activity categories for all respondents

Activity	Mean time (mins/day)	% Doing	Time for "doers" (mins/day)[a]			Detailed activity with highest avg. minutes (code)
			Mean	Median	Maximum	
Work-related[b]	10	25	39	30	405	Eating at work/school/daycare (06)
Household	53	86	61	40	602	Travel to household (199)
Childcare	< 1	< 1	83	30	290	Other child care (27)
Goods/services	21	26	81	60	450	Errands (38)
Personal needs and care[c]	794	100	794	770	1440	Night sleep (45)
Education[d]	110	35	316	335	790	School classes (50)
Organizational activities	4	4	111	105	435	Attend meetings (60)
Entertain/social	15	17	87	60	490	Visiting with others (75)
Recreation	239	92	260	240	835	Games (87)
Communication/passive leisure	192	93	205	180	898	TV use (91)
Don't know/not coded	2	4	41	15	600	—
All activities[e]	**1441**					

[a] "Doers" indicate the respondents who reported participating in each activity category.
[b] Includes eating at school or daycare, an activity not grouped under the "education activities" (codes 50-59, 549).
[c] Personal care includes night sleep and daytime naps, eating, travel for personal care.
[d] Education includes student and other classes, homework, library, travel for education.
[e] Column total may not sum to 1440 due to rounding error.

Source: Wiley et al., 1991

Table 9-9. Mean time children spent in 10 major activity categories grouped by age and gender

Activity	Time (mins/day)									
	Boys					Girls				
	0–2 yrs	3–5 yrs	6–8 yrs	9–11 yrs	0–11 yrs	0–2 yrs	3–5 yrs	6–8 yrs	9–11 yrs	0–11 yrs
Work-related	4	9	14	12	10	5	12	11	10	10
Household	33	45	55	65	48	58	44	51	76	57
Childcare	0	0	0	1	< 1	0	0	0	4	1
Goods/Services	20	22	19	14	19	22	25	23	22	23
Personal needs and care[a]	914	799	736	690	792	906	816	766	701	797
Education[b]	60	67	171	138	106	41	95	150	176	115
Organizational activities	1	3	7	6	4	6	1	4	6	4
Entertainment/social	3	15	5	34	13	5	16	9	36	17
Recreation	217	311	236	229	250	223	255	238	194	228
Communication/passive leisure	187	166	195	250	197	171	173	189	213	186
Don't know/not coded	1	4	1	1	2	3	1	< 1	3	2
All activities[c]	**1440**	**1441**	**1439**	**1440**	**1442**	**1440**	**1438**	**1441**	**1441**	**1440**
Sample sizes (unweighted Ns)	172	151	145	156	624	141	151	124	160	576

[a] Personal needs and care includes night sleep and daytime naps, eating, travel for personal care.
[b] Education includes student and other classes, homework, library, travel for education.
[c] The column totals may differ from 1440 due to rounding error.

Source: Wiley et al., 1991

Table 9-10. Mean time children ages 12 years and under spent in 10 major activity categories grouped by seasons and regions

Activity	Time (mins/day)								
	Season					Region of California			
	Winter (Jan–Mar)	Spring (Apr–June)	Summer (July–Sept)	Fall (Oct–Dec)	All Seasons	So. Coast	Bay Area	Rest of State	All Regions
Work-related	10	10	6	13	10	10	10	8	10
Household	47	58	53	52	53	45	62	55	53
Childcare	< 1	1	< 1	< 1	< 1	< 1	< 1	1	< 1
Goods/Services	19	17	26	23	21	20	21	23	21
Personal needs and care[a]	799	774	815	789	794	799	785	794	794
Education[b]	124	137	49	131	110	109	115	109	110
Organizational activities	3	5	5	3	4	2	6	6	4
Entertainment/social	14	12	12	22	15	17	10	16	15
Recreation	221	243	282	211	239	230	241	249	239
Communication/passive leisure	203	180	189	195	192	206	190	175	192
Don't know/not coded	< 1	2	3	< 1	2	1	1	3	2
All activities[c]	**1442**	**1439**	**1441**	**1441**	**1441**	**1440**	**1442**	**1439**	**1441**
Sample sizes (unweighted)	318	204	407	271	1200	224	263	713	1200

[a] Personal needs and care includes night sleep and daytime naps, eating, travel for personal care.
[b] Education includes student and other classes, homework, library, travel for education.
[c] The column totals may not be equal to 1440 due to rounding error.

Source: Wiley et al., 1991

Table 9-11. Mean time children ages 12 years and under spent in six major location categories for all respondents

Location	Time (mins/day)	% Doing	Time for "doers" (mins/day) Mean	Median	Maximum	Detailed location with highest average time
Home	1078	99	1086	1110	1440	Home - bedroom
School/childcare	109	33	330	325	1260	School or daycare facility
Friend's/other's house	80	32	251	144	1440	Friend's/other's house - bedroom
Stores, restaurants, shopping places	24	35	69	50	475	Shopping mall
In-transit	69	83	83	60	1111	Traveling in car
Other locations	79	57	139	105	1440	Park, playground
Don't know/not coded	< 1	1	37	30	90	—
All locations	**1440**					

Source: Wiley et al., 1991

Table 9-12. Mean time children spent in six location categories grouped by age and gender

Location	Time (mins/day) Boys 0–2 yrs	3-5 yrs	6-8 yrs	9-11 yrs	All Boys	Girls 0-2 yrs	3-5 yrs	6-8 yrs	9-11 yrs	All Girls
Home	1157	1134	1044	1020	1094	1151	1099	1021	968	1061
School/childcare	86	88	144	120	108	59	102	133	149	111
Friend's/other's house	67	73	77	109	80	56	47	125	102	80
Stores, restaurants, shopping places	21	25	22	15	21	23	35	27	26	28
In-transit	54	62	61	62	59	76	88	53	93	79
Other locations	54	58	92	114	77	73	68	81	102	81
Don't know/not coded	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
All locations[a]	**1439**	**1440**	**1439**	**1440**	**1439**	**1438**	**1440**	**1440**	**1440**	**1440**
Sample sizes (unweighted)	172	151	145	156	624	141	151	124	160	576

[a] The column totals may not sum to 1440 due to rounding error.
Source: Wiley et al., 1991

Table 9-13. Mean time children spent in six location categories grouped by season and region

Location	Time (mins/day)								
	Season					Region of California			
	Winter (Jan–Mar)	Spring (Apr-June)	Summer (July-Sept)	Fall (Oct-Dec)	All Seasons	So. Coast	Bay Area	Rest of State	All Regions
Home	1091	1042	1097	1081	1078	1078	1078	1078	1078
School/childcare	119	141	52	124	109	113	103	108	109
Friend's/other's house	69	75	108	69	80	73	86	86	80
Stores, restaurants, shopping places	22	21	30	24	24	26	23	23	24
In-transit	75	75	60	65	69	71	73	63	69
Other locations	63	85	93	76	79	79	76	81	79
Don't know/not coded	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
All locations[a]	**1439**	**1439**	**1440**	**1439**	**1439**	**1439**	**1440**	**1440**	**1439**
Sample sizes (unweighted Ns)	318	204	407	271	1200	224	263	713	1200

[a] The column totals may not sum to 1440 due to rounding error.

Source: Wiley et al., 1991

Table 9-14. Mean time children spent in proximity to three potential exposures grouped by all respondents, age, and gender

Potential Exposure	Time (mins/day)										
		Boys					Girls				
	All Children	0-2 yrs	3–5 yrs	6–8 yrs	9–11 yrs	All Boys	0–2 yrs	3–5 yrs	6–8 yrs	9–11 yrs	All Girls
Tobacco smoke	77	115	75	66	66	82	77	68	71	74	73
Gasoline fumes	2	2	1	1	4	2	1	1	3	1	1
Gas oven fumes	11	10	15	12	11	12	12	10	10	7	10
Sample sizes (unweighted Ns)	1,166[a]	168	148	144	150	610	140	147	122	147	556

[a] Respondents with missing data were excluded.

Source: Wiley et al., 1991

Table 9-15. Mean time spent indoors and outdoors grouped by age

Age (years)	Time indoors (hrs/day)	Time outdoors (hrs/day)
0–2	20.0	4.0
3–5	18.8	5.2
6–8	19.7	4.4
9–11	19.9	4.1

Source: Adapted from Wiley et al., 1991

Table 9-16. Range of recommended defaults for dermal exposure factors

Factor	Water Contact				Soil Contact	
	Bathing		Swimming			
	Central	Upper	Central	Upper	Central	Upper
Event time and frequency[a]	10 min/event 1 event/day 350 days/yr	15 min/event 1 event/day 350 days/yr	0.5 hr/event 1 event/day 5 days/yr	1.0 hr/event 1 event/day 150 days/yr	40 events/yr	350 events/yr
Exposure duration (years)	9	30	9	30	9	30

[a] Bathing event time is presented to be representative of baths as well as showers.

Source: U.S. EPA, 1992

Table 9-17. Number of times taking a shower by number of respondents

Age (years)	N	Times/day									
		0	1	2	3	4	5	8	10	11:1-0+	"Don't Know"
1–4	41	*	30	9	1	*	*	*	*	*	1
5–11	140	*	112	26	1	*	*	*	*	*	1
12–17	270	*	199	65	6	*	*	*	*	*	*

Note: * Signifies missing data.

Source: Tsang and Klepeis, 1996

Table 9-18. Time spent taking a shower and spent in the shower room after taking a shower by the number of respondents

Age	N	Time in shower (mins)							Time in shower room (mins)						
		0–10	10–20	20–30	30–40	40–50	50–60	60–61[a]	0–10	10–20	20–30	30–40	40–50	50–60	60–61[a]
1–4	41	13	14	10	1	—[b]	2	—	5	31	3	1	*	1	*
5–11	140	60	52	18	3	2	4	—	9	110	14	3	*	*	1
12–17	270	94	104	40	13	9	7	1	17	206	29	10	3	2	1

[a] A value of 61 for number of minutes signifies that more than 60 minutes were spent.
[b] Signifies missing data.

Source: Tsang and Klepeis, 1996

Table 9-19. Time spent taking a shower and spent in the shower room immediately after showering

Age (years)	N	Percentiles[a]																							
		1st	2nd	5th	10th	25th	50th	75th	91st	95th	98th	99th	100th	1st	2nd	5th	10th	25th	50th	75th	91st	95th	98th	99th	100th
Time Spent Taking a Shower (mins)																									
1–4	40	5	5	5	5	5	10	17.5	30	50	60	60	60	0	0	0	0	1	5	10	15	20	45	45	45
5–11	139	3	4	5	5	10	15	20.0	30	40	60	60	60	0	0	0	1	2	5	10	15	20	30	30	60
12–17	268	5	5	5	7	10	15	25.0	35	45	60	60	61[b]	0	0	0	1	3	5	10	20	30	40	52	61[b]

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] A value of 61 for number of minutes signifies that more than 60 minutes were spent.

Source: Tsang and Klepeis, 1996

Table 9-20. Total time spent in the shower or bathtub and in the bathroom immediately after by number of respondents

Age (years)	N[a]	Minutes/Bath													
			0–0	0–10	10–20	20–30	30–40	40–50	50–60	70–80	80–90	90–100	100–110	110–120	121–121
Total time spent altogether in the shower or bathtub by the number of respondents															
1–4	198		–	35	84	50	2	13	7	1	1	1	*	4	*
5–11	265		–	64	107	66	3	7	7	2	2	1	1	2	1
12–17	239		*	78	96	46	5	5	8	*	*	*	*	1	*
Time spent in the bathroom immediately following a shower or bath by the number of respondents															
1-4	198		59	123	12	*	1	1	*	*	*	*	*	*	*
5-11	265		33	198[b]	23	3	1	*	1	*	*	*	*	1	*
12-17	239		17	165	34	16	1	3	2	*	*	*	*	*	*

[a] N = Doer sample size in specified range of number of minutes spent.
[b] A value of 121 for number of minutes signifies that more than 120 minutes were spent.
—Signifies missing data.

Source: Tsang and Klepeis, 1996

Table 9-21. Total number of minutes spent altogether in the shower or bathtub and spent in the bathroom immediately following a shower or bath

	Age (years)	Percentiles[a]											
		N[b]	1	2	5	10	25	50	75	90	95	98	99	100
Total number of minutes spent altogether in the shower or bathtub (mins/bath)														
Age (years)	1–4	198	1	5	5	10	15	20	30	45	60	120	120	120
Age (years)	5–11	263	4	5	5	10	13	20	30	30	60	90	120	121[c]
Age (years)	12–17	239	4	4	5	7	10	15	30	30	45	60	60	120
Number of minutes spent in the bathroom immediately following a shower or bath (mins/bath)														
Age (years)	1–4	196	0	0	0	0	0	2	5	10	15	20	35	45
Age (years)	5–11	260	0	0	0	0	2	5	10	15	15	30	35	120
Age (years)	12–17	238	0	0	0	2	5	5	10	20	30	45	45	60

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = Doer sample size.
[c] A value of 121 for number of minutes signifies that more than 120 minutes were spent.

Source: Tsang and Klepeis, 1996

Table 9-22. Number of times hands were washed at specified daily frequencies by the number of respondents

Age (years)	N[a]	Number of times/day							
		0–0	1–2	3–5	6–9	10–19	20–29	30+	"Don't Know"
1–4	263	15	62	125	35	11	2	3	10
5–11	348	5	61	191	48	21	4	2	15
12–17	326	6	46	159	64	30	7	2	9

[a] Sum of individual Ns may not equal total because of missing data.

Source: Tsang and Klepeis, 1996

Table 9-23. Number of minutes per day spent working or being near excessive dust in the air (mins/day)

Age (years)	N	Percentiles[a]											
		1st	2nd	5th	10th	25th	50th	75th	90th	95th	98th	99th	100th
1–4	22	0	0.0	0	2	5	75	121[b]	121	121	121	121	121
5–11	50	0	0.5	2	4	15	75	121	121	121	121	121	121
12–17	52	0	1.0	2	5	5	20	120	121	121	121	121	121

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] A value of 121 signifies that more than 120 minutes were spent.

Source: Tsang and Klepeis, 1996

Table 9-24. Number of times per day a motor vehicle was started in a garage or carport and started with the garage door closed by number of respondents

Age (years)	N[a]	Automobile or motor vehicle was started in a garage or carport (times/day)					Motor vehicle was started with garage door closed				
		1–2	3–5	6–9	10+	"Don't Know"	1–2	3–5	6–9	10+	"Don't Know"
1–4	111	68	39	2	2	—	99	8	2	—	2
5–11	150	93	49	6	—	2	141	6	—	—	3
12–17	145	86	42	12	1	4	127	9	4	1	4

[a] Sum of individual Ns may not equal total N because of missing data.
—Signifies missing data.

Source: Tsang and Klepeis, 1996

Table 9-25. Number of minutes spent playing on sand, gravel, dirt, or grass by number of respondents

Age (years)	N[a]	Minutes per day											
		0–0	0–10	10–20	20–30	30–40	40–50	50–60	70–80	80–90	90–100	110–120	121[b]
Spent playing on sand or gravel													
1–4	216	115	15	9	15	2	3	15	1	5	—	7	16
5–11	200	96	11	12	14	—	5	25	1	2	1	6	20
12–17	41	23	1	2	4	—	—	3	—	—	1	3	3
Spent playing in outdoors on sand, gravel, dirt, or grass when fill dirt was present													
1–4	216	118	14	10	13	1	4	18	4	—		7	16
5–11	200	103	14	8	15	—	1	17	1	—		9	17
12–17	41	19	3	2	7	—	—	4	1	—		2	—

[a] Sum of individual Ns may not equal total N because of missing data.
[b] A value of 121 signifies that more than 120 minutes were spent.
—Signifies missing data.

Source: Tsang and Klepeis, 1996

Table 9-26. Number of minutes spent playing in sand, gravel, dirt or grass by percentiles

Age (years)	N[b]	Percentile[a]											
		1st	2nd	5th	10th	25th	50th	75th	90th	95th	98th	99th	100th
Number of minutes per day spent playing on sand or gravel													
1–4	203	0	0	0	0	0	0.0	30	120	121[c]	121	121	121
5–11	193	0	0	0	0	0	3.0	60	121	121	121	121	121
12–17	40	0	0	0	0	0	0.0	45	120	121	121	121	121
Number of minutes per day spent playing on sand, gravel, dirt, or grass when fill dirt was present													
1–4	205	0	0	0	0	0	0.0	30	120	121	121	121	121
5–11	185	0	0	0	0	0	0.0	30	120	121	121	121	121
12–17	38	0	0	0	0	0	0.5	30	60	120	120	120	120

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] A value of 121 for number of minutes signifies that more than 120 minutes were spent.

Source: Tsang and Klepeis, 1996

Table 9-27. Number of minutes per day spent playing on grass in a day by the number of respondents

Age (years)	N[a,b]	Minutes per day													
		0–0	0–10	10–20	20–30	30–40	40–50	50–60	60–70	70–80	80–90	90–100	100–110	110–120	121–121[c]
1–4	216	24	19	21	25	1	4	35	—	1	8	—	1	18	49
5–11	200	24	10	10	19	2	3	38	1	—	8	1	—	20	49
12–17	41	5	1	2	8	—	1	8	—	—	1	—	—	8	5

[a] Sum of individual Ns may not equal total N because of missing data.
[b] N = doer sample size.
[c] A value of 121 for number of minutes signifies that more than 120 minutes were spent. Percentiles are the percentage of doers below or equal to a given number of minutes. Refused = respondent refused to answer. —Signifies missing data.

Source: Tsang and Klepeis, 1996

Table 9-28. Number of minutes spent playing on grass by percentile

Age (years)	N[b]	Percentile[a]											
		1st	2nd	5th	10th	25th	50th	75th	90th	95th	98th	99th	100th
1-4	206	0	0	0	0	15	60	120	121[c]	121	121	121	121
5-11	185	0	0	0	0	30	60	121	121	121	121	121	121
12-17	39	0	0	0	0	30	60	120	121	121	121	121	121

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] A value of 121 for number of minutes signifies that more than 120 minutes were spent.

Source: Tsang and Klepeis, 1996

Table 9-29. Number of times swimming in a month in freshwater swimming pool by the number of respondents

Age (years)	N[a]	Times/Month																																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20	23	24	25	26	28	29	30	31	32	40	42	45	50	60	DK
1–4	63	11	14	7	3	3	4	1	3	1	4	—	2	1	1	2	—	—	2	—	—	—	—	—	1	2	—	1	—	—	—	—	—	—
5–11	100	16	15	7	9	6	4	2	4	—	7	—	5	—	—	11	2	—	3	—	1	2	—	—	—	5	—	—	—	—	—	1	—	—
12–17	84	21	13	7	4	8	4	2	3	1	8	—	1	—	—	2	—	1	4	—	—	—	1	—	—	2	—	—	—	—	—	—	1	1

[a] Sum of individual Ns may not equal total N because of missing data.
—Signifies missing data.

Source: Tsang and Klepeis, 1996

Table 9-30. Number of minutes spent swimming in a month in freshwater swimming pool by percentile

Age (years)	N[b]	Percentiles[a]											
		1st	2nd	5th	10th	25th	50th	75th	90th	95th	98th	99th	100th
1–4	60	3	3	7.5	15	20	42.5	120	180[c]	181	181	181	181
5–11	95	2	3	20.0	30	45	60.0	120	180	181	181	181	181
12–17	83	4	5	15.0	20	40	60.0	120	180	181	181	181	181

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] A value of 181 for number of minutes signifies that more than 180 minutes were spent.

Source: Tsang and Klepeis, 1996

Table 9-31. Range of the average amount of time actually spent in the water by swimmers by number of respondents

Age (years)	N[a,b]	Minutes per month													
		0–10	10–20	20–30	30–40	40–50	50–60	60–70	70–80	80–90	90–100	110–120[c]	150–150	180–180	181–181
1–4	63	5	12	12	1	4	8	—	—	2	—	7	1	3	5
5–11	100	3	2	12	5	4	25	—	—	7	—	16	2	11	8
12–17	84	3	7	10	2	6	15	—	1	8	1	14	4	6	6

[a] Sum of individual Ns may not equal total N because of missing data.
[b] N = doer sample size.
[c] Values of 120, 150, and 180 for number of minutes signify that 2 hours, 2.5 hours, and 3 hours, respectively, were spent.
—Signifies missing data.

Source: Tsang and Klepeis, 1996

Table 9-32. Statistics for twenty-four hour cumulative number of minutes spent playing indoors and outdoors by percentiles

Age (years)	N[b,c]	Mean	SD	SE	Min	Max	Percentiles[a] 5th	25th	50th	75th	90th	95th	98th	99th	N[b,c]	Mean	SD	SE	Min	Max	Percentiles[a] 5th	25th	50th	75th	90th	95th	98th	99th
24-hour cumulative number of minutes spent in indoor playing															24-hour cumulative number of minutes spent in outdoor playing													
1–4	11	130.000	80.200	24.200	15	270	15	60	115	180	255	270	270	270	4	83.250	89.660	44.830	15	210	15	20	54	146.5	210	210	210	210
5–11	11	93.600	64.300	19.400	30	195	30	30	60	175	180	195	195	195	9	148.333	144.265	48.088	5	360	5	55	60	280.0	360	360	360	360
12–17	4	82.500	45.000	22.500	30	120	30	45	90	120	120	120	120	120	1	15.000	—	—	15	15	15	15	15	15.0	15	15	15	15

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers.
—Signifies missing data.

Source: Tsang and Klepeis, 1996

Table 9-33. Statistics for twenty-four hour cumulative number of minutes spent sleeping/napping by percentiles

Age (years)	N[a]	Mean[c]	SD	SE	Min	Max	Percentiles[a] 5th	25th	50th	75th	90th	95th	98th	99th
1–4	499	732.363	124.328	5.5657	270	1320	540	655	720	810	900	930	1005	1110
5–11	702	625.058	100.656	3.7990	120	1110	480	570	630	680	725	780	840	875
12–17	588	563.719	110.83	4.5706	150	1015	395	484	550	630	705	750	810	900

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers.

Source: Tsang and Klepeis, 1996

Table 9-34. Statistics for twenty-four hour cumulative number of minutes spent attending full-time school by percentiles

Age (years)	N[b]	Mean[c]	SD	SE	Min	Max	Percentiles[a] 5th	25th	50th	75th	90th	95th	98th	99th
1–4	56	365.036	199.152	26.6128	20	710	30	172.5	427.5	530	595	628	665	710
5–11	297	387.811	98.013	5.6873	60	645	170	360.0	390.0	435	485	555	600	630
12–17	271	392.28	84.986	5.1625	10	605	200	375.0	405.0	435	460	485	510	555

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers.

Source: Tsang and Klepeis, 1996

Table 9-35. Statistics for twenty-four hour cumulative number of minutes spent in active sports and for time spent in sports/exercise by percentiles

Age (years)	N[b]	Mean[c]	SD	SE	Min	Max	Percentiles[a] 5th	25th	50th	75th	90th	95th	98th	99th
Statistics for 24-hour cumulative number of minutes spent in active sports														
1–4	105	115.848	98.855	9.6472	10	630	30	45	90	159	250	330	345	390
5–11	247	148.870	126.627	8.0571	2	975	20	60	120	188	320	390	510	558
12–17	215	137.460	124.516	8.4919	5	1065	15	60	110	180	265	375	470	520
Statistics for 24-hour cumulative number of minutes spent in sports/exercise[d]														
1–4	114	118.982	109.170	10.2247	10	670	25	45	90	159	250	330	390	630
5–11	262	153.496	130.580	8.0673	2	975	20	60	120	200	330	415	525	580
12–17	237	134.717	122.228	7.9396	5	1065	15	60	110	179	265	360	470	520

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers.
[d] Includes active sports, exercise, hobbies.

Source: Tsang and Klepeis, 1996

Table 9-36. Statistics for twenty-four hour cumulative number of minutes spent in outdoor recreation and spent walking by percentiles

Age (years)	N[b]	Mean[c]	SD	SE	Min	Max	Percentiles[a] 5th	25th	50th	75th	90th	95th	98th	99th
24-hour cumulative number of minutes spent in outdoor recreation														
1–4	13	166.5400	177.0600	49.1090	15	630	15	30	130	180	370	630	630	630
5–11	21	206.1400	156.1700	34.0780	30	585	60	90	165	245	360	574	585	585
12–17	27	155.0700	128.2800	24.6870	5	465	5	60	135	225	420	420	465	465
24-hour cumulative number of minutes spent walking														
1–4	58	24.3276	26.3268	3.4569	1	160	2	10	15	35	60	60	70	160
5–11	155	18.2129	21.0263	1.6889	1	170	1	5	10	25	40	60	65	100
12–17	223	25.8341	32.3753	2.1680	1	190	2	6	15	30	60	100	135	151

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers.

Source: Tsang and Klepeis, 1996

Table 9-37. Statistics for twenty-four hour cumulative number of minutes spent in bathing[a] by percentiles

Age (years)	N[c]	Mean[d]	SD	SE	Min	Max	Percentiles[b] 5th	25th	50th	75th	90th	95th	98th	99th
1–4	330	29.9727	19.4226	1.0692	1	170	10	15	30	31	54.5	60	85	90
5–11	438	25.7511	35.3164	1.6875	1	690	5	15	20	30	45.0	60	60	75
12–17	444	23.1216	18.7078	0.8878	1	210	5	10	18	30	45.0	60	65	90

[a] Includes baby and child care, personal care services, washing and personal hygiene (bathing, showering, etc.).
[b] Percentiles are the percentage of doers below or equal to a given number of minutes.
[c] N = doer sample size.
[d] Mean = Mean 24-hour cumulative number of minutes for doers.

Source: Tsang and Klepeis, 1996

Table 9-38. Statistics for twenty-four hour cumulative number of minutes eating or drinking by percentiles

Age (years)	N[b]	Mean[c]	SD	SE	Min	Max	Percentiles[a] 5th	25th	50th	75th	90th	95th	98th	99th
1-4	492	93.4837	52.8671	2.3834	2	345	20	60	90	120	160	190.0	225	270
5-11	680	68.5412	38.9518	1.4937	5	255	15	40	65	90	120	142.5	165	195
12-17	538	55.8587	34.9903	1.5085	2	210	10	30	50	75	105	125.0	150	170

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers.

Source: Tsang and Klepeis, 1996

Table 9-39. Statistics for twenty-four hour cumulative number of minutes spent indoors at school and indoors at a restaurant by percentiles

Age (years)	N[b]	Mean[c]	SD	SE	Min	Max	Percentiles[a] 5th	25th	50th	75th	90th	95th	98th	99th
24-hour cumulative number of minutes spent indoors at school														
1–4	43	288.465	217.621	33.187	5	665	10	60	269	500	580	595	665	665
5–11	302	396.308	109.216	6.285	5	665	170	365	403	445	535	565	625	640
12–17	287	402.551	125.512	7.409	15	855	120	383	420	450	500	565	710	778
24-hour cumulative number of minutes spent indoors at a restaurant														
1–4	61	62.705	47.701	6.1075	4	330	10	35	55	85	115	120	130	330
5–11	84	56.690	38.144	4.1618	5	180	10	30	45	85	120	120	140	180
12–17	122	69.836	78.361	7.0945	2	455	10	30	45	65	165	250	325	360

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers.

Source: Tsang and Klepeis, 1996

Table 9-40. Statistics for twenty-four hour cumulative number of minutes spent outdoors on school grounds/playground, at a park/golf course, and at a pool/river/lake by percentiles

Age (years)	N[b]	Mean[c]	SD	SE	Min	Max	Percentiles[a]							
							5th	25th	50th	75th	90th	95th	98th	99th
24-hour cumulative number of minutes spent outdoors on school grounds/playground														
1–4	9	85.000	61.084	20.3600	10	175	10	30	65.0	140.0	175	175	175	175
5–11	64	88.016	95.638	11.9600	5	625	10	30	60.0	120.0	170	220	315	625
12–17	76	78.658	88.179	10.1200	3	570	5	25	55.0	105.0	165	225	370	570
24-hour cumulative number of minutes spent outdoors at a park/golf course														
1– 4	21	149.857	176.250	38.4609	21	755	25	50	85.0	150.0	360	425	755	755
5–11	54	207.556	184.496	25.1068	25	665	35	70	125.0	275.0	555	635	660	665
12–17	52	238.462	242.198	33.5869	15	1065	15	60	147.5	337.5	590	840	915	1065
24-hour cumulative number of minutes spent outdoors at a pool/river/lake														
1–4	14	250.571	177.508	47.441	90	630	90	130	168.0	370.0	560	630	630	630
5–11	29	175.448	117.875	21.889	25	390	30	60	145.0	293.0	365	375	390	390
12–17	22	128.318	94.389	20.124	40	420	58	60	82.5	210.0	225	235	420	420

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers. Min = minimum number of minutes.

Source: Tsang and Klepeis, 1996

Table 9-41. Statistics for twenty-four hour cumulative number of minutes spent at home in the kitchen bathroom, bedroom, and in a residence (all rooms) by percentiles

Age (years)	N[b]	Mean[c]	SD	SE	Min	Max	Percentiles[a] 5th	25th	50th	75th	90th	95th	98th	99th
24-hour cumulative number of minutes spent at home in the kitchen														
1–4	335	73.719	54.382	2.9712	5	392	15	30.0	60	100	140.0	180.0	225	240
5–11	477	60.468	52.988	2.4262	1	690	10	30.0	50	75	120.0	150.0	180	235
12–17	396	55.02	58.111	2.9202	1	450	5	15.0	36	65	125.0	155.0	240	340
24-hour cumulative number of minutes spent in the bathroom														
1–4	328	35.939	46.499	2.5675	1	600	10	15.0	30	40	60.0	75.0	125	270
5–11	490	30.9673	38.609	1.7442	1	535	5	15.0	27	35	52.5	60.0	100	200
12–17	445	29.0517	32.934	1.5612	1	547	5	15.0	20	35	60.0	65.0	90	100
24-hour cumulative number of minutes spent at home in the bedroom														
1–4	488	741.988	167.051	7.562	30	1440	489	635.0	740	840	930.0	990.0	1095	1200
5–11	689	669.144	162.888	6.2055	35	1440	435	600.0	665	740	840.0	915.0	1065	1140
12–17	577	636.189	210.883	8.7792	15	1375	165	542.0	645	750	875.0	970.0	1040	1210
24-hour cumulative number of minutes spent indoors in a residence (all rooms)														
1–4	498	1211.64	218.745	9.8022	270	1440	795	1065	1260	1410	1440	1440.0	1440	1440
5–11	700	1005.13	222.335	8.4035	190	1440	686	845.0	975	1165	1334	1412.5	1440	1440
12–17	588	969.5	241.776	9.9707	95	1440	585	811.5	950	1155	1310	1405.0	1440	1440

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers.

Source: Tsang and Klepeis, 1996

Table 9-42. Statistics for twenty-four hour cumulative number of minutes spent traveling inside a vehicle by percentiles

Age (years)	N[b]	Mean[c]	SD	SE	Min	Max	Percentile[a] 5th	25th	50th	75th	90th	95th	98th	99th
1–4	335	68.116	75.531	4.1267	1	955	10	30	47	85	150.0	200.0	245	270
5–11	571	71.033	77.620	3.2483	1	900	10	25	51	90	140.0	171.0	275	360
12–17	500	81.530	79.800	3.5687	1	790	10	30	60	100	165.5	232.5	345	405

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers. Min = minimum number of minutes. Max = maximum number of minutes.

Source: Tsang and Klepeis, 1996

Table 9-43. Statistics for twenty-four hour cumulative number of minutes spent outdoors (outside the residence) and outdoors other than near a residence or vehicle, such as parks, golf courses, or farms by percentiles

Age (years)	N[b]	Mean[c]	SD	SE	Min	Max	Percentile[a] 5th	25th	50th	75th	90th	95th	98th	99th
Statistics for 24-hour cumulative number of minutes spent outdoors (outside the residence)														
1–4	201	195.652	163.732	11.5488	3	715	30	75	135	270	430	535	625	699
5–11	353	187.564	158.575	8.4401	4	1250	20	80	150	265	365	479	600	720
12–17	219	135.260	137.031	9.2597	1	720	5	35	100	190	300	452	545	610
Statistics for 24-hour cumulative number of minutes spent outdoors other than near a residence or vehicle such as parks, golf courses, or farms														
1–4	54	164.648	177.340	24.1330	1	980	10	60	120	175	370	560	630	980
5–11	159	171.340	177.947	14.1120	5	1210	15	55	115	221	405	574	660	725
12–17	175	156.903	174.411	13.1840	5	1065	10	45	100	210	385	570	735	915

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers. Min = minimum number of minutes. Max = maximum number of minutes.

Source: Tsang and Klepeis, 1996

Table 9-44. Statistics for twenty-four hour cumulative number of minutes spent in malls, grocery stores, or other stores by percentiles

Age (years)	N[b]	Mean[c]	SD	SE	Min	Max	Percentile[a]							
							5th	25th	50th	75th	90th	95th	98th	99th
1–4	110	90.036	77.887	7.4263	5	420	10	40	65	105.0	210.0	250.0	359	360
5–11	129	77.674	68.035	5.9901	3	320	5	30	60	110.0	180.0	225.0	255	280
12–17	140	88.714	101.360	8.5666	1	530	5	20	45	123.5	222.5	317.5	384	413

[a] Percentiles are the percentage of doers below or equal to a given number of minutes.
[b] N = doer sample size.
[c] Mean = Mean 24-hour cumulative number of minutes for doers.

Source: Tsang and Klepeis, 1996

Table 9-45. Statistics for twenty-four hour cumulative number of minutes spent with smokers present by percentiles

Age (years)	N	Mean	SD	SE	Min	Max	Percentile							
							5th	25th	50th	75th	90th	95th	98th	99th
1–4	155	366.56	324.46	26.062	5	1440	30	90	273	570	825	1010	1140	1305
5–11	224	318.07	314.02	20.981	1	1440	25	105	190	475	775	1050	1210	1250
12–17	256	245.77	243.61	15.226	1	1260	10	60	165	360	595	774	864	1020

Table 9-46. Gender and age groups

Gender-age group	Subgroup	N	Age (years)
Adolescents	Males	98	12–17
	Females	85	12–17
Children[a]	Young males	145	6–8
	Young females	124	6–8
	Old males	156	9–11
	Old females	160	9–11

[a] Children under the age of 6 are excluded for the present study (too few responses in CARB study).

Source: Funk et al., 1998

Table 9-47. Assignment of at-home activities to ventilation levels for children

Low	Moderate
Watching child care	Outdoor cleaning
Night sleep	Food preparation
Watch personal care	Metal clean-up
Homework	Cleaning house
Radio use	Clothes care
TV use	Car/boat repair
Records/tapes	Home repair
Reading books	Plant care
Reading magazines	Other household
Reading newspapers	Pet care
Letters/writing	Baby care
Other leisure	Child care
Homework/watch TV	Helping/teaching
Reading/TV	Talking/reading
Reading/listen music	Indoor playing
Paperwork	Outdoor playing
	Medical child care
	Washing, hygiene
	Medical care
	Help and care
	Meals at home
	Dressing
	Visiting at home
	Hobbies
	Domestic crafts
	Art
	Music/dance/drama
	Indoor dance
	Conservations
	Painting room/home
	Building fire
	Washing/dressing
	Outdoor play
	Playing/eating
	Playing/talking
	Playing/watch TV
	TV/eating
	TV/something else
	Reading book/eating
	Read magazine/eat
	Read newspaper/eat

Source: Funk et al., 1998

Table 9-48. Aggregate time spent (mins/day) at home in activity groups by adolescents and children[a]

Activity Group	Adolescents		Children	
	Mean	SD	Mean	SD
Low	789	230	823	153
Moderate	197	131	241[b]	136
High	1	11	3	17
High participants[c]	43	72	58	47

[a] Time spent engaging in all activities embodied by ventilation level category (mins/day).
[b] Significantly different from adolescents (p<0.05).
[c] Represents time spent at home by individuals participating in high-ventilation levels.

Source: Funk et al., 1998

Table 9-49. Comparison of mean time (mins/day) spent at home by gender (adolescents)

Activity Group	Males		Females	
	Mean	SD	Mean	SD
Low	775	206	804	253
Moderate	181	126	241	134
High	2	16	0	0

Source: Funk et al., 1998

Table 9-50. Comparison of mean time (mins/day) spent at home by gender and age for children[a]

	Males				Females			
	6–8 Years		9–11 Years		6–8 Years		9–11 Years	
Activity Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Low	806	134	860	157	828	155	803	162
Moderate	259	135	198	111	256	141	247	146
High	3	17	7	27	1	9	2	10
High participants[c]	77	59	70	54	68	11	30	23

[a] Time spent engaging in all activities embodied by ventilation level category (mins/day).
[b] Participants in high-ventilation level activities.

Source: Funk et al., 1998

Table 9-51. Number of person-days/individuals for children in CHAD database[a]

Age Group	All Studies	California[b]	Cincinnati[c]	NHAPS-Air	NHAPS-Water
0 year	223/199	104	36/12	39	44
0-6 months		50	15/5		
6-12 months		54	21/7		
1 year	259/238	97	31/11	64	67
12–18 months		57			
18–24 months		40			
2 years	317/264	112	81/28	57	67
3 years	278/242	113	54/18	51	60
4 years	259/232	91	41/14	64	63
5 years	254/227	98	40/14	52	64
6 years	237/199	81	57/19	59	40
7 years	243/213	85	45/15	57	56
8 years	259/226	103	49/17	51	55
9 years	229/195	90	51/17	42	46
10 years	224/199	105	38/13	39	42
11 years	227/206	121	32/11	44	30
Total	3009/2640	1200	556/187	619	634

[a] The number of person-days of data are the same as the number of individuals for all studies except for the Cincinnati study. Because up to 3 days of activity pattern data were obtained from each participant in this study, the number of person-days of data is approximately three times the number of individuals. CHAD (Consolidated Human Activity Database) is available at www.epa.gov/chadnet1/.

[b] Wiley et al. (1991)

[c] Johnson (1989).

NHAPS = National Human Activity Pattern study

Source: Hubal et al., 2000

Table 9-52. Number of hours per day children spent in various microenvironments, by age: average ± SD (percent of children reporting > 0 hours in microenvironment)

Age (years)	Indoors at Home	Outdoors at Home	Indoors at School	Outdoors at Park	In Vehicle
0	19.6 ± 4.3 (99)	1.4 ± 1.5 (20)	3.5 ± 3.7 (2)	1.6 ± 1.5 (9)	1.2 ± 1.0 (65)
1	19.5 ± 4.1 (99)	1.6 ± 1.3 (35)	3.4 ± 3.8 (5)	1.9 ± 2.7 (10)	1.1 ± 0.9 (66)
2	17.8 ± 4.3 (100)	2.0 ± 1.7 (46)	6.2 ± 3.3 (9)	2.0 ± 1.7 (17)	1.2 ± 1.5 (76)
3	18.0 ± 4.2 (100)	2.1 ± 1.8 (48)	5.7 ± 2.8 (14)	1.5 ± 0.9 (17)	1.4 ± 1.9 (73)
4	17.3 ± 4.3 (100)	2.4 ± 1.8 (42)	4.9 ± 3.2 (16)	2.3 ± 1.9 (20)	1.1 ± 0.8 (78)
5	16.3 ± 4.0 (99)	2.5 ± 2.1 (52)	5.4 ± 2.5 (39)	1.6 ± 1.5 (28)	1.3 ± 1.8 (80)
6	16.0 ± 4.2 (98)	2.6 ± 2.2 (48)	5.8 ± 2.2 (34)	2.1 ± 2.4 (32)	1.1 ± 0.8 (79)
7	15.5 ± 3.9 (99)	2.6 ± 2.0 (48)	6.3 ± 1.3 (40)	1.5 ± 1.0 (28)	1.1 ± 1.1 (77)
8	15.6 ± 4.1 (99)	2.1 ± 2.5 (44)	6.2 ± 1.1 (41)	2.2 ± 2.4 (37)	1.3 ± 2.1 (82)
9	15.2 ± 4.3 (99)	2.3 ± 2.8 (49)	6.0 ± 1.5 (39)	1.7 ± 1.5 (34)	1.2 ± 1.2 (76)
10	16.0 ± 4.4 (96)	1.7 ± 1.9 (40)	5.9 ± 1.5 (39)	2.2 ± 2.3 (40)	1.1 ± 1.1 (82)
11	14.9 ± 4.6 (98)	1.9 ± 2.3 (45)	5.9 ± 1.5 (41)	2.0 ± 1.7 (44)	1.6 ± 1.9 (74)

Source: Hubal et al., 2000

Table 9-53. Average number of hours per day children spent doing various macroactivities while indoors at home, by age (percent of children reporting > 0 hours for microenvironment/macroactivity)

Age (years)	Eating	Sleeping or napping	Shower or bathe	Playing games	Watching TV or listening to radio	Reading, writing, doing homework	Thinking, relaxing, passive
0	1.9 (96)	12.6 (99)	0.4 (44)	4.3 (29)	1.1 (9)	0.4 (4)	3.3 (62)
1	1.5 (97)	12.1 (99)	0.5 (56)	3.9 (68)	1.8 (41)	0.6 (19)	2.3 (20)
2	1.3 (92)	11.5 (100)	0.5 (53)	2.5 (59)	2.1 (69)	0.6 (27)	1.4 (18)
3	1.2 (95)	11.3 (99)	0.4 (53)	2.6 (59)	2.6 (81)	0.8 (27)	1.0 (19)
4	1.1 (93)	10.9 (100)	0.5 (52)	2.6 (54)	2.5 (82)	0.7 (31)	1.1 (17)
5	1.1 (95)	10.5 (98)	0.5 (54)	2.0 (49)	2.3 (85)	0.8 (31)	1.2 (19)
6	1.1 (94)	10.4 (98)	0.4 (49)	1.9 (35)	2.3 (82)	0.9 (38)	1.1 (14)
7	1.0 (93)	9.9 (99)	0.4 (56)	2.1 (38)	2.5 (84)	0.9 (40)	0.6 (10)
8	0.9 (91)	10.0 (96)	0.4 (51)	2.0 (35)	2.7 (83)	1.0 (45)	0.7 (7)
9	0.9 (90)	9.7 (96)	0.5 (43)	1.7 (28)	3.1 (83)	1.0 (44)	0.9 (17)
10	1.0 (86)	9.6 (94)	0.4 (43)	1.7 (38)	3.5 (79)	1.5 (47)	0.6 (10)
11	0.9 (89)	9.3 (94)	0.4 (45)	1.9 (27)	3.1 (85)	1.1 (47)	0.6 (10)

Source: Hubal et al., 2000

Table 9-54. Respondents with children and those reporting outdoor play[a] activities in both warm and cold weather

Survey Population	N respondents with children	Child players[a]		Child nonplayers		Warm-weather player[b]	Cold-weather player	Player in both seasons
		N	%	N	%	N	N	%
SCS-II base	197	128	65.0	69	35.0	127	100	50.8
SCS-II oversample	483	372	77.0	111	23.0	370	290	60.0
Total	**680**	**500**	**73.5**	**180**	**26.5**	**497**	**390**	**57.4**

[a] "Play" and "player" refer specifically to participation in outdoor play on bare dirt or mixed grass and dirt.
[b] Does not include three "Don't know/refused" responses regarding warm-weather play.

Table 9-55. Play frequency and duration for all child players (from SCS-II data) by percentiles

Percentile	Cold weather			Warm weather		
	Frequency (days/wk)	Duration (hrs/day)	Total (hrs/wk)	Frequency (days/wk)	Duration (hrs/day)	Total (hrs/wk)
N	372	374	373	488	479	480
5th percentile	1	1	1	2	1	4
50th percentile	3	1	5	7	3	20
95th percentile	7	4	20	7	8	50

Table 9-56. Hand washing and bathing frequency for all child players (from SCS-II data) by percentiles

Percentile	Cold weather		Warm weather	
	Hand washing (times/day)	Bathing (times/wk)	Hand washing (times/day)	Bathing (times/wk)
N	329	388	433	494
5th percentile	2	2	2	3
50th percentile	4	7	4	7
95th percentile	10	10	12	14

Table 9-57. NHAPS and SCS-II play duration[a] comparison

Survey Population	Mean play duration (min/day)			X^2 test[b]
	Cold weather	Warm weather	Total	p<0.0001
NHAPS	114	109	223	
SCS-II	102	206	308	

[a] Selected previous day activities in NHAPS, average day outdoor play on bare dirt or mixed grass and dirt in SCS-II.
[b] 2x2 chi-square test for contingency between NHAPS and SCS-II.

Table 9-58. Comparison of NHAPS and SCS-II hand-washing frequencies

Survey Population	Season	Percent reporting by frequency (times/day)								X^2 test[a]
		0	1–2	3–5	6–9	10–19	20–29	30+	"Don't know"	
NHAPS	Cold	3	18	51	17	7	1	1	3	
SCS-II	Cold	1	16	50	11	7	1	0	15	p=0.060
NHAPS	Warm	3	18	51	15	7	2	1	4	
SCS-II	Warm	0	12	46	16	10	1	0	13	p=0.001

[a] 2x2 chi-square test for contingency between NHAPS and SCS-II.

Table 9-59. Confidence in activity patterns recommendations

Considerations	Rationale	Rating
Time spent indoors vs. outdoors		
Study Elements		
Level of peer review	The study received high level of peer review.	High
Accessibility	The study is widely available to the public.	High
Reproducibility	The reproducibility of these studies is left to question. Evidence has shown that activities have tended to shift over the past decade since the study was published due to economic conditions and technological developments, etc. Thus, it is assumed there would be differences in results. However, if data were reanalyzed in the same manner, the results are expected to be the same.	Medium
Focus on factor of interest	The study focused on general activity patterns.	High
Data pertinent to U.S.	The study focused on the U.S. population.	High
Primary data	Data were collected via questionnaires and interviews.	High
Currency	The studies were published in 1985 (data were collected 1981–1982).	Medium
Adequacy of data-collection period	Households were sampled four times during 3-month intervals from February to December 1981.	High
Validity of approach	A 24-hour recall time diary method was used to collect data.	High
Study size	The sample population was 922 children between the ages of 3 and 17 years.	High
Representativeness of the population	The study focused on activities of children.	High
Characterization of variability	Variability was characterized by age, gender, day of the week, location of activities, and various age categories for children.	Medium
Lack of bias in study design (high rating is desirable)	Biases noted were sampled during time when children were in school (activities during vacation time are not represented); activities in the 1980's may be different than they are now.	Medium
Measurement error	Measurement or recording error may occur because the diaries were based on recall (in most cases a 24-hour recall).	Medium
Other Elements		
Number of studies	Two	High
Agreement between researchers	Difficult to compare due to varying categories of activities and the unique age distributions found within each study.	Not Ranked
Overall Rating		**Medium**

Table 9-59. Confidence in activity patterns recommendations (continued)

Considerations	Rationale	Rating
Time spent showering		
Study Elements		
Level of peer review	The study received high level of peer review.	High
Accessibility	Currently, raw data are available only to EPA. It is not known when data will be publicly available.	Low
Reproducibility	Results are reproducible.	High
Focus on factor of interest	The study focused specifically on time spent showering.	High
Data pertinent to U.S.	The study focused on the U.S. general population.	High
Primary data	The study was based on primary data.	High
Currency	The study was published in 1996.	High
Adequacy of data-collection period	The data were collected between October 1992 and September 1994.	High
Validity of approach	The study used a valid methodology and approach that collected information from 24-hour diaries as well as information on temporal conditions and demographic data such as geographic location and socioeconomic status for various U.S. subgroups.	High
Study size	Study consisted of 9386 total participants of all ages; 450 respondents ages 1–17 years were included in this category.	Medium-Low
Representativeness of the population	The data were representative of the U.S. population.	High
Characterization of variability	The study provides a distribution on showering duration.	High
Lack of bias in study design (high rating is desirable)	The study includes distributions for showering duration. Study is based on short-term data.	High
Measurement error	Measurement or recording error may occur because diaries were based on 24-hour recall.	Medium
Other Elements		
Number of studies	One; the study was a national study.	Low
Agreement between researchers	The recommendation is based on the data (presented in ranges) from only one study (NHAPS), but it is a widely accepted study. The recommended value was selected on the basis of professional judgment because the data were presented as a range (10–20 minutes).	Low-Medium
Overall Rating		**Medium**
Shower frequency		

Table 9-59. Confidence in activity patterns recommendations (continued)

Considerations	Rationale	Rating
Study Elements		
Level of peer review	The study received high level of peer review.	High
Accessibility	Currently, raw data are available only to EPA. It is not known when data will be publicly available.	Low
Reproducibility	Results can be reproduced or methodology can be followed and evaluated, provided comparable economic and social conditions exists.	High
Focus on factor of interest	The survey collected information on duration and frequency of selected activities and time spent in selected microenvironments.	High
Data pertinent to U.S.	The data represent the U.S. population.	High
Primary data	The study was based on primary data.	High
Currency	The study was published in 1996.	High
Adequacy of data-collection period	The data were collected between October 1992 and September 1994.	High
Validity of approach	The study used a valid methodology and approach that collected information from 24-hour diaries as well as information on temporal conditions and demographic data such as geographic location and socioeconomic status for various U.S. subgroups. Responses were weighted according to these demographic data.	High
Study size	The study consisted of 9386 total participants of all age groups; 451 respondents ages 1–17 years participated in this category.	Medium-low
Representativeness of the population	Studies were based on the U.S. population.	High
Characterization of variability	The study provided data that varied across geographic region, race, gender, employment status, educational level, day of the week, seasonal conditions, and medical conditions of respondent.	High
Lack of bias in study design (high rating is desirable)	Study is based on short-term data.	Medium
Measurement error	Measurement or recording error may occur because diaries were based on 24-hour recall.	Medium
Other Elements		
Number of studies	One; the study was based on one primary national study.	Low
Agreement between researchers	Recommendation was based on only one study.	Not Ranked
Overall Rating		**Medium**
Time spent swimming		

Table 9-59. Confidence in activity patterns recommendations (continued)

Considerations	Rationale	Rating
Study Elements		
Level of peer review	Study received high level of peer review.	High
Accessibility	Currently, raw data are available only to EPA. It is not known when data will be publicly available.	Low
Reproducibility	Results can be reproduced or methodology can be followed and evaluated, provided comparable economic and social conditions exists.	High
Focus on factor of interest	The survey collected information on duration and frequency of selected activities and time spent in selected microenvironments. It addresses only time swimming at a swimming pool.	Medium
Data pertinent to U.S.	The data represent the U.S. population.	High
Primary data	The study was based on primary data.	High
Currency	The study was published in 1996.	High
Adequacy of data-collection period	The data were collected between October 1992 and September 1994.	High
Validity of approach	The study used a valid methodology and approach that collected information from 24-hour diaries as well as information on temporal conditions and demographic data such as geographic location and socioeconomic status for various U.S. subgroups. Responses were weighted according to these demographic data.	High
Study size	The study consisted of 9386 total participants of all age groups; 238 respondents aged 1–17 years participated in this category.	Low
Representativeness of the population	Studies were based on the U.S. population.	High
Characterization of variability	The study provided data that varied across geographic region, race, gender, employment status, educational level, day of the week, seasonal conditions, and medical conditions of respondent.	High
Lack of bias in study design (high rating is desirable)	The study includes distributions for swimming duration. Study is based on short-term data.	Medium
Measurement error	Measurement or recording error may occur because diaries were based on 24-hour recall.	Medium
Other Elements		
Number of studies	One; the study was based on one primary national study.	Low
Agreement between researchers	Recommendation was based on only one study.	Not Ranked
Overall Rating		**Medium**
Time spent playing on sand, gravel, or grass		

Considerations	Rationale	Rating
Study Elements		
Level of peer review	The study received high level of peer review.	High
Accessibility	Currently, raw data are available only to EPA. It is not known when data will be publicly available.	Low
Reproducibility	Results can be reproduced or methodology can be followed and evaluated provided comparable economic and social conditions exists.	High
Focus on factor of interest	The survey collected information on duration and frequency of selected activities and time spent in selected micro-environments.	High
Data pertinent to U.S.	The data represent the U.S. population.	High
Primary data	The study was based on primary data.	High
Currency	The study was published in 1996.	High
Adequacy of data-collection period	The data were collected between October 1992 and September 1994.	High
Validity of approach	The study used a valid methodology and approach that collected information from 24-hour diaries as well as information on temporal conditions and demographic data such as geographic location and socioeconomic status for various U.S. subgroups. Responses were weighted according to these demographic data.	High
Study size	The study consisted of 9386 total participants of all age groups; 457 respondents aged 1–17 years participated in this category.	Medium-low
Representativeness of the population	The studies were based on the U.S. population.	High
Characterization of variability	The study provided data that varied across geographic region, race, gender, employment status, educational level, day of the week, seasonal conditions, and medical conditions of respondent.	High
Lack of bias in study design (high rating is desirable)	The study includes distributions for bathing duration. Study is based on short-term data.	Medium
Measurement error	Measurement or recording error may occur because diaries were based on 24-hour recall.	Medium
Other Elements		
Number of studies	One; the study was based on one primary national study.	Low
Agreement between researchers	Recommendation was based on only one study. Recommendations based on 50% time spent playing in grass.	Not Ranked
Overall Rating		**Medium**

Table 9-60. Summary of activity pattern studies

Study	Age Groups (years)	Sample Size	Population	Activities
Timmer et al., 1985	3–5, 6–8, 9–11, 12–14, 15–17	922	National	18 microenvironments
Robinson and Thomas, 1991	12–adults	1762 (California) 2762 (national)	California and national	16 microenvironments
Wiley et al., 1991	0–2, 3–5, 6–8, 9–11	1200	California	10 microenvironments
Tsang and Klepeis, 1996	1–4, 5–11, 12–17	Varies with age groups and activities	National	23 microenvironments
Funk et al., 1998	6–11, 12–17	768	California	Activities grouped into low-, medium-, and high-ventilation levels
Hubal et al. 2000	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	2640	Based on Wiley et al., 1991; Johnson, 1989; and Tsang and Klepeis, 1996	Activities grouped into indoors at home, indoors at school, outdoors at home, outdoors at part, and in vehicle

Table 9-61. Summary of mean time spent indoors and outdoors from several studies

Age (years)	Time Indoors (hrs/day)[a]	Time Outdoors (hrs/day)[a]	Study
3–5 6–8 9–11 12–14 15–17	19.0 20.0 20.0 20.0 19.0	2.8 (National) 2.2 1.8 1.8 1.9	Timmer et al., 1985
12 and older	21 (National) 21 (California)	1.2 (National) 1.4 (California)	Robinson and Thomas, 1991
0–2 3–5 6–8 9–11	20.0 18.8 19.7 19.9	4 (California) 5.2 4.4 4.1	Wiley et al., 1991
1–4 5–11 12–17	— — —	6.0 6.0 5.0	Tsang and Klepeis, 1996

[a] Mean of weekday and weekend rounded up to two significant figures.

Table 9-62. Summary of recommended values for activity factors

Type	Value	Study
Time indoors	At residence Ages (years) / Mean (hrs) / 95th percentile 1–4 / 20 / 24 5–11 / 17 / 24 12–17 / 16 / 23 Use values in Table 9-41 for other percentile data.	Tsang and Klepeis, 1996
	Total time indoors Ages (years) / Mean (hrs) 3–5 / 19 6–8 / 20 9–11 / 20 12–14 / 20 15–17 / 19 Mean is mean of weekday and weekend rounded up to two significant figures. Use Table 9-3 for mean values spent indoors weekend and weekday.	Timmer et al., 1985
Time outdoors	At residence Ages (years) / Mean (hrs) / 95th percentile 1–4 / 3 / 9 5–11 / 3 / 8 12–17 / 2 / 8 Use values in Table 9-43 for other percentile data.	Tsang and Klepeis, 1996
	Total time outdoors Ages (years) / Mean (hrs) 3–5 / 3 6–8 / 2 9–11 / 2 12–14 / 2 15–17 / 2 Mean is mean of weekday and weekend rounded up to one significant figure. Use Table 9-3 for mean values spent outdoors weekend and weekday.	Timmer et al., 1985

Table 9-62. Summary of recommended values for activity factors (continued)

Type	Value	Study
Taking shower	10 min/day shower duration 1 shower event/day	Tsang and Klepeis, 1996 Tsang and Klepeis, 1996
Swimming	1 event/mo 60 mins/event	Tsang and Klepeis, 1996
Playing on sand or gravel	60 mins/day	Tsang and Klepeis, 1996
Playing on grass	60 mins/day	Tsang and Klepeis, 1996

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10. CONSUMER PRODUCTS

10.1. BACKGROUND

Consumer products may contain toxic or potentially toxic chemical constituents to which children may be exposed. For example, methylene chloride and other solvents and carriers are common in consumer products and may prompt health concerns. Potential pathways of exposure to consumer products or chemicals released from consumer products during use can occur via ingestion, inhalation, and dermal contact. This chapter presents information on the amount of product used, the frequency of use, and the duration of use for various consumer products typically found in households.

Limited data are available on consumer product use for the general population and especially for children. Children can be in environments where household consumer products such as cleaners, solvents, and paints are used, and they can be passively exposed to chemicals in these products. Table 10-1 provides a list of household consumer products that are commonly found in some U.S. households. It should be noted that these are 1987 data, and consumer use of some of the products listed (e.g., aerosol products) may be limited. The studies presented in the following sections represent readily available surveys for which data were collected on the frequency and duration of use and the amount of use of cleaning products, painting products, household solvent products, cosmetics and other personal care products, household equipment, pesticides, and tobacco. The reader is referred to *Exposure Factors Handbook* (U.S. EPA, 1997) for a more detailed presentation for use of consumer products for the general population.

10.2. CONSUMER PRODUCTS USE STUDIES

10.2.1. Tsang and Klepeis, 1996

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. More than 9000 individuals from all age groups in 48 contiguous states participated in this National Human Activity Pattern Survey (NHAPS). The survey was conducted between October 1992 and September 1994. Individuals were asked to categorize their 24-hour routines (diaries) and/or answer follow-up exposure questions that were related to exposure events. Data were collected on the basis of selected socioeconomic (gender, age, race, education, etc.) and geographic (census region, state, etc.) factors and time/season (day of week, month). Data were collected for a maximum of 82 possible microenvironments and 91 different activities (Tsang and Klepeis, 1996).

As part of the survey, data were also collected on the duration and frequency of use of selected consumer products by parents who had children in various age groups. These data are presented in Tables 10-2 through 10-6 for age groups 1–4, 5–11, and 12–17 years. 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 in ranges for the number of times an activity involving a consumer product was performed. Total N denotes the number of respondents for that specific activity category. The data in this document are for age groups 1–17 years old only, where data are available.

The advantages of the NHAPS is that the data were collected for a large number of individuals and are representative of the U.S. general population. However, means cannot be calculated for consumers who spent more than 60 or 120 minutes (depending on the activity) in an activity using a consumer product. Therefore, a good estimate of the high consumer activities cannot be captured.

10.3. 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 had been done in other chapters of this handbook. The user is referred to the contents and references in Chapter 16 of *Exposure Factors Handbook* (U.S. EPA, 1997) to derive appropriate exposure factors and review its associated recommendations.

Table 10-1. Consumer products commonly found in some U.S. households[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 Hair sprays (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 waterproofing (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) Fabric rinse/softener (liquid)

Table 10-1. Consumer products commonly found in some U.S. households[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)	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 10-1. Consumer products commonly found in some U.S. households[a] (continued)

Consumer Product Category	Consumer Product
Home building/improvement products (DIY) (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 the mouth)

[a] A subjective listing, based on consumer use profiles.
x > DIY = Do It Yourself.

Source: U.S. EPA, 1987

Table 10-2. Number of minutes per day spent in activities working with or near household cleaning agents such as scouring powders or ammonia

Age groups (years)	N [a]	Percentiles											
		1st	2nd	5th	10th	25th	50th	75th	90th	95th	98th	99th	100th
1–4	21	0	0	0	0	5	10	15	20	30	121[b]	121[b]	121[b]
5–11	26	1	1	2	2	3	5	15	30	30	30	30	30
12–17	41	0	0	0	0	2	5	10	40	60	60	60	60

[a] N is the doer sample size; percentiles are the percentage of doers below or equal to a given number of minutes.
[b] A value of 121 for number of minutes signifies that more than 120 minutes were spent.

Source: Tsang and Klepeis, 1996

Table 10-3. Number of minutes per day spent using any microwave oven

Age groups (years)	N [a]	Percentiles											
		1st	2nd	5th	10th	25th	50th	75th	90th	95th	98th	99th	100th
5–11	62	0	0	0	1	1	2	5	10	15	20	30	30
12–17	141	0	0	0	1	2	3	5	10	15	30	30	60

[a] 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 10-4. Number of respondents using a humidifier at home

Age group (years)	N	Frequency				
		Almost every day	3–5 times a week	1–2 times a week	1–2 times a month	Don't Know
1– 4	111	33	16	7	53	2
5–11	88	18	10	12	46	2
12–17	83	21	7	5	49	1

Source: Tsang and Klepeis, 1996

Table 10-5. Number of respondents reporting that pesticides were applied by a professional at their home by number of times applied over a 6-month period[a]

Age group (years)	N	Number of times applied					
		0	1–2	3–5	6–9	10+	Don't Know
1–4	113	60	35	11	6	1	*
5–11	150	84	37	10	18	1	*
12–17	143	90	40	5	6	*	2

[a] Applied to eradicate insects, rodents, or other pests.
* = Missing data.

Source: Tsang and Klepeis, 1996

Table 10-6. Number of respondents reporting that pesticides were applied by the consumer at home by number of times applied over a 6-month period

Age group (years)	M	Number of times applied					
		0	1–2	3–5	6–9	10+	Don't Know
1–4	113	46	46	15	3	3	*
5–11	150	50	70	24	1	4	1
12–17	143	45	64	21	5	8	*

[a] Applied to eradicate insects, rodents, or other pests
* = Missing Data.

Source: Tsang and Klepeis, 1996

REFERENCES FOR CHAPTER 10

Tsang, AM; Klepeis, NE. (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 (U.S. Environmental Protection Agency). (1997) Exposure Factors Handbook, National Center for Environmental Assessment, Office of Research and Development, Washington, DC EPA/600/P-95/002FC.

11. BODY WEIGHT STUDIES

11.1. INTRODUCTION

An average daily dose is a dose that is typically normalized to the average body weight of the exposed population. 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 key published studies on body weight for children in the general U.S. population, as described in *Exposure Factors Handbook* (U.S. EPA, 1997). Recommended values are based on the results of these studies.

11.2. BODY WEIGHT STUDIES

11.2.1. Hamill et al., 1979

A National Center for Health Statistics (NCHS) Task Force that included academic investigators and representatives from the Centers for Disease Control Nutrition Surveillance Program selected, collated, integrated, and defined appropriate data sets to generate growth curves for the ages of birth to 36 months (Hamill et al., 1979). The percentile curves were developed to assess the physical growth of children in the U.S. They are based on accurate measurements made on large, nationally representative samples of children. Smoothed percentile curves were derived for body weight by age. Curves were developed for boys and for girls. The data used to construct the curves were provided by the Fels Research Institute, Yellow Springs, OH. These data came from an ongoing longitudinal study where anthromopetric data from direct measurements are collected regularly from participants (~1000) in various areas of the U.S. The NCHS used advanced statistical and computer technology to generate the growth curves. Table 11-1 presents the percentiles of weight-by-sex and age. Figures 11-1 and 11-2 present weight-by-age percentiles for boys and for girls ages birth to 36 months, respectively. Limitations of this study are that mean body weight values were not reported, and the data are more that 15 years old. However, this study does provide body weight data for infants younger than 6 months old.

11.2.2. National Center for Health Statistics, 1987

Statistics on anthropometric measurements, including body weight, for the U.S. population were collected by NCHS through the second National Health and Nutrition Examination Survey (NHANES II). NHANES II was conducted on a nationwide probability sample of 27,801 persons ages 6 months to 74 years from the civilian, noninstitutionalized population of the U.S. A total of 20,322 individuals in the sample were interviewed and examined—a response rate of 73.1%. 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.

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 an individual's weight may vary between winter and summer and may fluctuate with recency of food and water intake and other daily activities. Percentile data for children, by age, are presented in Table 11-2 for males and in Table 11-3 for females.

11.2.3. Burmaster and Crouch, 1997

Burmaster and Crouch (1997) performed data analysis to fit normal and lognormal distributions to the body weights of females and males at age 9 months to 70 years. *Exposure Factors Handbook* (U.S. EPA, 1997) used a pre-published version of this paper. The numbers reported in Tables 11-4 and 11-5 vary slightly from those reported in *Exposure Factors Handbook*.

Data used in this analysis were from NHANES II, which included 27,801 persons 6 months to 74 years of age in the U.S. The NHANES II data had been statistically adjusted for nonresponse and probability of selection and stratified by age, sex, and race to reflect the entire U.S. population prior to reporting. Burmaster and Crouch conducted exploratory and quantitative data analyses and fit normal and lognormal distributions to percentiles of body weights of children, teens, and adults as a function of age. Cumulative distribution functions were plotted for female and male body weights on both linear and logarithmic scales.

The maximum likelihood estimation to fit lognormal distributions to the data. Linear and quadratic regression lines were fitted to the data. A number of goodness-of-fit measures were conducted on data generated. The investigations found that lognormal distributions gave strong fits to the data for each sex across all age groups. Statistics for the lognormal probability plots for children ages 9 months to 20 years are presented in Tables 11-4 and 11-5. These data can be used for further analyses of body weight distribution (i.e., application of Monte Carlo analysis). The reader is referred to the original study for a more detailed description.

11.2.4. U.S. EPA, 2000

EPA's Office of Water has estimated body weights for children by age and gender using data from NHANES III, which was conducted from 1988 to 1994. NHANES III collected body weight data for approximately 15,000 children between the ages of 2 months and 17 years. Table 11-6 presents the body weight estimates by age and gender. Table 11-7 shows the body weight estimates for the infants under the age of 3 months and/or younger; Figures 11-3 and 11-4 compare the body weights (mean and median) of males and females of various age groups, respectively.

The limitations of these data are that the data were not available for infants younger than 2 months old, and the data are roughly 6–12 years old. With the upward trends in body weight from NHANES II (1976–1980) to NHANES III, which may still be valid, the data in Tables 11-6 and 11-7 may underestimate current body weights. Adjustment factors may be needed to update the estimates from 1988–1994 data to 2000. However, the data are national in scope and represent the general children's population.

11.3. RECOMMENDATIONS

The recommended values for body weight are summarized in Table 11-8. Table 11-9 presents the confidence ratings for body weight recommendations.

For infants (birth to 6 months), appropriate values for body weight may be selected from Table 11-1. These data (percentile only) are presented for male and female infants.

For children, appropriate mean values for weights may be selected from Tables 11-7 and 11-8. If percentile values are needed, these data are presented in Table 11-2 for male children and in Table 11-3 for female children.

Table 11-1. Smoothed percentiles of weight by sex and age: statistics from NCHS and data from Fels Research Institute

Sex and Age	Smoothed Percentile[a]						
	5th	10th	25th	50th	75th	90th	95th
	Weight in kilograms						
Male							
Birth	2.54	2.78	3.00	3.27	3.64	3.82	4.15
1 month	3.16	3.43	3.82	4.29	4.75	5.14	5.38
3 months	4.43	4.78	5.32	5.98	6.56	7.14	7.37
6 months	6.20	6.61	7.20	7.85	8.49	9.10	9.46
9 months	7.52	7.95	8.56	9.18	9.88	10.49	10.93
12 months	8.43	8.84	9.49	10.15	10.91	11.54	11.99
18 months	9.59	9.92	10.67	11.47	12.31	13.05	13.44
24 months	10.54	10.85	11.65	12.59	13.44	14.29	14.70
30 months	11.44	11.80	12.63	13.67	14.51	15.47	15.97
36 months	12.26	12.69	13.58	14.69	15.59	16.66	17.28
Female							
Birth	2.36	2.58	2.93	3.23	3.52	3.64	3.81
1 month	2.97	3.22	3.59	3.98	4.36	4.65	4.92
3 months	4.18	4.47	4.88	5.40	5.90	6.39	6.74
6 months	5.79	6.12	6.60	7.21	7.83	8.38	8.73
9 months	7.00	7.34	7.89	8.56	9.24	9.83	10.17
12 months	7.84	8.19	8.81	9.53	10.23	10.87	11.24
18 months	8.92	9.30	10.04	10.82	11.55	12.30	12.76
24 months	9.87	10.26	11.10	11.90	12.74	13.57	14.08
30 months	10.78	11.21	12.11	12.93	13.93	14.81	15.35
36 months	11.60	12.07	12.99	13.93	15.03	15.97	16.54

[a] Smoothed by cubic-spline approximation.

Source: Hamill et al., 1979

Table 11-2. Weight in kilograms for males 6 months to 19 years of age by sex and age, U.S. population 1976–1980[a]

Age	N	Mean (kg)	SD	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	60.1	64.9	68.7	72.8	81.3
16 years	178	67.1	12.4	51.4	54.3	56.1	57.6	64.4	73.6	78.1	82.2	91.2
17 years	173	66.7	11.5	50.7	53.4	54.8	58.8	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	82.1

[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.

Source: National Center for Health Statistics, 1987

Table 11-3. Weight in kilograms for females 6 months to 19 years of age by sex and age, U.S. population 1976–1980[a]

Age	N	Mean (kg)	SD	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

[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.

Source: National Center for Health Statistics, 1987

Table 11-4. Statistics for probability plot regression analyses female's body weights 6 months to 20 years of age

Age midpoint (years)	Lognormal probability plots linear curve	
	μ_2[a]	σ_2[a]
0.75	2.16	0.145
1.50	2.38	0.129
2.50	2.56	0.112
3.50	2.69	0.136
4.50	2.83	0.134
5.50	2.98	0.164
6.50	3.10	0.174
7.50	3.19	0.174
8.50	3.31	0.156
9.50	3.46	0.214
10.50	3.57	0.199
11.50	3.71	0.226
12.50	3.82	0.213
13.50	3.92	0.215
14.50	3.99	0.187
15.50	4.00	0.156
16.50	4.05	0.167
17.50	4.08	0.165
18.50	4.07	0.147
19.50	4.10	0.149

[a] μ_2 and σ_2 correspond to the mean and standard deviation, respectively, of the lognormal distribution of body weight (kg).

Source: Burmaster et al., 1997

Table 11-5. Statistics for probability plot regression analyses male's body weights 6 months to 20 years of age

Age midpoint (years)	Lognormal probability plots linear curve	
	μ_2[a]	σ_2[a]
0.75	2.23	0.132
1.50	2.46	0.119
2.50	2.60	0.120
3.50	2.75	0.114
4.50	2.87	0.133
5.50	2.98	0.138
6.50	3.13	0.145
7.50	3.21	0.151
8.50	3.33	0.181
9.50	3.43	0.165
10.5	3.59	0.195
11.5	3.69	0.252
12.5	3.78	0.224
13.5	3.88	0.215
14.5	4.02	0.181
15.5	4.09	0.159
16.5	4.20	0.168
17.5	4.19	0.167
18.5	4.25	0.159
19.5	4.26	0.154

[a] μ_2 and σ_2 correspond to the mean and standard deviation, respectively, of the lognormal distribution of body weight (kg).

Source: Burmaster et al., 1997

Table 11-6. Body weight estimates (in kilograms) by age and gender, U.S. population 1988–1994

Age	Sample Size	Population	Male and Female		Male		Female	
			Median	Mean	Median	Mean	Median	Mean
2–6 months	1,020	1,732,702	7.4	7.4	7.6	7.7	7.0	7.0
7–12 months	1,072	1,925,573	9.4	9.4	9.7	9.7	9.1	9.1
1 year	1,258	3,935,114	11.3	11.4	11.7	11.7	10.9	11.0
2 years	1,513	4,459,167	13.2	12.9	13.5	13.1	13.0	12.5
3 years	1,309	4,317,234	15.3	15.1	15.5	15.2	15.1	14.9
4 years	1,284	4,008,079	17.2	17.1	17.2	17.0	17.3	17.2
5 years	1,234	4,298,097	19.6	19.4	19.7	19.3	19.6	19.4
6 years	750	3,942,457	21.3	21.7	21.5	22.1	20.9	21.3
7 years	736	4,064,397	25.0	25.5	25.4	25.5	24.1	25.6
8 years	711	3,863,515	27.4	28.1	27.2	28.4	27.9	27.9
9 years	770	4,385,199	31.8	32.7	32.0	32.3	31.1	33.0
10 years	751	3,991,345	35.2	35.6	35.9	36.0	34.3	35.2
11 years	754	4,270,211	40.6	41.5	38.8	40.0	43.4	42.8
12 years	431	3,497,661	47.2	46.9	48.1	49.1	45.7	48.6
13 years	428	3,567,181	53.0	55.1	52.6	54.5	53.7	55.9
14 years	415	4,054,117	56.9	61.1	61.3	64.5	53.7	57.9
15 years	378	3,269,777	59.6	62.8	62.6	66.9	57.1	59.2
16 years	427	3,652,041	63.2	65.8	66.6	69.4	56.3	61.6
17 years	410	3,719,690	65.1	67.5	70.0	72.4	60.7	62.2
1 and older	31,311	251,097,002	66.5	64.5	73.9	89.0	80.8	80.3
1–3 years	4,080	12,711,515	13.2	13.1	13.4	13.4	13.0	12.9
1–14 years	12,344	56,653,796	24.9	29.9	25.1	30.0	24.7	29.7
15–44 years	10,393	118,430,653	70.8	73.5	77.5	80.2	63.2	67.3

Source: U.S. EPA, 2000

Table 11-7. Body weight estimates by age, U.S. population 1988–1994[a]

Age	Sample Size	Population	Male and Female		
			Median	Mean	95% CI
2 months	243	408,837	6.3	6.3	6.1–6.4
3 months	190	332,823	7.0	6.9	6.7–7.1
3 months and older	433	741,660	6.6	6.6	6.4–6.7

[a] Data not available for infants younger than 2 months.

Source: U.S. EPA, 2000

Table 11-8. Summary of recommended values for body weight

Population	Mean	Upper Percentile	Multiple Percentiles
Children	See Tables 11-6 and 11-7	See Tables 11-2 and 11-3	See Tables 11-2 and 11-3
Infants	See Tables 11-6 and 11-7	See Table 11-7	See Table 11-1

Table 11-9. Confidence in body weight recommendations

Considerations	Rationale	Rating
Study Elements		
Level of peer review	NHANES III was the major source for central tendency values. This analysis has not yet been published. Percentile data are based on NHANES II and published by the National Center for Health Statistics (1987) and Hamill et al. (1979). Both of these studies received a high level of peer review.	Low for central tendency; high for percentiles
Accessibility	The National Center for Health Statistics (1987) study and Hamill et al. (1979) are available to the public. U.S. EPA (2000) is available upon request.	High
Reproducibility	Results can be reproduced by analyzing NHANES II data, NHANES III data, and the Fels Research Institute data.	High
Focus on factor of interest	The studies focused on body weight, the exposure factor of interest.	High
Data pertinent to U.S.	The data represent the U.S. population.	High
Primary data	The primary data were generated from NHANES II and III data and Fels studies; thus these data are secondary.	Medium
Currency	The data were collected between 1976 and 1980 for Hamill et al. (1979) and NHANES II. U.S. EPA (2000) covered the years 1988–1994.	High for central tendency; medium for percentiles
Adequacy of data collection period	The NHANES II study included data collected over a period of 4 years. Body weight measurements were taken at various times of the day and at different seasons of the year. NHANES III study included data collected over a 7-year period.	High
Validity of approach	Direct body weights were measured for both studies. For NHANES II, subgroups at risk for malnutrition were oversampled. Weighting was accomplished by inflating examination results for those not examined and were stratified by race, age, and sex. The Fels data are from an ongoing longitudinal study where the data are collected regularly.	High
Study size	The sample size consisted of 28,000 persons for NHANES II. Hamill et al. (1979) noted that the data set was large. NHANES III study included 12,344 children 1–14 years of age.	High
Representativeness of the population	Data collected focused on the U.S. population for both studies.	High
Characterization of variability	All studies characterized variability regarding age and sex. Additionally, NHANES II characterized race (for Blacks, Whites and total populations) and sampled persons with low income.	High
Lack of bias in study design (high rating is desirable)	There are no apparent biases in the study designs for NHANES II. The study design for collecting the Fels data was not provided.	Medium-high
Measurement error	For NHANES II and III, measurement error should be low because 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. Hamill et al. (1979) reported that study data are based on accurate direct measurements from an ongoing longitudinal study.	High
Other Elements		
Number of studies	There are three studies.	High
Agreement between researchers	There is consistency among the two studies.	High
Overall Rating		**High**

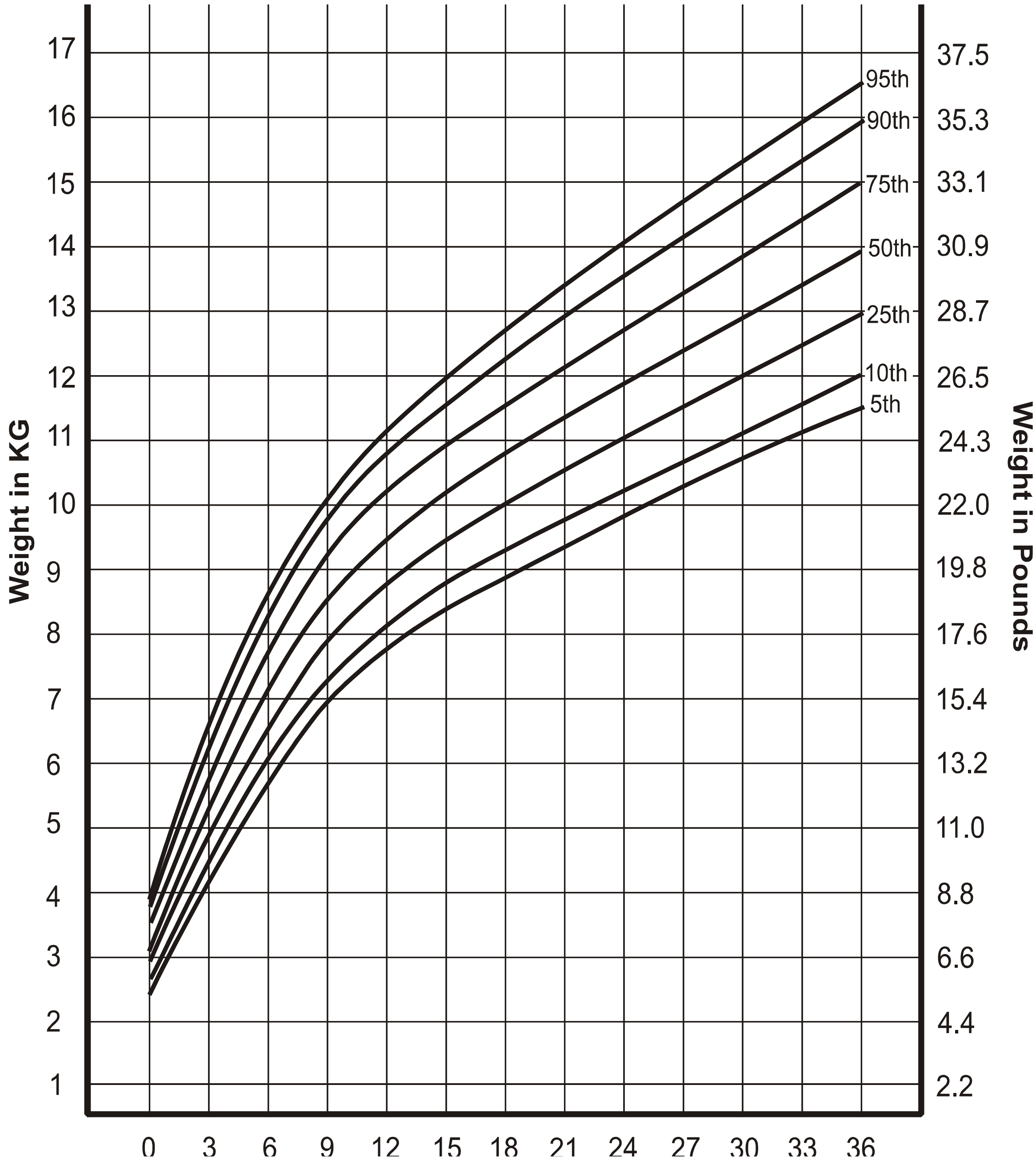

Figure 11-1. Weight by age percentiles for girls ages birth to 36 months.

Source: Hamill et al., 1979

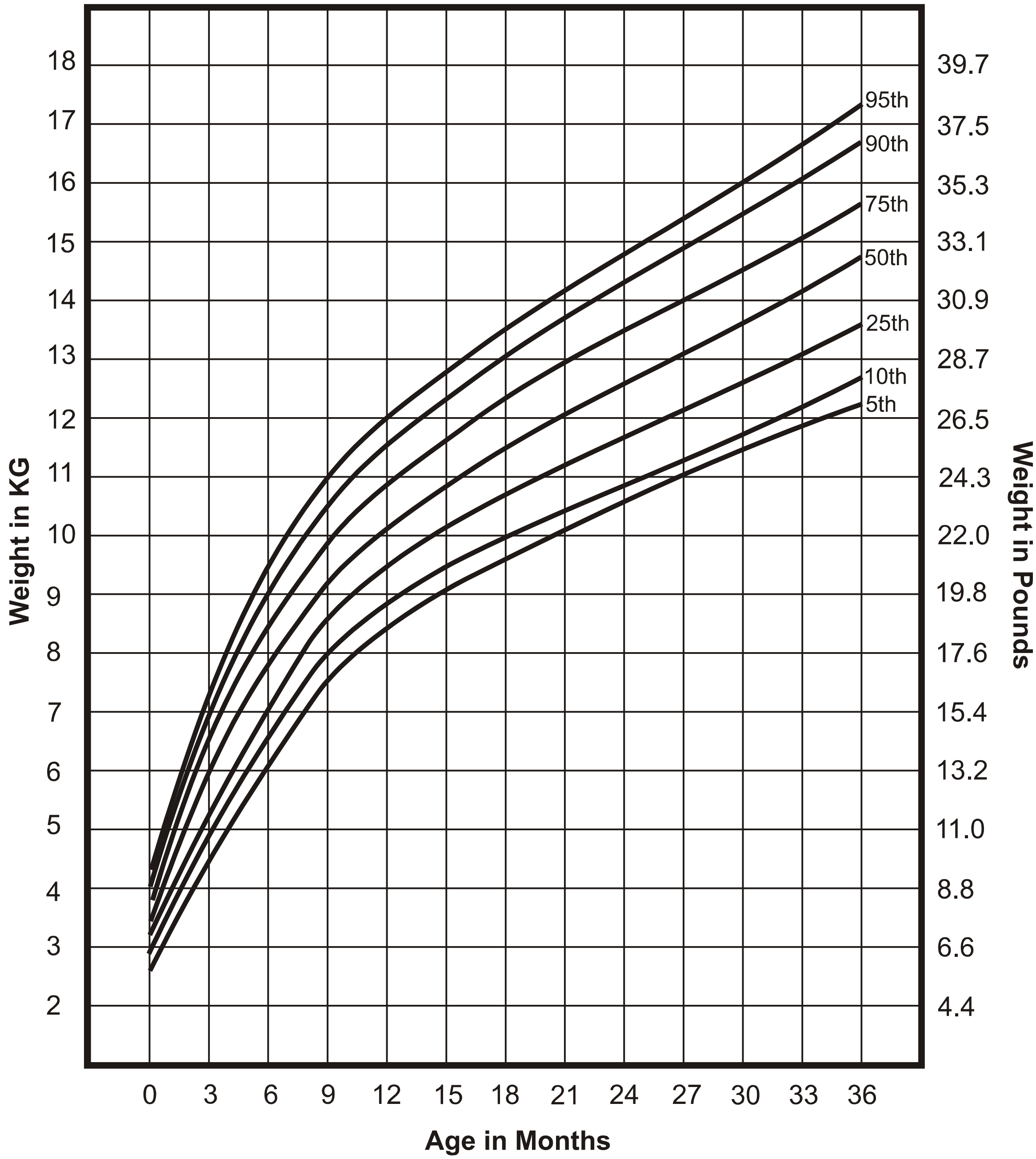

Figure 11-2. Weight by age percentiles for boys ages birth to 36 months.

Source: Hamill et al., 1979

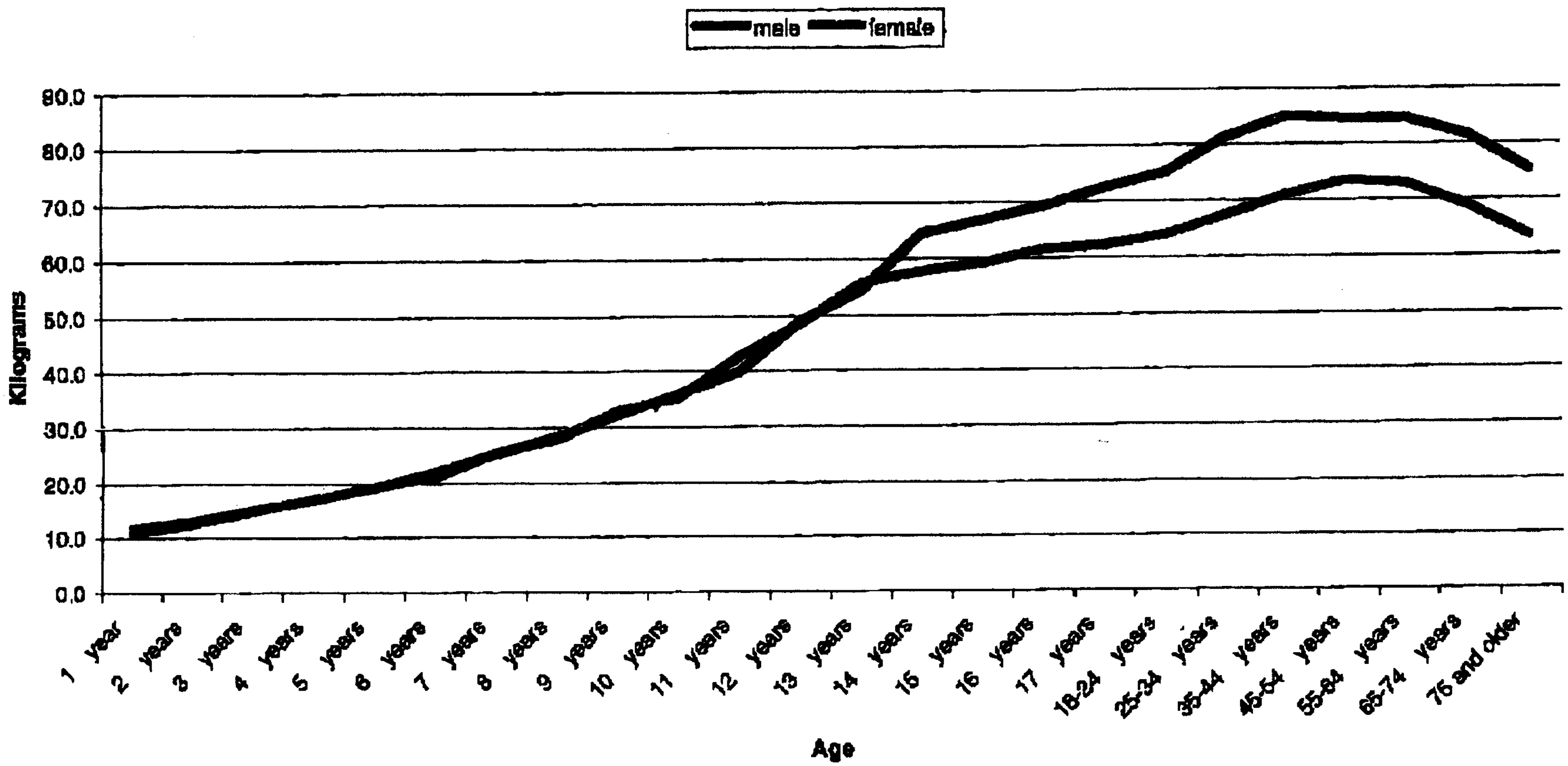

Figure 11-3. Mean body weights estimates, U.S. population, 1988–1994.

Source: U.S. EPA, 2000

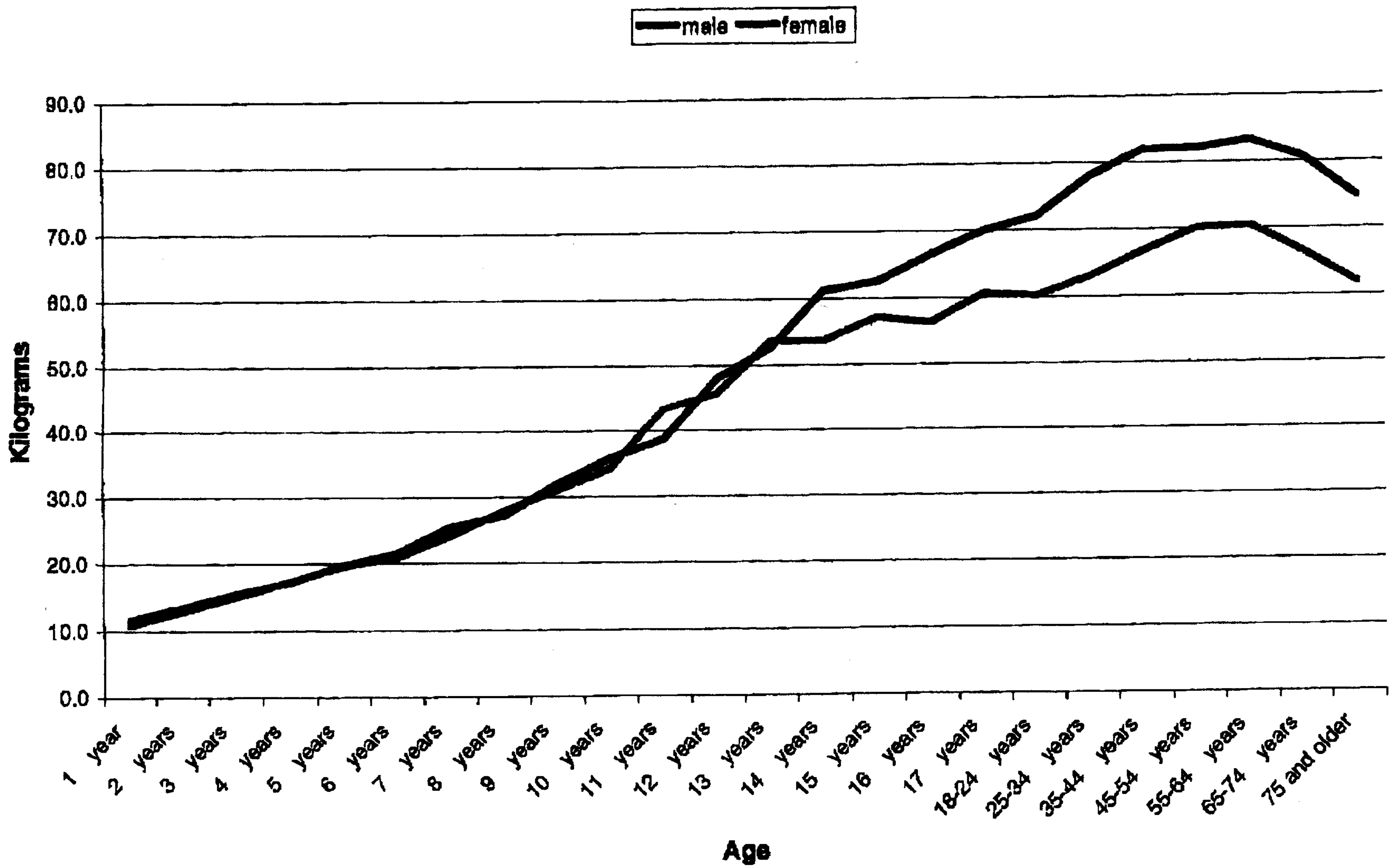

Figure 11-4. Median body weights estimates, U.S. population, 1988–1994.

Source: U.S. EPA, 2000

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12. LIFETIME

12.1. INTRODUCTION

The length of a typical life is potentially a factor to consider when evaluating cancer risk, because the standard approach for carcinogens has been to calculate the dose estimate averaged over a “typical” lifetime of 70 years.

Because this typical life span value is found in the denominator of the dose equation for cancer, adjusting this value to a shorter typical lifetime could result in a higher estimate of lifetime average daily dose if assessing an exposure that is fixed (i.e., not a situation of a constant lifetimes such that changing the expected lifespan would similarly change both the numerator and denominator and therefore would have no net effect), and conversely, adjusting this value to a longer life expectancy when assessing an exposure with a fixed duration could produce a lower lifetime average daily dose estimate. If the same estimates of lifetime risk per average lifetime dose are then used, the result would be counterintuitive, given that the longer a person lives, the higher his/her chances could be of developing a chronic disease, or a disease that often has long latency period, such as cancer.

Children have more years of future life than do adults. Therefore, they have more time to develop any chronic diseases that might be triggered by early environmental exposures. Diseases initiated by chemical hazards require several decades to develop, and early childhood exposure to certain carcinogens or toxicants is more likely to lead to disease than the same exposures later in life (NRDC, 1997). In addition, recent data published by the U.S. Census Bureau indicate that overall life expectancy in the U.S. has increased. For example, the projected life expectancy for children born in 2000 is almost 4% longer than that of children born in 1980.

12.2. RECOMMENDATIONS

Although it is standard practice to calculate lifetime average daily doses for carcinogens using a standard assumption of a 70-year lifespan, a different approach may be appropriate when considering effects of childhood exposures if children are more sensitive than adults. Specifically, it may not be appropriate to average childhood exposures over a full lifetime, because this implies that childhood exposure is equivalent to full-life exposure at a lower rate (U.S. EPA, 1999).

Recent data show that the U.S. human population lives longer than 70 years. However, because there are some issues that need to be addressed regarding methodology for estimating environmental exposures and risks to children, EPA is not ready to suggest a change in the current default value of 70 years life expectancy when calculating the lifetime average daily dose. Issues regarding estimation of cancer risks to children are under discussion in the revisions to the Cancer Guidelines. In addition, issues related to life expectancy and less-than-lifetime exposures have been recognized by the RfD Technical Panel, the Harmonization Technical Panel of the Risk Assessment Forum. Guidance on these issues will be developed in the future.

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