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**EXPOSURE FACTORS HANDBOOK:
2011 EDITION**

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

DISCLAIMER

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FOREWORD

The U.S. Environmental Protection Agency (U.S. EPA), Office of Research and Development (ORD), National Center for Environmental Assessment's (NCEA) mission is to provide guidance and risk assessments aimed at protecting human health and the environment. To accomplish this mission, NCEA works to develop and improve the models, databases, tools, assumptions, and extrapolations used in risk assessments. NCEA established the Exposure Factors Program to develop tools and databases that improve the scientific basis of exposure and risk assessment by (1) identifying exposure factors needs in consultation with clients, and exploring ways for filling data gaps; (2) compiling existing data on exposure factors needed for assessing exposures/risks; and (3) assisting clients in the use of exposure factors data. The *Exposure Factors Handbook* and the *Child-Specific Exposure Factors Handbook*, as well as other companion documents such as *Example Exposure Scenarios*, are products of the Exposure Factors Program.

The *Exposure Factors Handbook* provides information on various physiological and behavioral factors commonly used in assessing exposure to environmental chemicals. The handbook was first published in 1989 and was updated in 1997. Since then, new data have become available. This updated edition incorporates data available since 1997 up to July 2011. It also reflects the revisions made to the *Child-Specific Exposure Factors Handbook*, which was updated and published in 2008. This edition of the handbook supersedes the information presented in the 2008 *Child-Specific Exposure Factors Handbook*. Each chapter in the 2011 edition of the *Exposure Factors Handbook* presents recommended values for the exposure factors covered in the chapter as well as a discussion of the underlying data used in developing the recommendations. These recommended values are based solely on NCEA's interpretations of the available data. In many situations, different values may be appropriate to use in consideration of policy, precedent, or other factors.

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The U.S. EPA Office of Water and Office of Pesticide Programs made important contributions by conducting an analysis of the U.S. Department of Agriculture (USDA) Continuing Survey of Food Intakes by Individual (CSFII) data in previous versions of the handbook. More recently, the Office of Pesticide Programs conducted an analysis of the National Health and Nutrition Examination Survey (NHANES) 2003–2006 to update the Food Commodity Intake Database (FCID) and food consumption chapters of this edition of the handbook.

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EXECUTIVE SUMMARY

Some of the steps for performing an exposure assessment are (1) identifying the source of the environmental contamination and the media that transports the contaminant; (2) determining the contaminant concentration; (3) determining the exposure scenarios, and pathways and routes of exposure; (4) determining the exposure factors related to human behaviors that define time, frequency, and duration of exposure; and (5) identifying the exposed population. Exposure factors are factors related to human behavior and characteristics that help determine an individual's exposure to an agent. This *Exposure Factors Handbook* has been prepared to provide information and recommendations on various factors used in assessing exposure to both adults and children. The purpose of the *Exposure Factors Handbook* is to (1) summarize data on human behaviors and characteristics that affect exposure to environmental contaminants, and (2) recommend values to use for these factors. This handbook provides nonchemical-specific data on the following exposure factors:

- Ingestion of water and other selected liquids (see Chapter 3),
- Non-dietary ingestion factors (see Chapter 4),
- Ingestion of soil and dust (see Chapter 5),
- Inhalation rates (see Chapter 6),
- Dermal factors (see Chapter 7),
- Body weight (see Chapter 8),
- Intake of fruits and vegetables (see Chapter 9),
- Intake of fish and shellfish (see Chapter 10),
- Intake of meat, dairy products, and fats (see Chapter 11),
- Intake of grain products (see Chapter 12),
- Intake of home-produced food (see Chapter 13),
- Total food intake (see Chapter 14),
- Human milk intake (see Chapter 15),
- Activity factors (see Chapter 16),
- Consumer products (see Chapter 17),
- Lifetime (see Chapter 18), and
- Building characteristics (see Chapter 19).

The handbook was first published in 1989 and was revised in 1997 (U.S. EPA, 1989, 1997). Recognizing that exposures among infants, toddlers, adolescents, and teenagers can vary significantly, the U.S. EPA published the *Child-Specific Exposure Factors Handbook* in 2002 (U.S. EPA, 2002) and its revision in 2008 (U.S. EPA, 2008). The 2008 revision of the *Child-Specific Exposure Factors Handbook* as well as this 2011 edition of the

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Exposure Factors Handbook reflect the age categories recommended in the U.S. EPA *Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants* (U.S. EPA, 2005). This 2011 edition of the *Exposure Factors Handbook* also incorporates new factors and data provided in the 2008 *Child-Specific Exposure Factors Handbook* (and other relevant information published through July 2011). The information presented in this 2011 edition of the *Exposure Factors Handbook* supersedes the 2008 *Child-Specific Exposure Factors Handbook*.

The data presented in this handbook have been compiled from various sources, including government reports and information presented in the scientific literature. The data presented are the result of analyses by the individual study authors. However, in some cases, the U.S. EPA conducted additional analysis of published primary data to present results in a way that will be useful to exposure assessors and/or in a manner that is consistent with the recommended age groups. Studies presented in this handbook were chosen because they were seen as useful and appropriate for estimating exposure factors based on the following considerations: (1) soundness (adequacy of approach and minimal or defined bias); (2) applicability and utility (focus on the exposure factor of interest, representativeness of the population, currency of the information, and adequacy of the data collection period); (3) clarity and completeness (accessibility, reproducibility, and quality assurance); (4) variability and uncertainty (variability in the population and uncertainty in the results); and (5) evaluation and review (level of peer review and number and agreement of studies). Generally, studies were designated as “key” or “relevant” studies. Key studies were considered the most up-to-date and scientifically sound for deriving recommendations; while relevant studies provided applicable or pertinent data, but not necessarily the most important for a variety of reasons (e.g., data were outdated, limitations in study design). The recommended values for exposure factors are based on the results of key studies. The U.S. EPA also assigned confidence ratings of *low*, *medium*, or *high* to each recommended value based on the evaluation elements described above. These ratings are not intended to represent uncertainty analyses; rather, they represent the U.S. EPA’s judgment on the quality of the underlying data used to derive the recommendations.

Key recommendations from the handbook are summarized in Table ES-1. Additional recommendations and detailed supporting information for these recommendations can be found in the individual chapters of this handbook. In providing recommendations for the various exposure factors, an attempt was made to present percentile values that are consistent with the exposure estimators defined in the *Guidelines for Exposure Assessment* (U.S. EPA, 1992) (i.e., mean and upper percentile). However, this was not always possible because the data available were limited for some factors, or the authors of the study did not provide such information. As used throughout this handbook, the term “upper percentile” is intended to represent values in the upper tail (i.e., between 90th and 99.9th percentile) of the distribution of values for a particular exposure factor. The 95th percentile was used throughout the handbook to represent the upper tail because it is the middle of the range between 90th and 99th percentile. Other percentiles are presented, where available, in the tables at the end of each chapter. It should be noted that users of the handbook may use the exposure metric that is most appropriate for their particular situation.

The recommendations provided in this handbook are not legally binding on any U.S. EPA program and should be interpreted as suggestions that program offices or individual exposure/risk assessors can consider and modify as needed based on their own evaluation of a given risk assessment situation. In certain cases, different

values may be appropriate in consideration of policy, precedent, strategy, or other factors (e.g., more up-to-date data of better quality or more representative of the population of concern).

REFERENCES FOR THE EXECUTIVE SUMMARY

- NCHS (National Center for Health Statistics). (1993) Joint policy on variance estimation and statistical reporting standards on NHANES III and CSFII reports: HNIS/NCHS Analytic Working Group recommendations. In: Analytic and reporting guidelines: the third National Health and Nutrition Examination Survey, NHANES III (1988-94). Centers for Disease Control and Prevention, Hyattsville, MD, pp. 39-45. Available online at <http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf>.
- U.S. EPA (Environmental Protection Agency). (1989) Exposure factors handbook. Exposure Assessment Group, Office of Research and Development, Washington, DC; EPA/600/8-89/043. Available online at http://rais.ornl.gov/documents/EFH_1989_EPA600889043.pdf.
- U.S. EPA (Environmental Protection Agency). (1992) Guidelines for exposure assessment. Risk Assessment Forum, Washington, DC; EPA/600/Z-92/001. Available online at <http://cfpub.epa.gov/ncea/cfm/cfm?deid=15263>.
- U.S. EPA (Environmental Protection Agency). (1997) Exposure factors handbook. Office of Research and Development, Washington, DC; EPA/600/P-95/002Fa,b,c. Available online at <http://www.epa.gov/ncea/pdfs/efh/efh-complete.pdf>.
- U.S. EPA (Environmental Protection Agency). (2002) Child-specific exposure factors handbook. Interim final. National Center for Environmental Assessment, Washington, DC; EPA/P-00/002B. Available online at <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=55145>.
- U.S. EPA (Environmental Protection Agency). (2005) Guidance on selecting age groups for monitoring and assessing childhood exposures to environmental contaminants. Risk Assessment Forum, Washington, DC; EPA/630/P-03/003F. Available online at <http://www.epa.gov/raf/publications/pdfs/AGEGROUPS.PDF>.
- U.S. EPA (Environmental Protection Agency) (2008) Child-specific exposure factors handbook. National Center for Environmental Assessment Washington, DC; EPA/600/R-06/096F. Available online at <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=199243>.

Table ES-1. Summary of Exposure Factor Recommendations

| Chapter 3 | PER CAPITA INGESTION OF DRINKING WATER | | | | | | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|-----------------------------|-----------------------------------------|-----------------------------|--------------------|-----------------------------|-----------------------------------------|-----------------------------|
| | CONSUMERS-ONLY INGESTION OF DRINKING WATER | | | | | | | |
| | Mean | | 95 th Percentile | | Mean | | 95 th Percentile | |
| | mL/day | mL/kg-day | mL/day | mL/kg-day | mL/day | mL/kg-day | mL/day | mL/kg-day |
| <u>Children</u> | | | | | | | | |
| Birth to 1 month | 184 | 52 | 839 ^a | 232 ^a | 470 ^a | 137 ^a | 858 ^a | 238 ^a |
| 1 to <3 months | 227 ^a | 48 | 896 ^a | 205 ^a | 552 | 119 | 1,053 ^a | 285 ^a |
| 3 to <6 months | 362 ^a | 52 | 1,056 | 159 | 556 | 80 | 1,171 ^a | 173 ^a |
| 6 to <12 months | 360 | 41 | 1,055 | 126 | 467 | 53 | 1,147 | 129 |
| 1 to <2 years | 271 | 23 | 837 | 71 | 308 | 27 | 893 | 75 |
| 2 to <3 years | 317 | 23 | 877 | 60 | 356 | 26 | 912 | 62 |
| 3 to <6 years | 327 | 18 | 959 | 51 | 382 | 21 | 999 | 52 |
| 6 to <11 years | 414 | 14 | 1,316 | 43 | 511 | 17 | 1,404 | 47 |
| 11 to <16 years | 520 | 10 | 1,821 | 32 | 637 | 12 | 1,976 | 35 |
| 16 to <18 years | 573 | 9 | 1,783 | 28 | 702 | 10 | 1,883 | 30 |
| 18 to <21 years | 681 | 9 | 2,368 | 35 | 816 | 11 | 2,818 | 36 |
| <u>Adults</u> | | | | | | | | |
| >21 years | 1,043 | 13 | 2,958 | 40 | 1,227 | 16 | 3,092 | 42 |
| >65 years | 1,046 | 14 | 2,730 | 40 | 1,288 | 18 | 2,960 | 43 |
| <u>Pregnant women</u> | 819 ^a | 13 ^a | 2,503 ^a | 43 ^a | 872 ^a | 14 ^a | 2,589 ^a | 43 ^a |
| <u>Lactating women</u> | 1,379 ^a | 21 ^a | 3,434 ^a | 55 ^a | 1,665 ^a | 26 ^a | 3,588 ^a | 55 ^a |
| ^a Estimates are less statistically reliable based on guidance published in the <i>Joint Policy on Variance Estimation and Statistical Reporting Standards on NHANES III and CSFII Reports: NHIS/NCHS Analytical Working Group Recommendations</i> (NCHS, 1993). | | | | | | | | |
| Chapter 3 | INGESTION OF WATER WHILE SWIMMING | | | | | | | |
| | Mean | | | | Upper Percentile | | | |
| | mL/event ^a | | mL/hour | | mL/event | | mL/hour | |
| Children | 37 | | 49 | | 90 ^b | | 120 ^b | |
| Adults | 16 | | 21 | | 53 ^c | | 71 ^c | |
| ^a Participants swam for 45 minutes. | | | | | | | | |
| ^b 97 th percentile | | | | | | | | |
| ^c Based on maximum value. | | | | | | | | |
| Chapter 4 | MOUTHING FREQUENCY AND DURATION | | | | | | | |
| | Hand-to-Mouth | | | | Object-to-Mouth | | | |
| | Indoor Frequency | | Outdoor Frequency | | Indoor Frequency | | Outdoor Frequency | |
| | Mean | 95 th Percentile | Mean | 95 th Percentile | Mean | 95 th Percentile | Mean | 95 th Percentile |
| | contacts/hour | contacts/hour | contacts/hour | contacts/hour | contacts/hour | contacts/hour | contacts/hour | contacts/hour |
| Birth to 1 month | - | - | - | - | - | - | - | - |
| 1 to <3 months | - | - | - | - | - | - | - | - |
| 3 to <6 months | 28 | 65 | - | - | 11 | 32 | - | - |
| 6 to <12 months | 19 | 52 | 15 | 47 | 20 | 38 | - | - |
| 1 to <2 years | 20 | 63 | 14 | 42 | 14 | 34 | 8.8 | 21 |
| 2 to <3 years | 13 | 37 | 5 | 20 | 9.9 | 24 | 8.1 | 40 |
| 3 to <6 years | 15 | 54 | 9 | 36 | 10 | 39 | 8.3 | 30 |
| 6 to <11 years | 7 | 21 | 3 | 12 | 1.1 | 3.2 | 1.9 | 9.1 |
| 11 to <16 years | - | - | - | - | - | - | - | - |
| 16 to <21 years | - | - | - | - | - | - | - | - |
| | Object-to-Mouth | | | | | | | |
| | Duration | | | | | | | |
| | Mean minute/hour | | 95 th Percentile minute/hour | | Mean minute/hour | | 95 th Percentile minute/hour | |
| Birth to 1 month | - | | - | | - | | - | |
| 1 to <3 months | - | | - | | - | | - | |
| 3 to <6 months | 11 | | 26 | | - | | - | |
| 6 to <12 months | 9 | | 19 | | - | | - | |
| 1 to <2 years | 7 | | 22 | | - | | - | |
| 2 to <3 years | 10 | | 11 | | - | | - | |
| 3 to <6 years | - | | - | | - | | - | |
| 6 to <11 years | - | | - | | - | | - | |
| 11 to <16 years | - | | - | | - | | - | |
| 16 to <21 years | - | | - | | - | | - | |
| - No data. | | | | | | | | |

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Table ES-1. Summary of Exposure Factor Recommendations (continued)

| Chapter 5 SOIL AND DUST INGESTION | | | | | | | | | | |
|------------------------------------------------|--------------------------------------------|--------------------------------------------|-----------------------------|-----------------------------------------|-------------------------------------------------|--------------------------------------------|--------------------------------------------|--------------------------------------------|-----------------------------|-----------------------------------------|
| | Soil | | | | Dust | | Soil + Dust | | | |
| | General Population Central Tendency mg/day | High End | | | Central Tendency mg/day | General Population Upper Percentile mg/day | General Population Central Tendency mg/day | General Population Upper Percentile mg/day | | |
| | | General Population Upper Percentile mg/day | Soil-Pica mg/day | Geophagy mg/day | | | | | | |
| 6 weeks to <1 year | 30 | - | - | - | 30 | - | 60 | - | | |
| 1 to <6 years | 50 | - | 1,000 | 50,000 | 60 | - | 100 | - | | |
| 3 to <6 years | - | 200 | - | - | - | 100 | - | 200 | | |
| 6 to <21 years | 50 | - | 1,000 | 50,000 | 60 | - | 100 | - | | |
| Adult | 20 | - | - | 50,000 | 30 | - | 50 | - | | |
| - No data. | | | | | | | | | | |
| Chapter 6 INHALATION | | | | | | | | | | |
| Long-Term Inhalation Rates | | | | | | | | | | |
| | Mean m ³ /day | | | | 95 th Percentile m ³ /day | | | | | |
| Birth to 1 month | 3.6 | | | | 7.1 | | | | | |
| 1 to <3 months | 3.5 | | | | 5.8 | | | | | |
| 3 to <6 months | 4.1 | | | | 6.1 | | | | | |
| 6 to <12 months | 5.4 | | | | 8.0 | | | | | |
| 1 to <2 years | 5.4 | | | | 9.2 | | | | | |
| Birth to <1 year | 8.0 | | | | 12.8 | | | | | |
| 2 to <3 years | 8.9 | | | | 13.7 | | | | | |
| 3 to <6 years | 10.1 | | | | 13.8 | | | | | |
| 6 to <11 years | 12.0 | | | | 16.6 | | | | | |
| 11 to <16 years | 15.2 | | | | 21.9 | | | | | |
| 16 to <21 years | 16.3 | | | | 24.6 | | | | | |
| 21 to <31 years | 15.7 | | | | 21.3 | | | | | |
| 31 to <41 years | 16.0 | | | | 21.4 | | | | | |
| 41 to <51 years | 16.0 | | | | 21.2 | | | | | |
| 51 to <61 years | 15.7 | | | | 21.3 | | | | | |
| 61 to <71 years | 14.2 | | | | 18.1 | | | | | |
| 71 to <81 years | 12.9 | | | | 16.6 | | | | | |
| ≥81 years | 12.2 | | | | 15.7 | | | | | |
| Short-Term Inhalation Rates, by Activity Level | | | | | | | | | | |
| | Sleep or Nap | | Sedentary/Passive | | Light Intensity | | Moderate Intensity | | High Intensity | |
| | Mean m ³ /minute | 95 th m ³ /minute | Mean m ³ /minute | 95 th m ³ /minute | Mean m ³ /minute | 95 th m ³ /minute | Mean m ³ /minute | 95 th m ³ /minute | Mean m ³ /minute | 95 th m ³ /minute |
| | minute | minute | minute | minute | minute | minute | minute | minute | minute | minute |
| Birth to <1 year | 3.0E-03 | 4.6E-03 | 3.1E-03 | 4.7E-03 | 7.6E-03 | 1.1E-02 | 1.4E-02 | 2.2E-02 | 2.6E-02 | 4.1E-02 |
| 1 to <2 years | 4.5E-03 | 6.4E-03 | 4.7E-03 | 6.5E-03 | 1.2E-02 | 1.6E-02 | 2.1E-02 | 2.9E-02 | 3.8E-02 | 5.2E-02 |
| 2 to <3 years | 4.6E-03 | 6.4E-03 | 4.8E-03 | 6.5E-03 | 1.2E-02 | 1.6E-02 | 2.1E-02 | 2.9E-02 | 3.9E-02 | 5.3E-02 |
| 3 to <6 years | 4.3E-03 | 5.8E-03 | 4.5E-03 | 5.8E-03 | 1.1E-02 | 1.4E-02 | 2.1E-02 | 2.7E-02 | 3.7E-02 | 4.8E-02 |
| 6 to <11 years | 4.5E-03 | 6.3E-03 | 4.8E-03 | 6.4E-03 | 1.1E-02 | 1.5E-02 | 2.2E-02 | 2.9E-02 | 4.2E-02 | 5.9E-02 |
| 11 to <16 years | 5.0E-03 | 7.4E-03 | 5.4E-03 | 7.5E-03 | 1.3E-02 | 1.7E-02 | 2.5E-02 | 3.4E-02 | 4.9E-02 | 7.0E-02 |
| 16 to <21 years | 4.9E-03 | 7.1E-03 | 5.3E-03 | 7.2E-03 | 1.2E-02 | 1.6E-02 | 2.6E-02 | 3.7E-02 | 4.9E-02 | 7.3E-02 |
| 21 to <31 years | 4.3E-03 | 6.5E-03 | 4.2E-03 | 6.5E-03 | 1.2E-02 | 1.6E-02 | 2.6E-02 | 3.8E-02 | 5.0E-02 | 7.6E-02 |
| 31 to <41 years | 4.6E-03 | 6.6E-03 | 4.3E-03 | 6.6E-03 | 1.2E-02 | 1.6E-02 | 2.7E-02 | 3.7E-02 | 4.9E-02 | 7.2E-02 |
| 41 to <51 years | 5.0E-03 | 7.1E-03 | 4.8E-03 | 7.0E-03 | 1.3E-02 | 1.6E-02 | 2.8E-02 | 3.9E-02 | 5.2E-02 | 7.6E-02 |
| 51 to <61 years | 5.2E-03 | 7.5E-03 | 5.0E-03 | 7.3E-03 | 1.3E-02 | 1.7E-02 | 2.9E-02 | 4.0E-02 | 5.3E-02 | 7.8E-02 |
| 61 to <71 years | 5.2E-03 | 7.2E-03 | 4.9E-03 | 7.3E-03 | 1.2E-02 | 1.6E-02 | 2.6E-02 | 3.4E-02 | 4.7E-02 | 6.6E-02 |
| 71 to <81 years | 5.3E-03 | 7.2E-03 | 5.0E-03 | 7.2E-03 | 1.2E-02 | 1.5E-02 | 2.5E-02 | 3.2E-02 | 4.7E-02 | 6.5E-02 |
| ≥81 years | 5.2E-03 | 7.0E-03 | 4.9E-03 | 7.0E-03 | 1.2E-02 | 1.5E-02 | 2.5E-02 | 3.1E-02 | 4.8E-02 | 6.8E-02 |

Table ES-1. Summary of Exposure Factor Recommendations (continued)

| Chapter 7 SURFACE AREA | | | | | | | | | | | | |
|-------------------------------------------|------------------------|------------------------------------|------------------------|------------------------------------|------------------------|------------------------------------|-----------------------------------------------|------------------------------------|------------------------|------------------------------------|------------------------|------------------------------------|
| Total Surface Area | | | | | | | | | | | | |
| | Mean m ² | | | | | | 95 th Percentile m ² | | | | | |
| Birth to 1 month | 0.29 | | | | | | 0.34 | | | | | |
| 1 to <3 months | 0.33 | | | | | | 0.38 | | | | | |
| 3 to <6 months | 0.38 | | | | | | 0.44 | | | | | |
| 6 to <12 months | 0.45 | | | | | | 0.51 | | | | | |
| 1 to <2 years | 0.53 | | | | | | 0.61 | | | | | |
| 2 to <3 years | 0.61 | | | | | | 0.70 | | | | | |
| 3 to <6 years | 0.76 | | | | | | 0.95 | | | | | |
| 6 to <11 years | 1.08 | | | | | | 1.48 | | | | | |
| 11 to <16 years | 1.59 | | | | | | 2.06 | | | | | |
| 16 to <21 years | 1.84 | | | | | | 2.33 | | | | | |
| Adult Males | | | | | | | | | | | | |
| 21 to <30 years | 2.05 | | | | | | 2.52 | | | | | |
| 30 to <40 years | 2.10 | | | | | | 2.50 | | | | | |
| 40 to <50 years | 2.15 | | | | | | 2.56 | | | | | |
| 50 to <60 years | 2.11 | | | | | | 2.55 | | | | | |
| 60 to <70 years | 2.08 | | | | | | 2.46 | | | | | |
| 70 to <80 years | 2.05 | | | | | | 2.45 | | | | | |
| ≥80 years | 1.92 | | | | | | 2.22 | | | | | |
| Adult Females | | | | | | | | | | | | |
| 21 to <30 years | 1.81 | | | | | | 2.25 | | | | | |
| 30 to <40 years | 1.85 | | | | | | 2.31 | | | | | |
| 40 to <50 years | 1.88 | | | | | | 2.36 | | | | | |
| 50 to <60 years | 1.89 | | | | | | 2.38 | | | | | |
| 60 to <70 years | 1.88 | | | | | | 2.34 | | | | | |
| 70 to <80 years | 1.77 | | | | | | 2.13 | | | | | |
| ≥80 years | 1.69 | | | | | | 1.98 | | | | | |
| Percent Surface Area of Body Parts | | | | | | | | | | | | |
| | Head | | Trunk | | Arms | | Hands | | Legs | | Feet | |
| Mean Percent of Total Surface Area | | | | | | | | | | | | |
| Birth to 1 month | 18.2 | | 35.7 | | 13.7 | | 5.3 | | 20.6 | | 6.5 | |
| 1 to <3 months | 18.2 | | 35.7 | | 13.7 | | 5.3 | | 20.6 | | 6.5 | |
| 3 to <6 months | 18.2 | | 35.7 | | 13.7 | | 5.3 | | 20.6 | | 6.5 | |
| 6 to <12 months | 18.2 | | 35.7 | | 13.7 | | 5.3 | | 20.6 | | 6.5 | |
| 1 to <2 years | 16.5 | | 35.5 | | 13.0 | | 5.7 | | 23.1 | | 6.3 | |
| 2 to <3 years | 8.4 | | 41.0 | | 14.4 | | 4.7 | | 25.3 | | 6.3 | |
| 3 to <6 years | 8.0 | | 41.2 | | 14.0 | | 4.9 | | 25.7 | | 6.4 | |
| 6 to <11 years | 6.1 | | 39.6 | | 14.0 | | 4.7 | | 28.8 | | 6.8 | |
| 11 to <16 years | 4.6 | | 39.6 | | 14.3 | | 4.5 | | 30.4 | | 6.6 | |
| 16 to <21 years | 4.1 | | 41.2 | | 14.6 | | 4.5 | | 29.5 | | 6.1 | |
| Adult Males ≥21 | 6.6 | | 40.1 | | 15.2 | | 5.2 | | 33.1 | | 6.7 | |
| Adult Females ≥21 | 6.2 | | 35.4 | | 12.8 | | 4.8 | | 32.3 | | 6.6 | |
| Surface Area of Body Parts | | | | | | | | | | | | |
| | Head | | Trunk | | Arms | | Hands | | Legs | | Feet | |
| | Mean m ² | 95 th m ² | Mean m ² | 95 th m ² | Mean m ² | 95 th m ² | Mean m ² | 95 th m ² | Mean m ² | 95 th m ² | Mean m ² | 95 th m ² |
| Birth to 1 month | 0.053 | 0.062 | 0.104 | 0.121 | 0.040 | 0.047 | 0.015 | 0.018 | 0.060 | 0.070 | 0.019 | 0.022 |
| 1 to <3 months | 0.060 | 0.069 | 0.118 | 0.136 | 0.045 | 0.052 | 0.017 | 0.020 | 0.068 | 0.078 | 0.021 | 0.025 |
| 3 to <6 months | 0.069 | 0.080 | 0.136 | 0.157 | 0.052 | 0.060 | 0.020 | 0.023 | 0.078 | 0.091 | 0.025 | 0.029 |
| 6 to <12 months | 0.082 | 0.093 | 0.161 | 0.182 | 0.062 | 0.070 | 0.024 | 0.027 | 0.093 | 0.105 | 0.029 | 0.033 |
| 1 to <2 years | 0.087 | 0.101 | 0.188 | 0.217 | 0.069 | 0.079 | 0.030 | 0.035 | 0.122 | 0.141 | 0.033 | 0.038 |
| 2 to <3 years | 0.051 | 0.059 | 0.250 | 0.287 | 0.088 | 0.101 | 0.028 | 0.033 | 0.154 | 0.177 | 0.038 | 0.044 |
| 3 to <6 years | 0.060 | 0.076 | 0.313 | 0.391 | 0.106 | 0.133 | 0.037 | 0.046 | 0.195 | 0.244 | 0.049 | 0.061 |
| 6 to <11 years | 0.066 | 0.090 | 0.428 | 0.586 | 0.151 | 0.207 | 0.051 | 0.070 | 0.311 | 0.426 | 0.073 | 0.100 |
| 11 to <16 years | 0.073 | 0.095 | 0.630 | 0.816 | 0.227 | 0.295 | 0.072 | 0.093 | 0.483 | 0.626 | 0.105 | 0.136 |
| 16 to <21 years | 0.076 | 0.096 | 0.759 | 0.961 | 0.269 | 0.340 | 0.083 | 0.105 | 0.543 | 0.687 | 0.112 | 0.142 |
| Adult Males ≥21 | 0.136 | 0.154 | 0.827 | 1.10 | 0.314 | 0.399 | 0.107 | 0.131 | 0.682 | 0.847 | 0.137 | 0.161 |
| Adult Females ≥21 | 0.114 | 0.121 | 0.654 | 0.850 | 0.237 | 0.266 | 0.089 | 0.106 | 0.598 | 0.764 | 0.122 | 0.146 |

Front Matter

| Table ES-1. Summary of Exposure Factor Recommendations (continued) | | | | | |
|--------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|--------|--------|
| Chapter 7 | MEAN SOLID ADEHERENCE TO SKIN (mg/cm ²) | | | | |
| | Face | Arms | Hands | Legs | Feet |
| Children | | | | | |
| Residential (indoors) ^a | - | 0.0041 | 0.0011 | 0.0035 | 0.010 |
| Daycare (indoors and outdoors) ^b | - | 0.024 | 0.099 | 0.020 | 0.071 |
| Outdoor sports ^c | 0.012 | 0.011 | 0.11 | 0.031 | - |
| Indoor sports ^d | - | 0.0019 | 0.0063 | 0.0020 | 0.0022 |
| Activities with soil ^e | 0.054 | 0.046 | 0.17 | 0.051 | 0.20 |
| Playing in mud ^f | - | 11 | 47 | 23 | 15 |
| Playing in sediment ^g | 0.040 | 0.17 | 0.49 | 0.70 | 21 |
| Adults | | | | | |
| Outdoor sports ⁱ | 0.0314 | 0.0872 | 0.1336 | 0.1223 | - |
| Activities with soil ^h | 0.0240 | 0.0379 | 0.1595 | 0.0189 | 0.1393 |
| Construction activities ^j | 0.0982 | 0.1859 | 0.2763 | 0.0660 | - |
| Clamming ^k | 0.02 | 0.12 | 0.88 | 0.16 | 0.58 |
| ^a | Based on weighted average of geometric mean soil loadings for 2 groups of children (ages 3 to 13 years; N = 10) playing indoors. | | | | |
| ^b | Based on weighted average of geometric mean soil loadings for 4 groups of daycare children (ages 1 to 6.5 years; N = 21) playing both indoors and outdoors. | | | | |
| ^c | Based on geometric mean soil loadings of 8 children (ages 13 to 15 years) playing soccer. | | | | |
| ^d | Based on geometric mean soil loadings of 6 children (ages ≥8 years) and 1 adult engaging in Tae Kwon Do. | | | | |
| ^e | Based on weighted average of geometric mean soil loadings for gardeners and archeologists (ages 16 to 35 years). | | | | |
| ^f | Based on weighted average of geometric mean soil loadings of 2 groups of children (age 9 to 14 years; N = 12) playing in mud. | | | | |
| ^g | Based on geometric mean soil loadings of 9 children (ages 7 to 12 years) playing in tidal flats. | | | | |
| ^h | Based on weighted average of geometric mean soil loadings of 3 groups of adults (ages 23 to 33 years) playing rugby and 2 groups of adults (ages 24 to 34) playing soccer. | | | | |
| ⁱ | Based on weighted average of geometric mean soil loadings for 69 gardeners, farmers, groundskeepers, landscapers, and archeologists (ages 16 to 64 years) for faces, arms and hands; 65 gardeners, farmers, groundskeepers, and archeologists (ages 16 to 64 years) for legs; and 36 gardeners, groundskeepers, and archeologists (ages 16 to 62) for feet. | | | | |
| ^j | Based on weighted average of geometric mean soil loadings for 27 construction workers, utility workers and equipment operators (ages 21 to 54) for faces, arms, and hands; and based on geometric mean soil loadings for 8 construction workers (ages 21 to 30 years) for legs. | | | | |
| ^k | Based on geometric mean soil loadings of 18 adults (ages 33 to 63 years) clamming in tidal flats. | | | | |
| - | No data. | | | | |
| Chapter 8 | BODY WEIGHT | | | | |
| | | | | Mean | |
| | | | | Kg | |
| Birth to 1 month | | | | 4.8 | |
| 1 to <3 months | | | | 5.9 | |
| 3 to <6 months | | | | 7.4 | |
| 6 to <12 months | | | | 9.2 | |
| 1 to <2 years | | | | 11.4 | |
| 2 to <3 years | | | | 13.8 | |
| 3 to <6 years | | | | 18.6 | |
| 6 to <11 years | | | | 31.8 | |
| 11 to <16 years | | | | 56.8 | |
| 16 to <21 years | | | | 71.6 | |
| Adults | | | | 80.0 | |

Table ES-1. Summary of Exposure Factor Recommendations (continued)

| Chapter 9 | | | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------------------|------------------|-----------------------------------------|
| FRUIT AND VEGETABLE INTAKE | | | | |
| | Per Capita | | Consumers-Only | |
| | Mean g/kg-day | 95 th Percentile g/kg-day | Mean g/kg-day | 95 th Percentile g/kg-day |
| Total Fruits | | | | |
| Birth to 1 year | 6.2 | 23.0 ^a | 10.1 | 25.8 ^a |
| 1 to <2 years | 7.8 | 21.3 ^a | 8.1 | 21.4 ^a |
| 2 to <3 years | 7.8 | 21.3 ^a | 8.1 | 21.4 ^a |
| 3 to <6 years | 4.6 | 14.9 | 4.7 | 15.1 |
| 6 to <11 years | 2.3 | 8.7 | 2.5 | 9.2 |
| 11 to <16 years | 0.9 | 3.5 | 1.1 | 3.8 |
| 16 to <21 years | 0.9 | 3.5 | 1.1 | 3.8 |
| 21 to <50 years | 0.9 | 3.7 | 1.1 | 3.8 |
| ≥50 years | 1.4 | 4.4 | 1.5 | 4.6 |
| Total Vegetables | | | | |
| Birth to 1 year | 5.0 | 16.2 ^a | 6.8 | 18.1 ^a |
| 1 to <2 years | 6.7 | 15.6 ^a | 6.7 | 15.6 ^a |
| 2 to <3 years | 6.7 | 15.6 ^a | 6.7 | 15.6 ^a |
| 3 to <6 years | 5.4 | 13.4 | 5.4 | 13.4 |
| 6 to <11 years | 3.7 | 10.4 | 3.7 | 10.4 |
| 11 to <16 years | 2.3 | 5.5 | 2.3 | 5.5 |
| 16 to <21 years | 2.3 | 5.5 | 2.3 | 5.5 |
| 21 to <50 years | 2.5 | 5.9 | 2.5 | 5.9 |
| ≥50 years | 2.6 | 6.1 | 2.6 | 6.1 |
| ^a Estimates are less statistically reliable based on guidance published in the <i>Joint Policy on Variance Estimation and Statistical Reporting Standards on NHANES III and CSFII Reports: NHIS/NCHS Analytical Working Group Recommendations</i> (NCHS, 1993). | | | | |
| Chapter 10 | | | | |
| FISH INTAKE | | | | |
| | Per Capita | | Consumers-Only | |
| | Mean g/kg-day | 95 th Percentile g/kg-day | Mean g/kg-day | 95 th Percentile g/kg-day |
| General Population—Finfish | | | | |
| All | 0.16 | 1.1 | 0.73 | 2.2 |
| Birth to 1 year | 0.03 | 0.0 ^a | 1.3 | 2.9 ^a |
| 1 to <2 years | 0.22 | 1.2 ^a | 1.6 | 4.9 ^a |
| 2 to <3 years | 0.22 | 1.2 ^a | 1.6 | 4.9 ^a |
| 3 to <6 years | 0.19 | 1.4 | 1.3 | 3.6 ^a |
| 6 to <11 years | 0.16 | 1.1 | 1.1 | 2.9 ^a |
| 11 to <16 years | 0.10 | 0.7 | 0.66 | 1.7 |
| 16 to <21 years | 0.10 | 0.7 | 0.66 | 1.7 |
| 21 to <50 years | 0.15 | 1.0 | 0.65 | 2.1 |
| Females 13 to 49 years | 0.14 | 0.9 | 0.62 | 1.8 |
| ≥50 years | 0.20 | 1.2 | 0.68 | 2.0 |
| General Population—Shellfish | | | | |
| All | 0.06 | 0.4 | 0.57 | 1.9 |
| Birth to 1 year | 0.00 | 0.0 ^a | 0.42 | 2.3 ^a |
| 1 to <2 years | 0.04 | 0.0 ^a | 0.94 | 3.5 ^a |
| 2 to <3 years | 0.04 | 0.0 ^a | 0.94 | 3.5 ^a |
| 3 to <6 years | 0.05 | 0.0 | 1.0 | 2.9 ^a |
| 6 to <11 years | 0.05 | 0.2 | 0.72 | 2.0 ^a |
| 11 to <16 years | 0.03 | 0.0 | 0.61 | 1.9 |
| 16 to <21 years | 0.03 | 0.0 | 0.61 | 1.9 |
| 21 to <50 years | 0.08 | 0.5 | 0.63 | 2.2 |
| Females 13 to 49 years | 0.06 | 0.3 | 0.53 | 1.8 |
| ≥50 years | 0.05 | 0.4 | 0.41 | 1.2 |

Front Matter

Table ES-1. Summary of Exposure Factor Recommendations (continued)

| General Population—Total Finfish and Shellfish | | | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------------------|------------------|-----------------------------------------|
| All | 0.22 | 1.3 | 0.78 | 2.4 |
| Birth to 1 year | 0.04 | 0.0 ^a | 1.2 | 2.9 ^a |
| 1 to <2 years | 0.26 | 1.6 ^a | 1.5 | 5.9 ^a |
| 2 to <3 years | 0.26 | 1.6 ^a | 1.5 | 5.9 ^a |
| 3 to <6 years | 0.24 | 1.6 ^a | 1.3 | 3.6 ^a |
| 6 to <11 years | 0.21 | 1.4 | 0.99 | 2.7 ^a |
| 11 to <16 years | 0.13 | 1.0 | 0.69 | 1.8 |
| 16 to <21 years | 0.13 | 1.0 | 0.69 | 1.8 |
| 21 to <50 years | 0.23 | 1.3 | 0.76 | 2.5 |
| Females 13 to 49 years | 0.19 | 1.2 | 0.68 | 1.9 |
| ≥50 years | 0.25 | 1.4 | 0.71 | 2.1 |
| ^a Estimates are less statistically reliable based on guidance published in the <i>Joint Policy on Variance Estimation and Statistical Reporting Standards on NHANES III and CSFII Reports: NHIS/NCHS Analytical Working Group Recommendations</i> (NCHS, 1993). | | | | |
| Recreational Population—Marine Fish—Atlantic | | | | |
| | Mean g/day | 95 th Percentile g/day | | |
| 3 to <6 years | 2.5 | 8.8 | | |
| 6 to <11 years | 2.5 | 8.6 | | |
| 11 to <16 years | 3.4 | 13 | | |
| 16 to <18 years | 2.8 | 6.6 | | |
| >18 years | 5.6 | 18 | | |
| Recreational Population—Marine Fish—Gulf | | | | |
| 3 to <6 years | 3.2 | 13 | | |
| 6 to <11 years | 3.3 | 12 | | |
| 11 to <16 years | 4.4 | 18 | | |
| 16 to <18 years | 3.5 | 9.5 | | |
| >18 years | 7.2 | 26 | | |
| Recreational Population—Marine Fish—Pacific | | | | |
| 3 to <6 years | 0.9 | 3.3 | | |
| 6 to <11 years | 0.9 | 3.2 | | |
| 11 to <16 years | 1.2 | 4.8 | | |
| 16 to <18 years | 1.0 | 2.5 | | |
| >18 years | 2.0 | 6.8 | | |
| Recreational Population—Freshwater Fish—See Chapter 10 | | | | |
| Native American Population—See Chapter 10 | | | | |
| Other Populations—See Chapter 10 | | | | |
| Chapter 11 MEATS, DAIRY PRODUCTS, AND FAT INTAKE | | | | |
| | Per Capita | | Consumers-Only | |
| | Mean g/kg-day | 95 th Percentile g/kg-day | Mean g/kg-day | 95 th Percentile g/kg-day |
| Total Meats | | | | |
| Birth to 1 year | 1.2 | 5.4 ^a | 2.7 | 8.1 ^a |
| 1 to <2 years | 4.0 | 10.0 ^a | 4.1 | 10.1 ^a |
| 2 to <3 years | 4.0 | 10.0 ^a | 4.1 | 10.1 ^a |
| 3 to <6 years | 3.9 | 8.5 | 3.9 | 8.6 |
| 6 to <11 years | 2.8 | 6.4 | 2.8 | 6.4 |
| 11 to <16 years | 2.0 | 4.7 | 2.0 | 4.7 |
| 16 to <21 years | 2.0 | 4.7 | 2.0 | 4.7 |
| 21 to <50 years | 1.8 | 4.1 | 1.8 | 4.1 |
| ≥50 years | 1.4 | 3.1 | 1.4 | 3.1 |
| Total Dairy Products | | | | |
| Birth to 1 year | 10.1 | 43.2 ^a | 11.7 | 44.7 ^a |
| 1 to <2 years | 43.2 | 94.7 ^a | 43.2 | 94.7 ^a |
| 2 to <3 years | 43.2 | 94.7 ^a | 43.2 | 94.7 ^a |
| 3 to <6 years | 24.0 | 51.1 | 24.0 | 51.1 |
| 6 to <11 years | 12.9 | 31.8 | 12.9 | 31.8 |
| 11 to <16 years | 5.5 | 16.4 | 5.5 | 16.4 |
| 16 to <21 years | 5.5 | 16.4 | 5.5 | 16.4 |
| 21 to <50 years | 3.5 | 10.3 | 3.5 | 10.3 |
| ≥50 years | 3.3 | 9.6 | 3.3 | 9.6 |

Table ES-1. Summary of Exposure Factor Recommendations (continued)

| Total Fats | | | | |
|------------------|-----|-----|-----|-----|
| Birth to 1 month | 5.2 | 16 | 7.8 | 16 |
| 1 to <3 months | 4.5 | 12 | 6.0 | 12 |
| 3 to <6 months | 4.1 | 8.2 | 4.4 | 8.3 |
| 6 to <12 months | 3.7 | 7.0 | 3.7 | 7.0 |
| 1 to <2 years | 4.0 | 7.1 | 4.0 | 7.1 |
| 2 to <3 years | 3.6 | 6.4 | 3.6 | 6.4 |
| 3 to <6 years | 3.4 | 5.8 | 3.4 | 5.8 |
| 6 to <11 years | 2.6 | 4.2 | 2.6 | 4.2 |
| 11 to <16 years | 1.6 | 3.0 | 1.6 | 3.0 |
| 16 to <21 years | 1.3 | 2.7 | 1.3 | 2.7 |
| 21 to <31 years | 1.2 | 2.3 | 1.2 | 2.3 |
| 31 to <41 years | 1.1 | 2.1 | 1.1 | 2.1 |
| 41 to <51 years | 1.0 | 1.9 | 1.0 | 1.9 |
| 51 to <61 years | 0.9 | 1.7 | 0.9 | 1.7 |
| 61 to <71 years | 0.9 | 1.7 | 0.9 | 1.7 |
| 71 to <81 years | 0.8 | 1.5 | 0.8 | 1.5 |
| ≥81 years | 0.9 | 1.5 | 0.9 | 1.5 |

^a Estimates are less statistically reliable based on guidance published in the *Joint Policy on Variance Estimation and Statistical Reporting Standards on NHANES III and CSFII Reports: NHIS/NCHS Analytical Working Group Recommendations* (NCHS, 1993).

| Chapter 12 GRAINS INTAKE | | | | |
|---------------------------------|------------------|-----------------------------------------|------------------|-----------------------------------------|
| | Per Capita | | Consumers-Only | |
| | Mean g/kg-day | 95 th Percentile g/kg-day | Mean g/kg-day | 95 th Percentile g/kg-day |
| Birth to 1 year | 3.1 | 9.5 ^a | 4.1 | 10.3 ^a |
| 1 to <2 years | 6.4 | 12.4 ^a | 6.4 | 12.4 ^a |
| 2 to <3 years | 6.4 | 12.4 ^a | 6.4 | 12.4 ^a |
| 3 to <6 years | 6.2 | 11.1 | 6.2 | 11.1 |
| 6 to <11 years | 4.4 | 8.2 | 4.4 | 8.2 |
| 11 to <16 years | 2.4 | 5.0 | 2.4 | 5.0 |
| 16 to <21 years | 2.4 | 5.0 | 2.4 | 5.0 |
| 21 to <50 years | 2.2 | 4.6 | 2.2 | 4.6 |
| ≥50 years | 1.7 | 3.5 | 1.7 | 3.5 |

^a Estimates are less statistically reliable based on guidance published in the *Joint Policy on Variance Estimation and Statistical Reporting Standards on NHANES III and CSFII Reports: NHIS/NCHS Analytical Working Group Recommendations* (NCHS, 1993).

| Chapter 13 HOME-PRODUCED FOOD INTAKE | | |
|-----------------------------------------------------------------|------------------|-----------------------------------------|
| | Mean g/kg-day | 95 th Percentile g/kg-day |
| Consumer-Only Home-Produced Fruits, Unadjusted ^a | | |
| 1 to 2 years | 8.7 | 60.6 |
| 3 to 5 years | 4.1 | 8.9 |
| 6 to 11 years | 3.6 | 15.8 |
| 12 to 19 years | 1.9 | 8.3 |
| 20 to 39 years | 2.0 | 6.8 |
| 40 to 69 years | 2.7 | 13.0 |
| ≥70 years | 2.3 | 8.7 |
| Consumer-Only Home-Produced Vegetables, Unadjusted ^a | | |
| 1 to 2 years | 5.2 | 19.6 |
| 3 to 5 years | 2.5 | 7.7 |
| 6 to 11 years | 2.0 | 6.2 |
| 12 to 19 years | 1.5 | 6.0 |
| 20 to 39 years | 1.5 | 4.9 |
| 40 to 69 years | 2.1 | 6.9 |
| ≥70 years | 2.5 | 8.2 |
| Consumer-Only Home-Produced Meats, Unadjusted ^a | | |
| 1 to 2 years | 3.7 | 10.0 |
| 3 to 5 years | 3.6 | 9.1 |
| 6 to 11 years | 3.7 | 14.0 |
| 12 to 19 years | 1.7 | 4.3 |
| 20 to 39 years | 1.8 | 6.2 |
| 40 to 69 years | 1.7 | 5.2 |
| ≥70 years | 1.4 | 3.5 |

Front Matter

Table ES-1. Summary of Exposure Factor Recommendations (continued)

| Consumer-Only Home-Caught Fish, Unadjusted ^a | | | | |
|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|---------------------------------------|-----------------------------------------|
| 1 to 2 years | - | - | - | - |
| 3 to 5 years | - | - | - | - |
| 6 to 11 years | 2.8 | | 7.1 | |
| 12 to 19 years | 1.5 | | 4.7 | |
| 20 to 39 years | 1.9 | | 4.5 | |
| 40 to 69 years | 1.8 | | 4.4 | |
| ≥70 years | 1.2 | | 3.7 | |
| Per Capita for Populations that Garden or (Farm) | | | | |
| | Home-Produced Fruits ^b | | Home-Produced Vegetables ^b | |
| | Mean g/kg-day | 95 th Percentile g/kg-day | Mean g/kg-day | 95 th Percentile g/kg-day |
| 1 to <2 years | 1.0 (1.4) | 4.8 (9.1) | 1.3 (2.7) | 7.1 (14) |
| 2 to <3 years | 1.0 (1.4) | 4.8 (9.1) | 1.3 (2.7) | 7.1 (14) |
| 3 to <6 years | 0.78 (1.0) | 3.6 (6.8) | 1.1 (2.3) | 6.1 (12) |
| 6 to <11 years | 0.40 (0.52) | 1.9 (3.5) | 0.80 (1.6) | 4.2 (8.1) |
| 11 to <16 years | 0.13 (0.17) | 0.62 (1.2) | 0.56 (1.1) | 3.0 (5.7) |
| 16 to <21 years | 0.13 (0.17) | 0.62 (1.2) | 0.56 (1.1) | 3.0 (5.7) |
| 21 to <50 years | 0.15 (0.20) | 0.70 (1.3) | 0.56 (1.1) | 3.0 (5.7) |
| 50+ years | 0.24 (0.31) | 1.1 (2.1) | 0.60 (1.2) | 3.2 (6.1) |
| Per Capita for Populations that Farm or (Raise Animals) | | | | |
| | Home-Produced Meats ^b | | Home-Produced Dairy | |
| | Mean g/kg-day | 95 th Percentile g/kg-day | Mean g/kg-day | 95 th Percentile g/kg-day |
| 1 to <2 years | 1.4 (1.4) | 5.8 (6.0) | 11 (13) | 76 (92) |
| 2 to <3 years | 1.4 (1.4) | 5.8 (6.0) | 11 (13) | 76 (92) |
| 3 to <6 years | 1.4 (1.4) | 5.8 (6.0) | 6.7 (8.3) | 48 (58) |
| 6 to <11 years | 1.0 (1.0) | 4.1 (4.2) | 3.9 (4.8) | 28 (34) |
| 11 to <16 years | 0.71 (0.73) | 3.0 (3.1) | 1.6 (2.0) | 12 (14) |
| 16 to <21 years | 0.71 (0.73) | 3.0 (3.1) | 1.6 (2.0) | 12 (14) |
| 21 to <50 years | 0.65 (0.66) | 2.7 (2.8) | 0.95 (1.2) | 6.9 (8.3) |
| 50+ years | 0.51 (0.52) | 2.1 (2.2) | 0.92 (1.1) | 6.7 (8.0) |
| ^a | Not adjusted to account for preparation and post cooking losses. | | | |
| ^b | Adjusted for preparation and post cooking losses. | | | |
| - | No data. | | | |
| Chapter 14 TOTAL PER CAPITA FOOD INTAKE | | | | |
| | Mean | | 95 th Percentile | |
| | g/kg-day | | g/kg-day | |
| Birth to 1 year | 91 | | 208 ^a | |
| 1 to <3 years | 113 | | 185 ^a | |
| 3 to <6 years | 79 | | 137 | |
| 6 to <11 years | 47 | | 92 | |
| 11 to <16 years | 28 | | 56 | |
| 16 to <21 years | 28 | | 56 | |
| 21 to <50 years | 29 | | 63 | |
| ≥50 years | 29 | | 59 | |
| ^a | Estimates are less statistically reliable based on guidance published in the <i>Joint Policy on Variance Estimation and Statistical Reporting Standards on NHANES III and CSFII Reports: NHIS/NCHS Analytical Working Group Recommendations</i> (NCHS, 1993). | | | |
| Chapter 15 HUMAN MILK AND LIPID INTAKE | | | | |
| | Mean | | Upper Percentile | |
| | mL/day | mL/kg-day | mL/day | mL/kg-day |
| Human Milk Intake | | | | |
| Birth to 1 month | 510 | 150 | 950 | 220 |
| 1 to <3 months | 690 | 140 | 980 | 190 |
| 3 to <6 months | 770 | 110 | 1,000 | 150 |
| 6 to <12 months | 620 | 83 | 1,000 | 130 |
| Lipid Intake | | | | |
| Birth to 1 month | 20 | 6.0 | 38 | 8.7 |
| 1 to <3 months | 27 | 5.5 | 40 | 8.0 |
| 3 to <6 months | 30 | 4.2 | 42 | 6.1 |
| 6 to <12 months | 25 | 3.3 | 42 | 5.2 |

Table ES-1. Summary of Exposure Factor Recommendations (continued)

| Chapter 16 | | | | | | | ACTIVITY FACTORS | | | | | | |
|-------------------|------------------------|-----------------------------|--|-----------------------------|-----------------------------|--|-----------------------------|-----------------------------|--|--|--|--|--|
| | Time Indoors (total) | | | Time Outdoors (total) | | | Time Indoors (at residence) | | | | | | |
| | minutes/day | | | minutes/day | | | minutes/day | | | | | | |
| | Mean | 95 th Percentile | | Mean | 95 th Percentile | | Mean | 95 th Percentile | | | | | |
| Birth to <1 month | 1,440 | - | | 0 | - | | - | - | | | | | |
| 1 to <3 months | 1,432 | - | | 8 | - | | - | - | | | | | |
| 3 to <6 months | 1,414 | - | | 26 | - | | - | - | | | | | |
| 6 to <12 months | 1,301 | - | | 139 | - | | - | - | | | | | |
| Birth to <1 year | - | - | | - | - | | 1,108 | 1,440 | | | | | |
| 1 to <2 years | 1,353 | - | | 36 | - | | 1,065 | 1,440 | | | | | |
| 2 to <3 years | 1,316 | - | | 76 | - | | 979 | 1,296 | | | | | |
| 3 to <6 years | 1,278 | - | | 107 | - | | 957 | 1,355 | | | | | |
| 6 to <11 years | 1,244 | - | | 132 | - | | 893 | 1,275 | | | | | |
| 11 to <16 years | 1,260 | - | | 100 | - | | 889 | 1,315 | | | | | |
| 16 to <21 years | 1,248 | - | | 102 | - | | 833 | 1,288 | | | | | |
| 18 to <64 years | 1,159 | - | | 281 | - | | 948 | 1,428 | | | | | |
| >64 years | 1,142 | - | | 298 | - | | 1,175 | 1,440 | | | | | |
| | Showering | | | Bathing | | | Bathing/Showering | | | | | | |
| | minutes/day | | | minutes/day | | | minutes/day | | | | | | |
| | Mean | 95 th Percentile | | Mean | 95 th Percentile | | Mean | 95 th Percentile | | | | | |
| Birth to <1 year | 15 | - | | 19 | 30 | | - | - | | | | | |
| 1 to <2 years | 20 | - | | 23 | 32 | | - | - | | | | | |
| 2 to <3 years | 22 | 44 | | 23 | 45 | | - | - | | | | | |
| 3 to <6 years | 17 | 34 | | 24 | 60 | | - | - | | | | | |
| 6 to <11 years | 18 | 41 | | 24 | 46 | | - | - | | | | | |
| 11 to <16 years | 18 | 40 | | 25 | 43 | | - | - | | | | | |
| 16 to <21 years | 20 | 45 | | 33 | 60 | | - | - | | | | | |
| 18 to <64 years | - | - | | - | - | | 17 | - | | | | | |
| >64 years | - | - | | - | - | | 17 | - | | | | | |
| | Playing on Sand/Gravel | | | Playing on Grass | | | Playing on Dirt | | | | | | |
| | minutes/day | | | minutes/day | | | minutes/day | | | | | | |
| | Mean | 95 th Percentile | | Mean | 95 th Percentile | | Mean | 95 th Percentile | | | | | |
| Birth to <1 year | 18 | - | | 52 | - | | 33 | - | | | | | |
| 1 to <2 years | 43 | 121 | | 68 | 121 | | 56 | 121 | | | | | |
| 2 to <3 years | 53 | 121 | | 62 | 121 | | 47 | 121 | | | | | |
| 3 to <6 years | 60 | 121 | | 79 | 121 | | 63 | 121 | | | | | |
| 6 to <11 years | 67 | 121 | | 73 | 121 | | 63 | 121 | | | | | |
| 11 to <16 years | 67 | 121 | | 75 | 121 | | 49 | 120 | | | | | |
| 16 to <21 years | 83 | - | | 60 | - | | 30 | - | | | | | |
| 18 to <64 years | 0 (median) | 121 | | 60 (median) | 121 | | 0 (median) | 120 | | | | | |
| >64 years | 0 (median) | - | | 121 (median) | - | | 0 (median) | - | | | | | |
| | Swimming | | | | | | | | | | | | |
| | Mean | | | 95 th Percentile | | | | | | | | | |
| Birth to <1 year | 96 | | | - | | | | | | | | | |
| 1 to <2 years | 105 | | | - | | | | | | | | | |
| 2 to <3 years | 116 | | | 181 | | | | | | | | | |
| 3 to <6 years | 137 | | | 181 | | | | | | | | | |
| 6 to <11 years | 151 | | | 181 | | | | | | | | | |
| 11 to <16 years | 139 | | | 181 | | | | | | | | | |
| 16 to <21 years | 145 | | | 181 | | | | | | | | | |
| 18 to <64 years | 45 (median) | | | 181 | | | | | | | | | |
| >64 years | 40 (median) | | | 181 | | | | | | | | | |

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|---------------------------------------------------------------------------|-------------------------------------------|-----------------------------|--------------------------------|-----------------------------|
| Occupational Mobility | | | | |
| | Median Tenure (years) | | Median Tenure (years) | |
| | Men | | Women | |
| All ages, ≥16 years | 7.9 | | 5.4 | |
| 16 to 24 years | 2.0 | | 1.9 | |
| 25 to 29 years | 4.6 | | 4.1 | |
| 30 to 34 years | 7.6 | | 6.0 | |
| 35 to 39 years | 10.4 | | 7.0 | |
| 40 to 44 years | 13.8 | | 8.0 | |
| 45 to 49 years | 17.5 | | 10.0 | |
| 50 to 54 years | 20.0 | | 10.8 | |
| 55 to 59 years | 21.9 | | 12.4 | |
| 60 to 64 years | 23.9 | | 14.5 | |
| 65 to 69 years | 26.9 | | 15.6 | |
| ≥70 years | 30.5 | | 18.8 | |
| Population Mobility | | | | |
| | Residential Occupancy Period (years) | | Current Residence Time (years) | |
| | Mean | 95 th Percentile | Mean | 95 th Percentile |
| All | 12 | 33 | 13 | 46 |
| - | No data. | | | |
| Chapter 17 | CONSUMER PRODUCTS - See Chapter 17 | | | |
| Chapter 18 | LIFE EXPECTANCY | | | |
| | Years | | | |
| Total | 78 | | | |
| Males | 75 | | | |
| Females | 80 | | | |
| Chapter 19 | BUILDING CHARACTERISTICS | | | |
| | Residential Buildings | | | |
| | Mean | | 10 th Percentile | |
| Volume of Residence (m ³) | 492 | | 154 | |
| Air Exchange Rate (air changes/hour) | 0.45 | | 0.18 | |
| | Non-Residential Buildings | | | |
| | Mean (Standard Deviation) | | 10 th Percentile | |
| Volume of Non-residential Buildings (m ³) | | | 408 | |
| Vacant | 4,789 | | 510 | |
| Office | 5,036 | | 2,039 | |
| Laboratory | 24,681 | | 1,019 | |
| Non-refrigerated warehouse | 9,298 | | 476 | |
| Food sales | 1,889 | | 816 | |
| Public order and safety | 5,253 | | 680 | |
| Outpatient healthcare | 3,537 | | 1,133 | |
| Refrigerated warehouse | 19,716 | | 612 | |
| Religious worship | 3,443 | | 595 | |
| Public assembly | 4,839 | | 527 | |
| Education | 8,694 | | 442 | |
| Food service | 1,889 | | 17,330 | |
| Inpatient healthcare | 82,034 | | 1,546 | |
| Nursing | 15,522 | | 527 | |
| Lodging | 11,559 | | 1,359 | |
| Strip shopping mall | 7,891 | | 35,679 | |
| Enclosed mall | 287,978 | | 510 | |
| Retail other than mall | 3,310 | | 459 | |
| Service | 2,213 | | 425 | |
| Other | 5,236 | | 527 | |
| All Buildings | 5,575 | | | |
| Air Exchange Rate (air changes/hour) | 1.5 (0.87) | | 0.60 | |
| | Range 0.3–4.1 | | | |

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ACRONYMS AND ABBREVIATIONS

| | | |
|-----------------|---|----------------------------------------------------------------------------|
| AAP | = | American Academy of Pediatrics |
| ACH | = | Air Changes per Hour |
| ADAFs | = | Age Dependent Adjustment Factors |
| ADD | = | Average Daily Dose |
| AF | = | Adherence Factor |
| AHS | = | American Housing Survey |
| AIR | = | Acid Insoluble Residue |
| API | = | Asian and Pacific Islander |
| ASHRAE | = | American Society of Heating, Refrigeration, and Air Conditioning Engineers |
| ASTM | = | American Society for Testing and Materials |
| ARS | = | Agricultural Research Service |
| ASCII | = | American Standard Code for Information Interchange |
| ATD | = | Arizona Test Dust |
| ATSDR | = | Agency for Toxic Substances and Disease Registry |
| ATUS | = | American Time Use Survey |
| BI | = | Bootstrap Interval |
| BMD | = | Benchmark Dose |
| BMI | = | Body Mass Index |
| BMR | = | Basal Metabolic Rate |
| BTM | = | Best Tracer Method |
| BW | = | Body Weight |
| C | = | Concentration |
| CATI | = | Computer-Assisted Telephone Interviewing |
| CDC | = | Centers for Disease Control and Prevention |
| CDFA | = | California Department of Food and Drugs |
| CDS | = | Child Development Supplement |
| CHAD | = | Consolidated Human Activity Database |
| CI | = | Confidence Interval |
| cm ² | = | Square Centimeter |
| cm ³ | = | Cubic Centimeter |
| CNRC | = | Children's Nutrition Research Center |
| CRITFC | = | Columbia River Inter-Tribal Fish Commission |
| CSFII | = | Continuing Survey of Food Intake by Individuals |
| CT | = | Central Tendency |
| CTFA | = | Cosmetic, Toiletry, and Fragrance Association |
| CV | = | Coefficient of Variation |
| DAF | = | Dosimetry Adjustment Factor |
| DARLING | = | Davis Area Research on Lactation, Infant Nutrition and Growth |
| DHHS | = | Department of Health and Human Services |
| DIR | = | Daily Inhalation Rate |
| DIY | = | Do-It-Yourself |
| DK | = | Respondent Replied "Don't Know" |
| DLW | = | Doubly Labeled Water |
| DOE | = | Department of Energy |
| DONALD | = | Dortmund Nutritional and Anthropometric Longitudinally Designed |
| E or EE | = | Energy Expenditure |
| EBF | = | Exclusively Breastfed |
| ECG | = | Energy Cost of Growth |
| ED | = | Exposure Duration |

ACRONYMS AND ABBREVIATIONS (continued)

| | | |
|--------|---|-----------------------------------------------------------|
| EFAST | = | Exposure and Fate Assessment Screening Tool |
| EI | = | Energy Intake |
| EPA | = | Environmental Protection Agency |
| ERV | = | Energy Recovery Ventilator |
| EVR | = | Equivalent Ventilation Rate |
| F | = | Fahrenheit |
| f_b | = | Breathing Frequency |
| FCID | = | Food Commodity Intake Database |
| FITS | = | Feeding Infant and Toddler Study |
| F/S | = | Food/Soil |
| g | = | Gram |
| GAF | = | General Assessment Factor |
| GM | = | Geometric Mean |
| GSD | = | Geometric Standard Deviation |
| H | = | Oxygen Uptake Factor |
| HEC | = | Human Equivalent Exposure Concentrations |
| HR | = | Heart Rate |
| HRV | = | Heat Recovery Ventilator |
| USHUD | = | United States Department of Housing and Urban Development |
| I | = | Tabulated Intake Rate |
| I_a | = | Adjusted Intake Rate |
| I-BEAM | = | Indoor Air Quality Building and Assessment Model |
| ICRP | = | International Commission on Radiological Protection |
| IEUBK | = | Integrated Exposure and Uptake Biokinetic Model |
| IFS | = | Iowa Fluoride Study |
| IOM | = | Institute of Medicine |
| IPCS | = | International Programme on Chemical Safety |
| IR | = | Intake Rate/Inhalation Rate |
| IRIS | = | Integrated Risk Information System |
| IUR | = | Inhalation Unit Risk |
| Kcal | = | Kilocalories |
| KJ | = | Kilo Joules |
| K-S | = | Kolmogorov-Smirnov |
| kg | = | Kilogram |
| L | = | Liter |
| L_1 | = | Cooking or Preparation Loss |
| L_2 | = | Post-cooking Loss |
| LADD | = | Lifetime Average Daily Dose |
| LCL | = | Lower Confidence Limit |
| LTM | = | Limiting Tracer Method |
| m^2 | = | Square Meter |
| m^3 | = | Cubic Meter |
| MCCEM | = | Multi-Chamber Concentration and Exposure Model |
| MEC | = | Mobile Examination Center |
| mg | = | Milligram |
| MJ | = | Mega Joules |
| mL | = | Milliliter |
| METS | = | Metabolic Equivalents of Work |
| MOA | = | Mode of Action |
| MSA | = | Metropolitan Statistical Area |
| MVPA | = | Moderate-to-Vigorous Physical Activity |
| N | = | Number of Subjects or Respondents |

ACRONYMS AND ABBREVIATIONS (continued)

| | | |
|--------|---|--------------------------------------------------------------|
| N_c | = | Weighted Number of Individuals Consuming Homegrown Food Item |
| N_T | = | Weighted Total Number of Individuals Surveyed |
| NAS | = | National Academy of Sciences |
| NCEA | = | National Center for Environmental Assessment |
| NCHS | = | National Center for Health Statistics |
| NERL | = | National Exposure Research Laboratory |
| NFCS | = | Nationwide Food Consumption Survey |
| NHANES | = | National Health and Nutrition Examination Survey |
| NHAPS | = | National Human Activity Pattern Survey |
| NHES | = | National Health Examination Survey |
| NIS | = | National Immunization Survey |
| NLO | = | Non-Linear Optimization |
| NMFS | = | National Marine Fisheries Service |
| NOAEL | = | No-Observed-Adverse-Effect-Level |
| NOPEs | = | Non-Occupational Pesticide Exposure Study |
| NR | = | Not Reported |
| NRC | = | National Research Council |
| NS | = | No Statistical Difference |
| OPP | = | Office of Pesticide Programs |
| ORD | = | Office of Research and Development |
| PBPK | = | Physiologically-Based Pharmacokinetic |
| PC | = | Percent Consuming |
| PDIR | = | Physiological Daily Inhalation Rate |
| PFT | = | Perfluorocarbon Tracer |
| PSID | = | Panel Study of Income Dynamics |
| PTEAM | = | Particle Total Exposure Assessment Methodology |
| RAGS | = | Risk Assessment Guidance for Superfund |
| RDD | = | Random Digit Dial |
| RECS | = | Residential Energy Conservation Survey |
| RfD | = | Reference Dose |
| RfC | = | Reference Concentration |
| ROP | = | Residential Occupancy Period |
| RTF | = | Ready to Feed |
| SA | = | Surface Area |
| SA/BW | = | Surface Area to Body Weight Ratio |
| SAS | = | Statistical Analysis Software |
| SCS | = | Soil Contact Survey |
| SD | = | Standard Deviation |
| SDA | = | Soaps and Detergent Association |
| SE | = | Standard Error |
| SEM | = | Standard Error of the Mean |
| SES | = | Socioeconomic Status |
| SHEDS | = | Stochastic Human Exposure and Dose Simulation Model |
| SMBRP | = | Santa Monica Bay Restoration Project |
| SMRB | = | Simmons Market Research Bureau |
| SOCAL | = | Southern California |
| SPS | = | Statistical Processing System |
| t | = | Exposure Time |
| TDEE | = | Total Daily Energy Expenditure |
| TRF | = | Tuna Research Foundation |

ACRONYMS AND ABBREVIATIONS (continued)

| | | |
|-----------------|---|---------------------------------------------|
| UCL | = | Upper Confidence Limit |
| USDA | = | United States Department of Agriculture |
| USDL | = | United States Department of Labor |
| VE | = | Volume of Air Breathed per Day |
| VO ₂ | = | Oxygen Consumption Rate |
| VOC | = | Volatile Organic Compounds |
| VQ | = | Ventilatory Equivalent |
| VR | = | Ventilation Rate |
| VT | = | Tidal Volume |
| WHO | = | World Health Organization |
| WIC | = | USDA's Women, Infants, and Children Program |