DRAFT
DO NOT CITE OR QUOTE

NCEA-W-0853
June 2000
External Review Draft

CHILD-SPECIFIC EXPOSURE FACTORS HANDBOOK

Prepared for:

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

Contract No. 68-W-99-041
Work Assignment No. 2-11

Prepared by:

Versar, Inc.
6850 Versar Center
Springfield, VA 22151

NOTICE

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

DISCLAIMER

This document is an external draft for review purposes only and does not constitute U.S. Environmental Protection Agency policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

TABLE OF CONTENTS

1. INTRODUCTION 1-1
- 1.1 BACKGROUND 1-1
- 1.2 PURPOSE 1-3
- 1.3 INTENDED AUDIENCE 1-3
- 1.4 SELECTION OF STUDIES FOR THE HANDBOOK 1-4
- 1.5 APPROACH USED TO DEVELOP RECOMMENDATIONS FOR EXPOSURE FACTORS 1-6
- 1.6 CHARACTERIZING VARIABILITY 1-7
- 1.7 USING THE HANDBOOK IN AN EXPOSURE ASSESSMENT 1-10
  - 1.7.1 General Equation for Calculating Dose 1-11
- 1.8 FUTURE OR ON-GOING WORK 1-15
- 1.9 RESEARCH NEEDS 1-16
- 1.10 ORGANIZATION 1-17
- 1.11 REFERENCES FOR CHAPTER 1 1-19

2. BREAST MILK INTAKE 2-1
- 2.1 INTRODUCTION 2-1
- 2.2 STUDIES ON BREAST MILK INTAKE 2-2
- 2.3 STUDIES ON LIPID CONTENT AND FAT INTAKE FROM BREAST MILK 2-5
- 2.4 OTHER FACTORS 2-7
- 2.5 RECOMMENDATIONS 2-8
- 2.6 REFERENCES FOR CHAPTER 2 2-10

3. FOOD INTAKE 3-1
- 3.1 INTRODUCTION 3-1
- 3.2 INTAKE RATE DISTRIBUTIONS FOR VARIOUS FOOD TYPES 3-3
- 3.3 FISH INTAKE RATES 3-6
  - 3.3.1 General Population Studies 3-6
  - 3.3.2 Freshwater Recreational Study 3-12
  - 3.3.3 Native American Subsistence Study 3-14
- 3.4 FAT INTAKE 3-15
- 3.5 TOTAL DIETARY INTAKE AND CONTRIBUTIONS TO DIETARY INTAKE 3-17
- 3.6 INTAKE OF HOME-PRODUCED FOODS 3-18
- 3.7 SERVING SIZE STUDY BASED ON THE USDA NFCS 3-23
- 3.8 CONVERSION BETWEEN AS CONSUMED AND DRY WEIGHT INTAKE RATES 3-23
- 3.9 FAT CONTENT OF MEAT AND DAIRY PRODUCTS 3-24

TABLE OF CONTENTS (Continued)

3.10 RECOMMENDATIONS 3-25
3.11 REFERENCES FOR CHAPTER 3 3-27

APPENDIX 3A Calculations Used in the 1994-96 CSFII Analysis to Correct for Mixtures
APPENDIX 3B Food Codes and Definitions Used in Analysis of the 1994-96 Usda CSFII Data
APPENDIX 3C Sample Calculation of Mean Daily Fat Intake Based On cdc (1994) Data
APPENDIX 3D Food Codes and Definitions Used in Analysis of the 1987-88 USDA NFCS Data

4. DRINKING WATER INTAKE 4-1
4.1 INTRODUCTION 4-1
4.2 DRINKING WATER INTAKE STUDIES 4-2
4.3. PREGNANT AND LACTATING WOMEN 4-7
4.4 RECOMMENDATIONS 4-8
4.5 REFERENCES FOR CHAPTER 4 4-9

5. SOIL INGESTION AND PICA 5-1
5.1 INTRODUCTION 5-1
5.2 SOIL INTAKE STUDIES 5-1
5.3 PREVALENCE OF PICA 5-18
5.4 DELIBERATE SOIL INGESTION AMONG CHILDREN 5-19
5.5 RECOMMENDATIONS 5-25
5.6 REFERENCES FOR CHAPTER 5 5-27

6. OTHER NON-DIETARY INGESTION FACTORS 6-1
6.1 INTRODUCTION 6-1
6.2 STUDIES RELATED TO NON-DIETARY INGESTION 6-2
6.3 RECOMMENDATIONS 6-9
6.4 REFERENCES FOR CHAPTER 6 6-11

7. INHALATION ROUTE 7-1
7.1 INTRODUCTION 7-1
7.2 INHALATION RATE STUDIES 7-1
7.3 RECOMMENDATIONS 7-7
7.4 REFERENCES FOR CHAPTER 7 7-9

APPENDIX 7A Ventilation Data 7A-1

TABLE OF CONTENTS (Continued)

8. DERMAL ROUTE 8-1
- 8.1 INTRODUCTION 8-1
- 8.2 SURFACE AREA 8-2
  - 8.2.1 Background 8-2
  - 8.2.2 Measurement Techniques 8-2
  - 8.2.3 Body Surface Area Studies 8-3
  - 8.2.4 Application of Body Surface Area Data 8-7
- 8.3 SOIL ADHERENCE TO SKIN 8-8
  - 8.3.1 Background 8-8
  - 8.3.2 Soil Adherence to Skin Studies 8-9
- 8.4 RECOMMENDATIONS 8-12
  - 8.4.1 Body Surface Area 8-12
  - 8.4.2 Soil Adherence to Skin 8-13
- 8.5 REFERENCES FOR CHAPTER 8 8-15

APPENDIX 8A Formulae for Total Body Surface Area

9. ACTIVITY FACTORS 9-1
- 9.1 INTRODUCTION 9-1
- 9.2 ACTIVITY PATTERNS 9-1
- 9.3 RECOMMENDATIONS 9-11
  - 9.3.1 Recommendations for Activity Patterns 9-11
  - 9.3.2 Summary of Recommended Activity Factors 9-13
- 9.4 REFERENCES FOR CHAPTER 9 9-14

10. CONSUMER PRODUCTS 10-1
- 10.1 BACKGROUND 10-1
- 10.2 CONSUMER PRODUCTS USE STUDIES 10-1
- 10.3 RECOMMENDATIONS 10-2
- 10.4 REFERENCES FOR CHAPTER 10 10-3

11. BODY WEIGHT STUDIES 11-1
- 11.1 INTRODUCTION 11-1
- 11.2 BODY WEIGHT STUDIES 11-1
- 11.3 RECOMMENDATIONS 11-3
- 11.4 REFERENCES FOR CHAPTER 11 11-5

TABLE OF CONTENTS (Continued)

12. LIFETIME 12-1
- 12.1 INTRODUCTION 12-1
- 12.2 DATA ON LIFETIME 12-1
- 12.3 RECOMMENDATIONS 12-2
- 12.4 REFERENCES FOR CHAPTER 12 12-3

LIST OF TABLES

Table 1-1. Considerations Used to Rate Confidence in recommended Values 1-21
Table 1-2. Summary of Exposure Factor Recommendations and Confidence Ratings 1-22
Table 1-3. Characterization of Variability in Exposure Factors 1-24

Table 2-1. Daily Intakes of Breast Milk 2-11
Table 2-2. Breast Milk Intake for Infants Aged 1 to 6 Months 2-11
Table 2-3. Breast Milk Intake among Exclusively Breast-fed Infants During the First 4 Months of Life 2-12
Table 2-4. Breast Milk Intake During a 24-hour Period 2-13
Table 2-5. Breast Milk Intake Estimated by the Darling Study 2-14
Table 2-6. Lipid Content of Human Milk and Estimated Lipid Intake among Exclusively Breast-fed Infants 2-14
Table 2-7. Predicted Lipid Intakes for Breast-fed Infants under 12 Months of Age 2-14
Table 2-8. Number of Meals per Day 2-15
Table 2-9. 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 2-16
Table 2-10. Confidence in Breast Milk Intake Recommendations 2-17
Table 2-11. Breast Milk Intake Rates Derived from Key Studies 2-18
Table 2-12. Summary of Recommended Breast Milk And Lipid Intake Rates 2-19

Table 3-1. Weighted and Unweighted Number of Observations, 1994/96 CSFII Analysis . . 3-29
Table 3-2. Per Capita Intake of the Major Food Groups (g/kg-day as consumed) 3-30
Table 3-3. Per Capita Intake of Individual Foods (g/kg-day as consumed) 3-31
Table 3-4. Per Capita Intake of USDA Categories of Vegetables and Fruits (g/kg-day as consumed) 3-33
Table 3-5. Per Capita Intake of Exposed/Protected Fruit and Vegetable Categories (g/kg-day as consumed) 3-34
Table 3-6. Per Capita Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - As Consumed 3-35
Table 3-7. Consumers Only Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - As Consumed 3-36
Table 3-8. Per Capita Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - Uncooked Fish Weight 3-37
Table 3-9. Per Capita Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - Uncooked Fish Weight 3-38
Table 3-10. Mean and 95th Percentile of Fish Consumption (g/day) by Sex and Age 3-39
Table 3-11. Best Fits of Lognormal Distributions Using the Nonlinear Optimization (Nlo) Method 3-40

LIST OF TABLES (Continued)

Table 3-12. Number of Respondents Reporting Consumption of a Specified Number of Servings of Seafood in 1 Month and Source of Seafood Eaten 3-40
Table 3-13. Mean Fish Intake Among Individuals Who Eat Fish and Reside in Households With Recreational Fish Consumption 3-41
Table 3-14. Children's 5 and Under Fish Consumption Rates - Throughout Year 3-41
Table 3-15. Fat Intake Among Children Based on Data from the Bogalusa Heart Study, 1973-1982 (g/day) 3-42
Table 3-16. Fat Intake Among Children Based on Data from the Bogalusa Heart Study, 1973-1982 (g/kg/day) 3-43
Table 3-17. Mean Total Daily Dietary Fat Intake (g/day) Grouped by Age and Gender 3-44
Table 3-18. Per Capita Total Dietary Intake 3-45
Table 3-19. Per Capita Intake of Major Food Groups (g/day, as consumed) 3-46
Table 3-20. Per Capita Intake of Major Food Groups (g/kg/day, as consumed) 3-48
Table 3-21. 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 3-50
Table 3-22. 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 3-52
Table 3-23. 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 3-54
Table 3-24. 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 3-56
Table 3-25. 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 3-58
Table 3-26. 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 3-60
Table 3-27. Weighted and Unweighted Number of Observations (Individuals) for NFCS Data Used in Analysis of Food Intake 3-62
Table 3-28. Consumer Only Intake of Homegrown Foods (g/kg-day)[a] - All Regions Combined 3-63
Table 3-29. Percent Weight Losses from Food Preparation 3-64
Table 3-30. Quantity (as consumed) of Food Groups Consumed Per Eating Occasion and the Percentage of Individuals Using These Foods in Three Days 3-65
Table 3-31. Mean Moisture Content of Selected Food Groups Expressed as Percentages of Edible Portions 3-67
Table 3-32. Percent Moisture Content for Selected Fish Species 3-71

LIST OF TABLES (Continued)

Table 3-33. Percentage Lipid Content (Expressed as Percentages of 100 Grams of Edible Portions) of Selected Meat, Dairy, and Fish Products 3-74
Table 3-34. Fat Content of Meat Products 3-78
Table 3-35. Summary of Recommended Values for Per Capita Intake of Foods, As Consumed 3-79
Table 3-36. Confidence Intake Recommendations for Various Foods, Including Fish (General Population) 3-81
Table 3-37. Confidence Intake Recommendations for Fish Consumption - Recreational Freshwater Angler Population 3-82
Table 3-38. Confidence Intake Recommendations for Fish Consumption - Native American Subsistence Population 3-83
Table 4-1. Estimated Direct and Indirect Community Total Water Ingestion By Source for U.S. Population 4-10
Table 4-2. Estimate of Total Direct and Indirect Water Ingestion, All Sources By Broad Age Category for U.S. Children 4-11
Table 4-3. Estimate of Direct and Indirect Community Water Ingestion By Fine Age Category for U.S. Children 4-12
Table 4-4. Estimate of Direct and Indirect Community Water Ingestion By Broad Age Category for U.S. Children 4-13
Table 4-5. Estimate of Direct and Indirect Bottled Water Ingestion By Fine Age Category for U.S. Children 4-14
Table 4-6. Estimate of Direct and Indirect Bottled Water Ingestion By Broad Age Category for U.S. Children 4-15
Table 4-7. Estimate of Direct and Indirect Other Water Ingestion By Fine Age Category for U.S. Children 4-16
Table 4-8. Estimate of Direct and Indirect Other Water Ingestion By Broad Age Category for U.S. Children 4-17
Table 4-9. Chi-square GOF statistics for 12 Models, Tapwater Data, Based on Maximum Likelihood Method of Parameter Estimation 4-18
Table 4-10. P-Values for Chi-Square GOF Tests of 12 Models, Tapwater Data 4-18
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 Modles 4-19
Table 4-12. Total Fluid Intake of Women 15-49 Years Old 4-20
Table 4-13. Total Tapwater Intake of Women 15-49 Years Old 4-20
Table 4-14. Total Fluid (mL/Day) Derived from Various Dietary Sources by Women Aged 15-49 Years 4-21
Table 4-15. Summary of Recommended Community Drinking Water Intake Rates 4-22
Table 4-16. Confidence in Tapwater Intake Recommendations 4-23
Table 5-1. Estimated Daily Soil Ingestion Based on Aluminum, Silicon, and Titanium Concentrations 5-29

LIST OF TABLES (Continued)

Table 5-2. Calculated Soil Ingestion by Nursery School Children 5-30
Table 5-3. Calculated Soil Ingestion by Hospitalized, Bedridden Children 5-31
Table 5-4. Mean and Standard Deviation Percentage Recovery of Eight Tracer Elements . . 5-31
Table 5-5. Soil and Dust Ingestion Estimates for Children Ages 1-4 Years 5-32
Table 5-6. Average Daily Soil Ingestion Values Based on Aluminum, Silicon, and Titanium as Tracer Elements 5-32
Table 5-7. Geometric Mean (Gm) and Standard Deviation (Gsd) Ltm Values for Children at Daycare Centers and Campgrounds 5-33
Table 5-8. Estimated Geometric Mean Ltm Values of Children Attending Daycare Centers According to Age, Weather Category, and Sampling Period 5-34
Table 5-9. Distribution of Average (Mean) Daily Soil Ingestion Estimates per Child for 64 Children (Mg/day) 5-35
Table 5-10. Estimated Distribution of Individual Mean Daily Soil Ingestion Based on Data for 64 Subjects Projected over 365 Days 5-35
Table 5-11. Estimated Soil Ingestion Rate Summary Statistics And Parameters for Distributions Using Binder et Al. (1986) Data with Actual Fecal Weights 5-36
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) 5-37
Table 5-13. Soil Ingestion Estimates for Median and Best Four Trace Elements Based on Food/Soil Ratios for 64 Anaconda Children (mg/day) Using Al, Si, Ti, Y, and Zr . . . 5-38
Table 5-14. Dust Ingestion Estimates for Median and Best Four Trace Elements Based on Food/Soil Ratios for 64 Anaconda Children (mg/day) Using Al, Si, Ti, Y, and Zr 5-39
Table 5-15. Daily Soil Ingestion Estimation in a Soil-pica Child by Tracer and by Week (mg/day) 5-40
Table 5-16. Ratios of Soil, Dust, and Residual Fecal Samples in the Soil Pica Child 5-41
Table 5-17. Daily variation of Soil Ingestion by Children Displaying Soil Pica in Wong (1988) 5-42
Table 5-18. Prevalence of Non-Food Ingestion Mouthing Behaviors by Child's Age: Percent of Children Whose Parents Reports the Behavior in the Past Month 5-43
Table 5-19. Average Outdoor Object Mouthing Scores for Children by Age, Frequency of Sand/Dirt Play, and General Mouthing Quartiles 5-46
Table 5-20. Summary of Estimates of Soil Ingestion by Children 5-47
Table 5-21. Summary of Recommended Values for Soil Ingestion 5-47
Table 5-22. Confidence in Soil Intake Recommendation 5-48
Table 6-1. Extrapolated Total Mouthing Times Minutes per Day (time awake) 6-12
Table 6-2. Frequency of Contact, by Contact Variable Contacts per Hour 6-13
Table 6-3. Summary of Studies on Mouthing Behavior 6-14
Table 6-4. Summary of Mouthing Frequency Data 6-15
Table 6-5. Confidence in Mouthing Behavior Recommendations 6-16
Table 7-1. Calibration And Field Protocols For Self-monitoring of Activities Grouped by Subject Panels 7-10

LIST OF TABLES (Continued)

Table 7-2. Subject Panel Inhalation Rates by Mean VR, Upper Percentiles, And Self-estimated Breathing Rates 7-10
Table 7-3. Distribution of Predicted Intake Rates by Location And Activity Levels For Elementary And High School Students 7-11
Table 7-4. Average Hours Spent Per Day in a Given Location and Activity Level For Elementary (EL) and High School (HS) Students 7-11
Table 7-5. Distribution Patterns of Daily Inhalation Rates For Elementary (EL) And High School (HS) Students Grouped by Activity Level 7-12
Table 7-6. Summary of Average Inhalation Rates (M^3/hr) by Age Group And Activity Levels For Laboratory Protocols 7-13
Table 7-7. Summary of Average Inhalation Rates (M^3/hr) by Age Group And Activity Levels in Field Protocols 7-14
Table 7-8. Comparisons of Estimated Basal Metabolic Rates (BMR) With Average Food-energy Intakes For Individuals Sampled in The 1977-78 NFCS 7-15
Table 7-9. Daily Inhalation Rates Calculated From Food-energy Intakes 7-16
Table 7-10. Daily Inhalation Rates Obtained From The Ratios Of Total Energy Expenditure to Basal Metabolic Rate (BMR) 7-17
Table 7-11. Inhalation Rates For Short-term Exposures 7-18
Table 7-12. Confidence in Inhalation Rate Recommendations 7-19
Table 7-13. Summary of Recommended Values For Inhalation 7-20
Table 7-14. Summary of Children's Inhalation Rates For Short-Term Exposure Studies . . . 7-21

Table 8-1. Total Body Surface Area of Male Children in Square Meters 8-17
Table 8-2. Total Body Surface Area of Female Children in Square Meters 8-18
Table 8-3. Percentage of Total Body Surface Area by Body Part For Children 8-19
Table 8-4. Descriptive Statistics For Surface Area/body Weight (SA/BW) Ratios (m^2/kg) . . 8-20
Table 8-5. Clothing choices and assumed body surface areas exposed 8-21
Table 8-6. Estimated skin surface exposed during warm weather outdoor play for children under age 5 (based on SCS-I data). 8-21
Table 8-7. Number and percentage of respondents with children and those reporting outdoor play activities in both warm and cold weather 8-22
Table 8-8. Play frequency and duration for all child players (from SCS-II data) 8-22
Table 8-9. Hand washing and bathing frequency for all child players (from SCS-II data) . . . 8-23
Table 8-10. NHAPS and SCS-II play duration comparison 8-23
Table 8-11. NHAPS and SCS-II hand wash frequency comparison 8-24
Table 8-12. Summary of Field Studies 8-25
Table 8-13. Geometric Mean And Geometric Standard Deviations of Soil Adherence by Activity And Body Region 8-26
Table 8-14. Summary of Groups Assayed in Round 2 of Field Measurements 8-27
Table 8-15. Attire for Individuals within Children's Groups Studied 8-28

LIST OF TABLES (Continued)

Table 8-16. Geometric Means (Geometric Standard Deviations) of Round 2 Post-activity Loadings 8-29
Table 8-17. Summary of Controlled Green House Trials - Children Playing 8-30
Table 8-18. Preactivity Loadings Recovered from Greenhouse Trial Children Volunteers . . 8-31
Table 8-19. Summary of Recommended Values For Skin Surface Area 8-33
Table 8-20. Confidence in Body Surface Area Measurement Recommendations 8-34
Table 8-21. Confidence in Soil Adherence to Skin Recommendations 8-35

Table 9-1. Mean Time Spent (minutes) Performing Major Activities Grouped by Age, Sex and Type of Day 9-15
Table 9-2. Mean Time Spent (minutes) in Major Activities Grouped by Type of Day for Five Different Age Groups 9-16
Table 9-3. Mean Time Spent Indoors and Outdoors Grouped by Age and Day of the Week 9-17
Table 9-4. Mean Time Spent at Three Locations for both CARB and National Studies (ages 12 years and older) 9-18
Table 9-5. Mean Time Spent (minutes/day) in Various Microenvironments Grouped by Total Population and Gender (12 years and over) in the National and CARB Data . . 9-19
Table 9-6. Mean Time Spent (minutes/day) in Various Microenvironments by Type of Day for the California and National Surveys 9-20
Table 9-7. Mean Time Spent (minutes/day) in Various Microenvironments by Age Groups for the National and California Surveys 9-21
Table 9-8. Mean Time (minutes/day) Children Ages 12 Years and Under Spent in Ten Major Activity Categories for All Respondents 9-22
Table 9-9. Mean Time Children Spent in Ten Major Activity Categories Grouped by Age and Gender 9-23
Table 9-10. Mean Time Children Ages 12 Years and Under Spent in Ten Major Activity Categories Grouped by Seasons and Regions 9-24
Table 9-11. Mean Time Children Ages 12 Years and Under Spent in Six Major Location Categories for All Respondents (minutes/day) 9-25
Table 9-12. Mean Time Children Spent in Six Location Categories Grouped by Age and Gender 9-25
Table 9-13. Mean Time Children Spent in Six Location Categories Grouped by Season and Region 9-26
Table 9-14. Mean Time Children Spent in Proximity to Three Potential Exposures Grouped by All Respondents, Age, and Gender 9-26
Table 9-15. Mean Time Spent Indoors and Outdoors Grouped by Age 9-31
Table 9-16. Range of Recommended Defaults for Dermal Exposure Factors 9-32
Table 9-17. Number of Times Taking a Shower at Specified Daily Frequencies by the Number of Respondents 9-32

LIST OF TABLES (Continued)

Table 9-18. Time (minutes) Spent Taking a Shower and Spent in the Shower Room After Taking a Shower by the Number of Respondents 9-32
Table 9-19. Time (minutes) Spent Taking a Shower and Spent in the Shower Immediately After Showering 9-33
Table 9-20. Total Time Spent Altogether in the Shower or Bathtub and Time Spent in the Bathroom Immediately After by Number of Respondents 9-33
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 9-34
Table 9-22. Range of Number of Times Washing the Hands at Specified Daily Frequencies by the Number of Respondents 9-34
Table 9-23. Number of Minutes Spent Working or Being Near Excessive Dust in the Air (minutes/day) 9-34
Table 9-24. Range of Number of Times per Day a Motor Vehicle was Started in a Garage or Carport and Started with the Garage Door Closed 9-35
Table 9-25. Number of Minutes Spent Playing on Sand, Gravel, Dirt, or Grass 9-35
Table 9-26. Number of Minutes Spent Playing in Sand, Gravel, Dirt or Grass (minutes/day) 9-36
Table 9-27. Range of Number of Minutes Spent Playing on Grass in a Day by the Number of Respondents 9-36
Table 9-28. Number of Minutes Spent Playing on Grass (minutes/day) 9-36
Table 9-29. Number of Times Swimming in a Month in Freshwater Swimming Pool by the Number of Respondents 9-37
Table 9-30. Number of Minutes Spent Swimming in a Month in Freshwater Swimming Pool (minutes/month) 9-37
Table 9-31. Range of the Average Amount of Time Actually Spent in the Water by Swimmers by the Number of Respondents 9-37
Table 9-32. Statistics for 24-Hour Cumulative Number of Minutes Spent Playing Indoors and Outdoors 9-38
Table 9-33. Statistics for 24-Hour Cumulative Number of Minutes Spent Sleeping/Napping 9-38
Table 9-34. Statistics for 24-Hour Cumulative Number of Minutes Spent Attending Full Time School 9-38
Table 9-35. Statistics for 24-Hour Cumulative Number of Minutes Spent in Active Sports and for Time Spent in Sports/Exercise 9-39
Table 9-36. Statistics for 24-Hour Cumulative Number of Minutes Spent in Outdoor Recreation and Spent Walking 9-39
Table 9-37. Statistics for 24-Hour Cumulative Number of Minutes Spent in Bathing 9-40
Table 9-38. Statistics for 24-Hour Cumulative Number of Minutes Eating or Drinking 9-40
Table 9-39. Statistics for 24-Hour Cumulative Number of Minutes Spent Indoors at School and Indoors at a Restaurant 9-40
Table 9-40. Statistics for 24-Hour Cumulative Number of Minutes Spent Outdoors on School Grounds/Playground, at a Park/Golf Course, and at a Pool/River/Lake 9-41

LIST OF TABLES (Continued)

Table 9-41. Statistics for 24-Hour Cumulative Number of Minutes Spent at Home in the Kitchen Bathroom, Bedroom, and in a Residence (All Rooms) 9-42
Table 9-42. Statistics for 24-Hour Cumulative Number of Minutes Spent Traveling Inside a Vehicle 9-43
Table 9-43. Statistics for 24-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 9-43
Table 9-44. Statistics for 24-Hour Cumulative Number of Minutes Spent in Malls, Grocery Stores, or Other Stores 9-43
Table 9-45. Statistics for 24-hour Cumulative Number of Minutes Spent with Smokers Present 9-44
Table 9-46. Range of Time (minutes) Spent Smoking Based on the Number of Respondents 9-45
Table 9-47. Number of Minutes Spent Smoking (minutes/day) 9-45
Table 9-48. Gender and Age Groups 9-46
Table 9-49. Assignment of At-Home Activities to Ventilation Levels for Children 9-47
Table 9-50. Aggregate Time Spent (minutes/day) At-Home in Activity Groups by Adolescents and Children 9-48
Table 9-51. Comparison of Mean Time (minutes/day) Spent At-Home by Gender (Adolescents) 9-48
Table 9-52. Comparison of Mean Time (minutes/day) Spent At-Home by Gender and Age for Children 9-48
Table 9-53. Number of Person-Days/Individuals[a] for Children in CHAD Database 9-49
Table 9-54. Number of Hours Per Day Children Spend in Various Microenvironments by Age Average ± Std. Dev. (Percent of Children Reporting >0 Hours in Microenvironment) 9-50
Table 9-55. Average Number of Hours Per Day Children Spend Doing Various Macroactivities *While Indoors at Home* by Age 9-51
Table 9-56. Confidence in Activity Patterns Recommendations 9-52
Table 9-57. Summary of Activity Pattern Studies 9-59
Table 9-58. Summary of Mean Time Spent Indoors and Outdoors from Several Studies . . . 9-60
Table 9-59. Summary of Recommended Values for Activity Factors 9-61

Table 10-1. Consumer Products Found in the Typical U.S. Household 10-4
Table 10-2. Number of Minutes Spent in Activities Working with or Near Household Cleaning Agents Such as Scouring Powders or Ammonia (minutes/day) 10-7
Table 10-3 Number of Minutes Spent Using Any Microwave Oven (minutes/day) 10-7
Table 10-4. Number of Respondents Using a Humidifier at Home 10-7
Table 10-5. Number of Respondents Indicating that Pesticides Were Applied by the Professional at Home to Eradicate Insects, Rodents, or Other Pests at Specified Frequencies 10-8
Table 10-6. Number of Respondents Reporting Pesticides Applied by the Consumer at Home To Eradicate Insects, Rodents, or Other Pests at Specified Frequencies 10-8

LIST OF TABLES (Continued)

Table 11-1. Smoothed Percentiles of Weight (In Kg) by Sex And Age: Statistics From NCHS And Data From Fels Research Institute, Birth to 36 Months 11-6
Table 11-2. Body Weights of Children[a] (Kilograms) 11-9
Table 11-3. Weight in Kilograms For Males 6 Months-19 Years of Age–number Examine, Mean, Standard Deviation, and Selected Percentiles, by Sex and Age: United States, 1976-1980 11-10
Table 11-4. Weight in Kilograms For Females 6 Months-19 Years of Age - Number Examine, Mean, Standard Deviation, And Selected Percentiles, By Sex And Age: United States, 1976-1980 11-11
Table 11-5. Best-fit Parameters for Lognormal Distributions 11-12
Table 11-6. Statistics for Probability Plot Regression Analyses Male's Body Weights 6 Months to 20 Years of Age 11-13
Table 11-7. Body Weight Estimates (in kilograms) by Age and Gender, U.S. Population 1988-94 11-14
Table 11-8. Body Weight Estimates (in kilograms) by Age, U.S. Population 1988-94 11-15
Table 11-9. Summary of Recommended Values for Body Weight 11-16
Table 11-10. Confidence in Body Weight Recommendations 11-17

Table 12-1. Expectation of Life at Birth, 1980 to 1993, And Projections, 1995 to 2010 (Years) 12-4
Table 12-2. Expectation of Life by Race, Sex, And Age: 1996 12-5
Table 12-3. Confidence in Lifetime Expectancy Recommendations 12-6

LIST OF FIGURES

Figure 1-1. Schematic of Dose and Exposure: Oral Route 1-12
Figure 8-1. Schematic of Dose and Exposure: Dermal Route 8-2
Figure 8-2. Skin Coverage as Determined by Fluorescence vs. Body Part for Adults Transplanting Plants and for Children Playing in Wet Soils 8-32
Figure 8-3. Gravimetric Loading vs. Body Part for Adult Transplanting Plants in Wet Soil and for Children Playing in Wet and Dry Soils 8-32

Figure 9-1. Distribution of the Number of Hours per Day Study Children Spent Indoors at Home 9-27
Figure 9-2. Distribution of the Number of Hours per Day Study Children Spent Indoors Away from Home 9-28
Figure 9-3. Distribution of the Number of Hours per Day Study Children Spent Outdoors at Home 9-29
Figure 9-4. Distribution of the Number of Hours per Day Study Children Spent Outdoors Away from Home 9-30

Figure 11-1. Weight by Age percentiles for Girls Aged Birth-36 Months 11-7
Figure 11-2. Weight by Age Percentiles for Boys Aged Birth-36 Months 11-8
Figure 11-3. Mean Body Weights Estimates, U.S. Population, 1988-94 11-18
Figure 11-4. Median Body Weights Estimates, U.S. Population, 1988-94 11-19

PREFACE

The National Center for Environmental Assessment (NCEA) of EPA's Office of Research and Development (ORD) has prepared this handbook to address factors commonly used in exposure assessments for children. 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.

The National Center for Environmental Assessment has published the *Exposure Factors Handbook* in 1997. This document 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 the Child-Specific Exposure Factors Handbook is to fulfill this need.

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.

The *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. This *Child-Specific Exposure Factors Handbook* is being prepared to focus on various factors used in assessing exposure, specifically for children ages 0 - 19 years old. The recommended values are based solely on our interpretations of the available data. In many situations different values may be appropriate to use in consideration of policy, precedent or other factors.

AUTHORS, CONTRIBUTORS, AND REVIEWERS

The National Center for Environmental Assessment (NCEA), Office of Research and Development was responsible for the preparation of this handbook. This document has been prepared by the Exposure Assessment Division of Versar Inc. in Springfield, VA under EPA Contract No. 68-W-99-041, Work Assignments Nos 1-10 and 2-11. Jackie Moya served as Work Assignment Manager, providing overall direction, technical assistance, and serving as contributing author.

AUTHORS	**WORD PROCESSING**
Versar Inc.	Versar Inc.
Linda Phillips	Susan Perry
Patricia Wood	Valerie Schwartz
Marit Espevik	
Todd Perryman	
Clarkson Meredith	
Didi Sinkowski	
U.S. EPA	
Jacqueline Moya	

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

Office of Research and Development	Amina Wilkins
Office of Water Health and Ecological Criteria Division	Denis R. Borum
EPA Regions	Lynn Flowers - Region III Youngmoo Kim - Region VI
National Exposure Research Laboratory	Tom McCurdy Nicole Tulve Valerie Zartarian

In addition, the National Exposure Research Laboratory (NERL) of the Office of Research and Development of EPA made an important contribution to this handbook by conducting additional analysis of mouthing behavior data from the Davis 1995 study. Data analysis was conducted by Nicolle Tulve.

TABLE OF CONTENTS

1. INTRODUCTION 1-1
1.1 BACKGROUND 1-1
1.2 PURPOSE 1-3
1.3 INTENDED AUDIENCE 1-3
1.4 SELECTION OF STUDIES FOR THE HANDBOOK 1-4
1.5 APPROACH USED TO DEVELOP RECOMMENDATIONS FOR EXPOSURE FACTORS 1-6
1.6 CHARACTERIZING VARIABILITY 1-7
1.7 USING THE HANDBOOK IN AN EXPOSURE ASSESSMENT 1-10
1.7.1 General Equation for Calculating Dose 1-11
1.8 FUTURE OR ON-GOING WORK 1-15
1.9 RESEARCH NEEDS 1-16
1.10 ORGANIZATION 1-17
1.11 REFERENCES FOR CHAPTER 1 1-19

LIST OF TABLES

Table 1-1. Considerations Used to Rate Confidence
in recommended Values 1-21
Table 1-2. Summary of Exposure Factor Recommendations
and Confidence Ratings 1-22
Table 1-3. Characterization of Variability in Exposure Factors 1-24

LIST OF FIGURES

Figure 1-1. Schematic of Dose and Exposure: Oral Route 1-12

1. INTRODUCTION

1.1 BACKGROUND

Because of differences in physiology and behaviors, exposures among children are expected to be different than among adults. Children may be more highly exposed to environmental toxicants than adults, because they consume more food and water, and have higher inhalation rates per unit of body weight, and have higher surface area to volume than adults. Also, young children play close to the ground and are more likely to come into contact with contaminated soil outdoors and with contaminated dust on surfaces and carpets indoors. Children may also be exposed to contaminants as a result of hand-to-mouth and object-to-mouth activities as a result of behaviors existing during certain phases of childhood. As another example, exposure to chemicals in breast milk affects specifically infants and young children. 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).

In April, 1997, President Clinton signed an Executive Order to Protect Children from Environmental Health Risks and Safety Risks. The Order requires all federal agencies to address health and safety risks to children, coordinate research priorities on children's health, and ensure that their standards take into account special risks to children. To implement the President's Executive Order, EPA 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) National Center for Environmental Assessment (NCEA) issued a Children's Risk Policy, which emphasized the need to evaluate exposures and risks among this population and ORD developed a Strategy for Research on Risks to Children (Children's Research Strategy) (U.S. EPA, 1997a; 1999a). 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 the *Exposure Factors Handbook* (U.S. EPA, 1997b). The Handbook includes exposure factors and related data on both adults and children. OCHP's recently-issued its child-related risk assessment policy and methodology guidance document survey (U.S. EPA, 1999b), highlighted the *Exposure Factors Handbook* (U.S. EPA, 1997b) as a source of information on exposure factors for children. EPA's *Children's Environmental Health Yearbook* (U.S. EPA, 1998) also listed the *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 non-chemical-specific data on exposure factors that can be used to assess doses from dietary and non-dietary ingestion exposure, dermal exposure, and inhalation exposure among children.

This handbook provides exposure factors for children in the following areas:

- breast milk ingestion;
- food ingestion, including homegrown foods and other dietary-related data;
- 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 described in detail in EPA's *Exposure Factors Handbook* (1997b), but data that have been published subsequent to release of the *Exposure Factors Handbook* are also presented. With very few exceptions, the data presented are the analyses of the individual study authors. Since the studies included in this handbook varied in terms of their objectives, design, scope, presentation of results, etc., the level of detail, statistics, and terminology may vary from study to study and from factor to factor. For example, some authors used geometric means to present their results, while others used arithmetic means or distributions. Authors have sometimes used different 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. Further, the strengths and limitations of each study are discussed to provide the reader with a better understanding of the uncertainties associated with the values derived from the study.

1.2 PURPOSE

The purpose of the *Child-specific Exposure Factors Handbook* is to: (1) summarize key data on human behaviors and characteristics which 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 which program offices or individual exposure assessors can consider and modify as needed. Most of these factors are best quantified on a site or situation-specific basis. The data presented in this handbook have come from various sources, including the 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 the issues which assessors should consider in assessing exposure among children, and may be used in conjunction with the EPA document: EPA/600/R-99/060 July 1999, entitled *Socio-demographic Data Used for Identifying Potentially Highly Exposed Subpopulations of Children*, which is currently being drafted and provides population data for children.

1.3 INTENDED AUDIENCE

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

1.4 SELECTION OF STUDIES FOR THE HANDBOOK

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

General Considerations

Many scientific studies were reviewed for possible inclusion in this handbook. Generally, studies identified in the *Exposure Factors Handbook* (U.S. EPA, 1997b) as key studies were also included in this children's document. New studies that became available after publication of the *Exposure Factors Handbook* were also included. Key studies from the *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 the *Exposure Factors Handbook*, the key studies were selected based on the following considerations:

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

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

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

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

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

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

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

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

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

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

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

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

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

1.5 APPROACH USED TO DEVELOP RECOMMENDATIONS FOR EXPOSURE FACTORS

As discussed above, EPA first reviewed all 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 to select in consideration of policy, precedent, strategy, or other factors such as site-specific information. EPA's procedure for developing recommendations was as follows:

1. Key studies were evaluated in terms of both quality and relevance to specific populations (general U. S. population, age groups, gender, etc.). The criteria for assessing the quality of studies is described in Section 1.4.
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 there were multiple key studies, all 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 were 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 were 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 mid-point 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. Limitations of the data 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 have been used in the derivation of the recommended value.
5. Finally, EPA assigned a confidence rating of low, medium or high to each recommended value. This rating is 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 earlier 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 depend 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 the factor of interest," and "data pertinent to the U.S." These elements are important for the study to be included in this handbook. However, a high score of 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 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, in the feces, the levels of certain elements found in soil. Body weight, however, can be measured directly and it is, therefore, a more reliable measurement. This 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 document attempts to characterize variability of each of the factors. Variability is characterized in one or more of three ways: (1) as tables with various percentiles or ranges of values; (2) as analytical distributions with specified parameters; and/or (3) as a qualitative discussion. Analyses to fit standard or parametric distributions (e.g., normal, lognormal) to the exposure data have not been performed by the authors of this handbook, but have been reproduced in this document wherever they were found in the literature. Recommendations on the use of these distributions are made where appropriate based on the adequacy of the supporting data. The list of exposure factors and the way that variability has been characterized (i.e., average, upper percentiles, multiple percentiles, fitted distribution) are presented in Table 1-3.

The term upper percentile is used throughout this handbook and it 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.

An attempt was made to present percentile values in the recommendations that are consistent with the exposure estimators defined in the Exposure Guidelines (i.e., mean, 50th, 90th, 95th, 98th, and 99.9th percentile). This was not, however, 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 Exposure Guidelines within the context of risk descriptors and not individual exposure factors. For example, the Guidelines stated 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 require a selection of distributions or histograms for the input parameters. Although this handbook is not intended to provide a complete guidance on the use of Monte Carlo and other probabilistic analyses, the following should be considered when using such techniques:

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

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

In addition to a qualitative statement of uncertainty, the representativeness assumption should be appropriately addressed as part of a sensitivity analysis.

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

- If only a range of values is known for an exposure factor, the assessor has several options.
  - keep that variable constant at its central value;
  - assume several values within the range of values for the exposure factor;
  - calculate a point estimate(s) instead of using probabilistic analysis; and
  - assume a distribution (The rationale for the selection of a distribution should be discussed at length.) There are, however, cases where assuming a distribution is not recommended. These include:
    - -- data are missing or very limited for a key parameter;
    - -- data were collected over a short time period and may not represent long term trends (the respondent usual behavior) - examples include: food consumption surveys; activity pattern data;
    - -- data are not representative of the population of interest because sample size was small or the population studied was selected from a local area and was therefore not representative of the area of interest - examples include: soil ingestion by children; and
    - -- ranges for a key variable are uncertain due to experimental error or other limitations in the study design or methodology - examples include: soil ingestion by children.

1.7 USING THE HANDBOOK IN AN EXPOSURE ASSESSMENT

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

- Guidelines for Exposure Assessment (U.S. EPA 1992a);

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

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 targeted (1) the general population (e.g., USDA food consumption surveys); and (2) a sample population from a specific area or group (e.g., Calabrese's et al. (1989) soil ingestion study using children from the Amherst, Massachusetts, area). Due to unique activity patterns, preferences, practices and biological differences, various segments of the population may experience exposures that are different from those of the general population, which, in many cases, may be greater. It is necessary for risk or exposure assessors characterizing a diverse population, to identify and enumerate certain groups within the general population who are at risk for greater contaminant exposures or exhibit a heightened sensitivity to particular chemicals. For further guidance on addressing susceptible populations, it is recommended to consult the EPA, National Center for Environmental Assessment document: EPA/600/R-99/060 July 1999, entitled, *Socio-demographic Data Used for Identifying Potentially Highly Exposed Subpopulations*.

1.7.1 General Equation for Calculating Dose

The definition of exposure as used in the Exposure Guidelines (U.S. EPA, 1992a) is "condition of a chemical contacting the outer boundary of a human." This means contact with the visible exterior of a person such as the skin, and openings such as the mouth, nostrils, and lesions. The process of a chemical entering the body can be described in two steps: contact (exposure), followed by entry (crossing the boundary). The magnitude of exposure (dose) is the amount of agent available at human exchange boundaries (skin, lungs, gut) where absorption takes place during some specified time. An example of exposure and dose for the oral route as presented in the EPA Exposure Guidelines is shown in Figure 1-1. Starting with a general integral equation for exposure (U.S. EPA 1992a), several dose equations can be derived depending upon boundary assumptions. One of the more useful of these derived equations is the Average Daily Dose (ADD). The ADD, which is used for many noncancer effects, averages exposures or doses over the period of time over which exposure occurred. The ADD can be calculated by averaging the potential dose (D_{pot}) over body weight and an averaging time.

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

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 average daily doses (LADDs). The LADD takes the form of the Equation 1-1 with lifetime replacing averaging time. The LADD is a very common term used in carcinogen risk assessment where linear non-threshold models are employed.

The total exposure can be expressed as follows:

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

Where:

C = Contaminant Concentration
IR = Intake Rate
ED = Exposure Duration

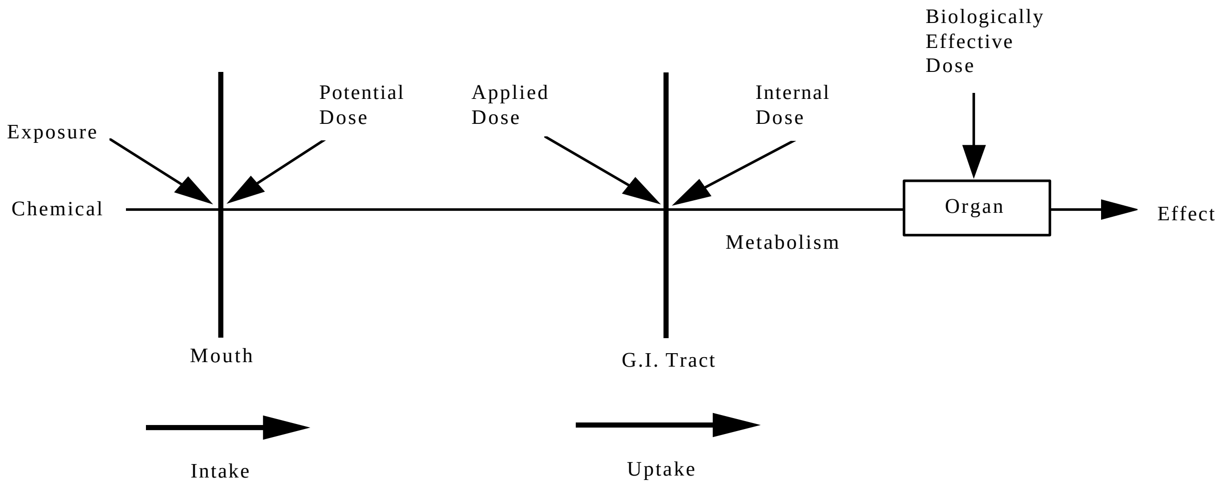


Figure 1-1. Schematic of Dose and Exposure: Oral Route

Source: U.S. EPA, 1992a

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

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

The exposure duration is the length of time that contaminant contact lasts. The time a person lives in an area, frequency of bathing, time spent indoors versus outdoors, etc. all affect the exposure duration. The Activity Factors Chapter (Chapter 9) gives some examples of population behavior patterns, which may be useful for estimating exposure durations to be used in the exposure calculations.

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

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 when current information indicates that the human absorption factor used in the derivation of the dose-response factor is inappropriate.

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

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

The units of intake in this handbook for the ingestion of fish, breast milk, and the inhalation of air are not normalized to body weight. In this case, the exposure assessor needs to use (in Equation 1-1) the average weight of the exposed population during the time when the exposure actually occurs. If the body weight of the individuals in the population whose risk is being evaluated is non-standard in some way, such as for children or for first-generation immigrants who may be smaller than the national population, and if reasonable values are not available in the literature, then a model of intake as a function of body weight must be used. One such model is discussed in Appendix 1A of the 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.

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 of importance 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, 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 have been presented in this handbook (Chapter 3) in both "as consumed" and uncooked basis. It is important for the assessor to be aware of these issues and choose intake rate data that best matches the concentration data that is being used.

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

- The intake rate can be based on an individual event (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.

1.8 FUTURE OR ON-GOING WORK

EPA is also developing guidance on the use of exposure factors data. For future information on the status of this guidance, it is recommended to consult the EPA National Center for Environmental Assessment homepage (www.epa.gov/ncea). Another on-going effort is the Risk Assessment Forum project on defining age groups for children that are appropriate for use in risk assessment.

1.9 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 breastmilk consumption.

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

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

- Research is needed to better estimate soil intake rates, particularly on how to extrapolate short-term data to chronic exposures. Research is also needed to refine the methods to calculate soil intake rates (i.e., inconsistencies among tracers and input/output misalignment errors indicate a fundamental problem with the methods). Additional information on soil ingestion among children that provides better estimates of upper percentile rates is needed, in particular.

- Further research is needed on non-dietary ingestion 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, 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.

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

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

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

- Additional data on inhalation rates that are specific to children's activities are needed.

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

- 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.

- Regarding breast milk ingestion, research is needed on incidence and duration of breast feeding.

1.10 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 breastmilk
Chapter 3	Provides factors for estimating human exposure through ingestion foods, including fish
Chapter 4	Provides factors for estimating exposure through 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 non-dietary 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 lifetime

1.11 REFERENCES FOR CHAPTER 1

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

Gilbert, R.O. (1987) Statistical methods for environmental pollution monitoring. New York: Van Nostrand Reinhold.

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

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

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

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

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

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

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

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

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

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

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

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

U.S. EPA. (1997a) Office of Research and Development strategy for research on risks to children. Washington, DC: Office of Research and Development, Science Council Review Draft.

U.S. EPA. (1997b) Exposure factors handbook. Washington, DC: National Center for Environmental Assessment, Office of Research and Development. EPA/600/P-95/002Fa,b,c.

U.S. EPA. (1998) The EPA children's environmental health yearbook. Washington, DC: U.S. Environmental Protection Agency.

U.S. EPA. (1999a) Strategy for research on environmental risks to children. Washington, DC: Office of Research and Development. External Peer Review Draft.

U.S. EPA. (1999b) Child-related risk assessment policy and methodology guidance document survey, draft report. Washington, DC: Office of Children's Health Protection.

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 high level of peer review (e.g., they appear 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 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 focused 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 focused 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 1980.
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	The sample size is greater than 100 samples. 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.	The sample size is less than 20 samples.
Representativeness of the population	The study population is the same as population of interest.	The study population is very different from the population of interest.[a]
Variability in the population	The studies characterized 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] Differences include age, sex, race, income, or other demographic parameters.

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

EXPOSURE FACTOR	RECOMMENDATION	CONFIDENCE RATING
Breast milk intake rate (1-6 months)	742 ml/day (average) 1,033 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 3-15	--
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 (ave.) Low (upper percentile) Low Low Low
Home produced food intake	See Table 3-28	Medium (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
Inhalation rate	Children (<1 year) 4.5 m^3/day (average) Children (1-12 years) 8.7 m^3/day (average)	High High

Table 1-2 (Cont'd). Summary of Exposure Factor Recommendations and Confidence Ratings

EXPOSURE FACTOR	RECOMMENDATION	CONFIDENCE RATING
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	High High
Soil adherence	Use values presented in Table 8-13 depending on activity and body part (central estimates only)	Low
Life expectancy	75 years	High
Body weights for children	Use values presented in Tables 11-3 and 11-4 (mean and percentiles)	High
Body weights for infants (birth to 6 months)	Use values presented in Table 11-1 (percentiles)	High
Showering/Bathing	Showering time 10 min/day (average) 1 shower event/day	High
Swimming	Frequency 1 event/month Duration 60 min/event (median)	High High
Time indoors	Children (ages 3-5 years) 19 hr/day Children (ages 6-14 years) 20 hr/day Children (ages 12-17 years) 19 hrs/day	Medium High
Time outdoors	Children (ages 3-5 years) 2.8 hr/day Children (ages 6-8 years) 2.2 hr/day Children (ages 9-14 years) 1.8 hr/day Children (ages 12-17 years) 19 hr/day	Medium High

Table 1-3. Characterization of Variability in Exposure Factors

Exposure Factors	Average	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	✓			
Life expectancy	✓			
Body weight	✓	✓	✓	
Time indoors	✓			
Time outdoors	✓			
Showering time	✓	✓	✓	
Occupational tenure	✓			
Population mobility	✓	✓	✓	

TABLE OF CONTENTS

2. BREAST MILK INTAKE 2-1
2.1 INTRODUCTION 2-1
2.2 STUDIES ON BREAST MILK INTAKE 2-2
2.3 STUDIES ON LIPID CONTENT AND FAT INTAKE FROM BREAST MILK 2-5
2.4 OTHER FACTORS 2-7
2.5 RECOMMENDATIONS 2-8
2.6 REFERENCES FOR CHAPTER 2 2-10

LIST OF TABLES

Table 2-1. Daily Intakes of Breast Milk 2-11
Table 2-2. Breast Milk Intake for Infants Aged 1 to 6 Months 2-11
Table 2-3. Breast Milk Intake among Exclusively Breast-fed Infants During the First 4 Months of Life 2-12
Table 2-4. Breast Milk Intake During a 24-hour Period 2-13
Table 2-5. Breast Milk Intake Estimated by the Darling Study 2-14
Table 2-6. Lipid Content of Human Milk and Estimated Lipid Intake among Exclusively Breast-fed Infants 2-14
Table 2-7. Predicted Lipid Intakes for Breast-fed Infants under 12 Months of Age 2-14
Table 2-8. Number of Meals per Day 2-15
Table 2-9. 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] 2-16
Table 2-10. Confidence in Breast Milk Intake Recommendations 2-17
Table 2-11. Breast Milk Intake Rates Derived from Key Studies 2-18
Table 2-12. Summary of Recommended Breast Milk And Lipid Intake Rates 2-19

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 quantity of breast milk consumed per day and the duration (months) over which breast-feeding occurs. Information on the fat content of breast milk is also needed for estimating dose from breast milk residue concentrations that have been indexed to lipid content.

Several studies have generated data on breast milk intake. Typically, breast milk intake has been measured over a 24-hour period by weighing the infant before and after each feeding without changing its clothing (test weighing). The sum of the difference between the measured weights over the 24-hour period is assumed to be equivalent to the amount of breast milk consumed daily. Intakes measured using this procedure are often corrected for evaporative water losses (insensible water losses) between infant weighings (NAS, 1991). Neville et al. (1988) evaluated the validity of the test weight approach among bottle-fed infants by comparing the weights of milk taken from bottles with the differences between the infants' weights before and after feeding. When test weight data were corrected for insensible water loss, they were not significantly different from bottle weights. Conversions between weight and volume of breast milk consumed are made using the density of human milk (approximately 1.03 g/mL) (NAS, 1991). Recently, techniques for measuring breast milk intake using stable isotopes have been developed. However, few data based on this new technique have been published (NAS, 1991).

Studies among nursing mothers in industrialized countries have shown that intakes among infants average approximately 750 to 800 g/day (728 to 777 mL/day) during the first 4 to 5 months of life with a range of 450 to 1,200 g/day (437 to 1,165 mL/day) (NAS, 1991). Similar intakes have also been reported for developing countries (NAS, 1991). Infant birth weight and nursing frequency have been shown to influence the rate of intake (NAS, 1991). Infants who are larger at birth and/or nurse more frequently have been shown to have higher intake rates. Also, breast milk production among nursing mothers has been reported to be somewhat higher than the amount actually consumed by the infant (NAS, 1991).

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 the *Exposure Factors Handbook*. Relevant data on lipid content and fat intake, breast-feeding duration and frequency, and the estimated percentage of the U.S. population that breast-feeds are also presented.

2.2 STUDIES ON BREAST MILK INTAKE

Pao et al. (1980) - Milk Intakes and Feeding Patterns of Breast-fed Infants - Pao et al. (1980) conducted a study of 22 healthy breast-fed infants to estimate breast milk intake rates. Infants were categorized as completely breast-fed or partially breast-fed. Breast feeding mothers were recruited through LaLeche League groups. Except for one black infant, all other infants were from white middle-class families in southwestern Ohio. The goal of the study was to enroll infants as close to one month of age as possible and to obtain records near one, three, six, and nine months of age (Pao et al., 1980). However, not all mother/infant pairs participated at each time interval. Data were collected for these 22 infants using the test weighing method. Records were collected for three consecutive 24-hour periods at each test interval. The weight of breast milk was converted to volume by assuming a density of 1.03 g/mL. Daily intake rates were calculated for each infant based on the mean of the three 24-hour periods. Mean daily breast milk intake rates for the infants surveyed at each time interval are presented in Table 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. Pao et al. (1980) also noted that intake rates for boys in both groups were slightly higher than 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 and may not be entirely representative of the U.S. population, based on race and socioeconomic status, which may introduce some bias in the results. In addition, this study did not account for insensible water loss which may underestimate the amount of breast milk ingested.

Dewey and Lönnerdal (1983) - Milk and Nutrient Intakes of Breast-fed Infants from 1 to 6 Months - Dewey and Lönnerdal (1983) monitored the dietary intake of 20 breast-fed infants between the ages of 1 and 6 months. Most of the infants in the study were exclusively breast-fed (five were given some formula, and several were given small amounts of solid foods after 3 months of age). According to Dewey and Lönnerdal (1983), the mothers were all well educated and recruited through Lamaze childbirth classes in the Davis area of California. Breast milk intake volume was estimated based on two 24-hour test weighings per month. Breast milk intake rates for the various age groups are presented in Table 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 based on two 24-hour observations per infant per month. Corrections for insensible water loss apparently were not made. Also, the number of infants in the study was relatively small and may not be representative of U.S. population, based on race and socioeconomic status.

Butte et al. (1984) - Human Milk Intake and Growth in Exclusively Breast-fed Infants - Breast milk intake was studied in exclusively breast-fed infants during the first 4 months of life (Butte et al., 1984). Breastfeeding mothers were recruited through the Baylor Milk Bank Program in Texas. Forty-five mother/infant pairs participated in the study. However, data for some time periods (i.e., 1, 2, 3, or 4 months) were missing for some mothers as a result of illness or other factors. The mothers were from the middle- to upper-socioeconomic stratum and had a mean age of 28.0 ± 3.1 years. A total of 41 mothers were white, 2 were Hispanic, 1 was Asian, and 1 was West Indian. Infant growth progressed satisfactorily over the course of the study. The amount of milk ingested over a 24-hour period was determined using the test weighing procedure. Test weighing occurred over a 24-hour period for most participants, but intake among several infants was studied over longer periods (48 to 96 hours) to assess individual variation in intake. The study did not indicate whether the data were corrected for insensible water loss. Mean breast milk intake ranged from 723 g/day (702 mL/day) at 3 months to 751 g/day (729 mL/day) at 1 month, with an overall mean of 733 g/day (712 mL/day) for the entire study period (Table 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 percent.

The advantage of this study is that data for a larger number of exclusively breast-fed infants were collected than were collected by Pao et al. (1980). However, data were collected over a shorter time period (i.e., 4 months compared to 6 months) and day-to-day variability was not characterized for all infants. In addition, the population studied may not be representative of the U.S. population based on race and socioeconomic status.

Neville et al. (1988) - Studies on Human Lactation - Neville et al. (1988) studied breast milk intake among 13 infants during the first year of life. The mothers were all multiparous, nonsmoking, Caucasian women of middle- to upper-socioeconomic status living in Denver, Colorado (Neville et al., 1988). All women in the study practiced exclusive breast-feeding for at least 5 months. Solid foods were introduced at mean age of 7 months. Daily milk intake was estimated by the test weighing method with corrections for insensible weight loss. Data were collected daily from birth to 14 days, weekly from weeks 3 through 8, and monthly until the study period ended at 1 year after inception. The estimated breast milk intakes for this study are listed in Table 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.

In comparison to the previously described studies, Neville et al. (1988) collected data on numerous days over a relatively long time period (12 months) and they were corrected for insensible weight loss. However, the intake rates presented in Table 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, and the population studied may not be representative of the U.S. population, based on race and socioeconomic status.

Dewey et al. (1991a; 1991b) - The DARLING Study - The Davis Area Research on Lactation, Infant Nutrition and Growth (DARLING) study was conducted in 1986 to evaluate growth patterns, nutrient intake, morbidity, and activity levels in infants who were breast-fed for at least the first 12 months of life (Dewey et al., 1991a; 1991b). Seventy-three infants aged 3 months were included in the study. The number of infants included in the study at subsequent time intervals was somewhat lower as a result of attrition. All infants in the study were healthy and of normal gestational age and weight at birth, and did not consume solid foods until after the first 4 months of age. The mothers were highly educated and of "relatively high socioeconomic status" from the Davis area of California (Dewey et al., 1991a; 1991b). Breast milk intake was estimated by weighing the infants before and after each feeding and correcting for insensible water loss. Test weighings were conducted over a 4-day period every 3 months. The results of the study indicate that breast milk intake declines over the first 12 months of life. Mean breast milk intake was estimated to be 812 g/day (788 mL/day) at 3 months and 448 g/day (435 mL/day) at 12 months (Table 2-5). Based on the estimated intakes at 3 months of age, variability between individuals (coefficient of variation (CV) = 16.3 percent) was higher than individual day-to-day variability (CV = 5.4 percent) for the infants in the study (Dewey et al., 1991a).

The advantages of this study are that data were collected over a relatively long-time (4 days) period at each test interval which would account for some day-to-day infant variability, and corrections for insensible water loss were made. However, the population studied may not be representative of the U.S. population, based on race and socioeconomic status.

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 (NAS, 1991). The lipid content of breast milk varies according to the length of time that an infant nurses. Lipid content increases from the beginning to the end of a single nursing session (NAS, 1991). The lipid portion accounts for approximately 4 percent of human breast milk (39± 4.0 g/L) (NAS, 1991). This value is supported by various studies that evaluated lipid content from human breast milk. Several studies also estimated the quantity of lipid consumed by breast-feeding infants. These values are appropriate for performing exposure assessments for nursing infants when the contaminant(s) have residue concentrations that are indexed to the fat portion of human breast milk.

Butte et al. (1984) - Human Milk Intake and Growth in Exclusively Breast-fed Infants - Butte et al., (1984) analyzed the lipid content of breast milk samples taken from women who participated in a study of breast milk intake among exclusively breast-fed infants. The study was conducted with over 40 women during a 4-month period. The mean lipid content of breast milk at various infants' ages is presented in Table 2-6. The overall lipid content for the 4-month study period was 34.3 ± 6.9 mg/g (3.4 percent). Butte et al. (1984) also calculated lipid intakes from 24-hour breast milk intakes and the lipid content of the human milk samples. Lipid intake was estimated to range from 23.6 g/day (3.8 g/kg-day) to 28.0 g/day (5.9 g/kg-day).

The number of women included in this study was small, and these women were selected primarily from middle- to upper-socioeconomic classes. Thus, data on breast milk lipid content from this study may not be entirely representative of breast milk lipid content among the U.S. population. Also, these estimates are based on short-term data and day-to-day variability was not characterized.

Maxwell and Burmaster (1993) - A Simulation Model to Estimate a Distribution of Lipid Intake from Breast Milk Intake During the First Year of Life -Maxwell and Burmaster (1993) used a hypothetical population of 5,000 infants between birth and 1 year of age to simulate a distribution of daily lipid intake from breast milk. The hypothetical population represented both bottle-fed and breast-fed infants aged 1 to 365 days. A distribution of daily lipid intake was developed based on data in Dewey et al. (1991b) on breast milk intake for infants at 3, 6, 9, and 12 months and breast milk lipid content, and survey data in Ryan et al. (1991) on the percentage of breast-fed infants under the age of 12 months (i.e., approximately 22 percent). A model was used to simulate intake among 1,113 of the 5,000 infants that were expected to be breast-fed. The results of the model indicated that lipid intake among nursing infants under 12 months of age can be characterized by a normal distribution with a mean of 26.8 g/day and a standard deviation of 7.4 g/day (Table 2-7). The model assumes that nursing infants are completely breast-fed and does not account for infants who are breast-fed longer than 1 year. Based on data collected by Dewey et al. (1991b), Maxwell and Burmaster (1993) estimated the lipid content of breast milk to be 36.7 g/L at 3 months (35.6 mg/g or 3.6%) 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. These results are, however, based on a simulation model and there are uncertainties associated with the assumptions made. The estimated mean lipid intake rate represents the average daily intake for nursing infants under 12 months of age. These data are useful for performing exposure assessments when the age of the infant cannot be specified (i.e., 3 months or 6 months). Also, because intake rates are indexed to the lipid portion of the breast milk, they may be used in conjunction with residue concentrations indexed to fat content.

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.

Frequency and Duration of Feeding - Hofvander et al. (1982) reported on the frequency of feeding among 25 bottle-fed and 25 breast-fed infants at ages 1, 2, and 3 months. The mean number of meals for these age groups was approximately 5 meals/day (Table 2-8). Neville et al. (1988) reported slightly higher mean feeding frequencies. The mean number of meals per day for exclusively breast-fed infants was 7.3 at ages 2 to 5 months and 8.2 at ages 2 weeks to 1 month. Neville et al. (1988) reported that, for infants between the ages of 1 week and 5 months, the average duration of a breast feeding session is 16-18 minutes.

Population of Nursing Infants and Duration of Breast-Feeding During Infancy - According to NAS (1991), the percentage of breast-feeding women has changed dramatically over the years. Between 1936 and 1940, approximately 77 percent of infants were breast fed, but the incidence of breast-feeding fell to approximately 22 percent in 1972. The duration of breast-feeding also dropped from about 4 months in the early 1930s to 2 months in the late 1950s. After 1972, the incidence of breast-feeding began to rise again, reaching its peak at approximately 61 percent in 1982. The duration of breast-feeding also increased between 1972 and 1982. Approximately 10 percent of the mothers who initiated breast-feeding continued for at least 3 months in 1972; however, in 1984, 37 percent continued breast-feeding beyond 3 months. In 1989, breast-feeding was initiated among 52.2 percent of newborn infants, and 40 percent continued for 3 months or longer (NAS, 1991). Based on the data for 1989, only about 18.1 percent of infants were still breast fed by age 6 months (Ryan, 1997). By 1995, the initiation of breastfeeding had increased to 59.7 percent and the rate of breastfeeding at 6 months had increased to 21.6 percent (Ryan, 1997). Data on the actual length of time that infants continue to breast-feed beyond 5 or 6 months are limited (NAS, 1991). However, Maxwell and Burmaster (1993) estimated that approximately 22 percent of infants under 1 year of age are breast-fed. This estimate is based on a reanalysis of survey data in Ryan et al. (1991) collected by Ross Laboratories (Maxwell and Burmaster, 1993). Studies have also indicated that breast-feeding practices may differ among ethnic and socioeconomic groups and among regions of the United States. The percentages of mothers who breast feed, based on ethnic background and demographic variables, are presented in Table 2-9 (NAS, 1991).

Intake Rates Based on Nutritional Status - Information on differences in the quality and quantity of breast milk consumed based on ethnic or socioeconomic characteristics of the population is limited. Lönnerdal et al. (1976) studied breast milk volume and composition (nitrogen, lactose, proteins) among underprivileged and privileged Ethiopian mothers. No significant differences were observed between the data for these two groups; and similar data for well-nourished Swedish mothers were observed. Lönnerdal et al. (1976) stated that these results indicate that breast milk quality and quantity are not affected by maternal malnutrition. However, Brown et al. (1986a; 1986b) noted that the lactational capacity and energy concentration of marginally-nourished women in Bangladesh were "modestly less than in better nourished mothers." Breast milk intake rates for infants of marginally-nourished women in this study were 690±122 g/day at 3 months, 722±105 g/day at 6 months, and 719±119 g/day at 9 months of age (Brown et al., 1986a). Brown et al. (1986a) observed that breast milk from women with larger measurements of arm circumference and triceps skinfold thickness had higher concentrations of fat and energy than mothers with less body fat. Positive correlations between maternal weight and milk fat concentrations were also observed. These results suggest that milk composition may be affected by maternal nutritional status.

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 utilized by 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 since 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 since intake rates may be higher on a body weight basis for younger infants. Also, the data used to derive the recommendations are over 10 years old and the sample size of the studies was 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 2-10 presents the confidence rating for breast milk intake recommendations.

Breast Milk Intake - The breast milk intake rates for nursing infants that have been reported in the studies described in this section are summarized in Table 2-11. Based on the combined results of these studies, 742 mL/day is recommended to represent an average breast milk intake rate, and 1,033 mL/day represents an upper-percentile intake rate (based on the middle range of the mean plus 2 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 2-11. It is consistent with the average intake rate of 718 to 777 mL/day estimated by NAS (1991) for infants during the first 4 to 5 months of life. Intake among older infants is somewhat lower, averaging 413 mL/day for 12-month olds (Neville et al. 1988; Dewey et al. 1991a; 1991b). When a time weighted average is calculated for the 12-month period, average breast milk intake is approximately 688 mL/day, and upper-percentile intake is approximately 980 mL/day. Table 2-12 summarizes these recommended intake rates.

Lipid Content and Lipid Intake - Recommended lipid intake rates are based on data from Butte et al. (1984) and Maxwell and Burmaster (1993). Butte et al. (1984) estimated that average lipid intake ranges from 23.6 ± 7.2 g/day (22.9 ± 7.0 mL/day) to 28.0 ± 8.5 g/day (27.2 ± 8.3 mL/day) between 1 and 4 months of age. These intake rates are consistent with those observed by Burmaster and Maxwell (1993) for infants under 1 year of age [(26.8 ± 7.4 g/day (26.0 ± 7.2 mL/day)]. Therefore, the recommended breast milk lipid intake rate for infants under 1 year of age is 26.0 mL/day and the upper-percentile value is 40.4 mL/day (based on the mean plus 2 standard deviations). The recommended value for breast milk fat content is 4.0 percent based on data from NAS (1991), Butte et al. (1984), and Maxwell and Burmaster (1993).

2.6 REFERENCES FOR CHAPTER 2

Brown, K.H.; Akhtar, N.A.; Robertson, A.D.; Ahmed, M.G. (1986a) Lactational capacity of marginally nourished mothers: relationships between maternal nutritional status and quantity and proximate composition of milk. Pediatrics. 78: 909-919.

Brown, K.H.; Robertson, A.D.; Akhtar, N.A. (1986b) Lactational capacity of marginally nourished mothers: infants' milk nutrient consumption and patterns of growth. Pediatrics. 78: 920-927.

Butte, N.F.; Garza, C.; Smith, E.O.; Nichols, B.L. (1984) Human milk intake and growth in exclusively breast-fed infants. Journal of Pediatrics. 104:187-195.

Dewey, K.G.; Lönnerdal, B. (1983) Milk and nutrient intake of breast-fed infants from 1 to 6 months:relation to growth and fatness. Journal of Pediatric Gastroenterology and Nutrition. 2:497-506.

Dewey, K.G.; Heinig, J.; Nommsen, L.A.; Lönnerdal, B. (1991a) Maternal versus infant factors related to breast milk intake and residual volume: the DARLING study. Pediatrics. 87:829-837.

Dewey, K.G.; Heinig, J.; Nommsen, L.; Lönnerdal, B. (1991b) Adequacy of energy intake among breast-fed infants in the DARLING study: relationships to growth, velocity, morbidity, and activity levels. The Journal of Pediatrics. 119:538-547.

Hofvander, Y.; Hagman, U.; Hillervik, C.; Sjolin, S. (1982) The amount of milk consumed by 1-3 months old breast- or bottle-fed infants. Acta Paediatr. Scand. 71:953-958.

Lönnerdal, B.; Forsum, E.; Gebre-Medhim, M.; Hombraes, L. (1976) Breast milk composition in Ethiopian and Swedish mothers: lactose, nitrogen, and protein contents. The American Journal of Clinical Nutrition. 29:1134-1141.

Maxwell, N.I.; Burmaster, D.E. (1993) A simulation model to estimate a distribution of lipid intake from breast milk during the first year of life. Journal of Exposure Analysis and Environmental Epidemiology. 3:383-406.

National Academy of Sciences (NAS). (1991) Nutrition during lactation. Washington, DC. National Academy Press.

Neville, M.C.; Keller, R.; Seacat, J.; Lutes, V.; Neifert, M.; et al. (1988) Studies in human lactation: milk volumes in lactating women during the onset of lactation and full lactation. American Journal of Clinical Nutrition. 48:1375-1386.

Pao, E.M.; Hines, J.M.; Roche, A.F. (1980) Milk intakes and feeding patterns of breast-fed infants. Journal of the American Dietetic Association. 77:540-545.

Ryan, A.S.; Rush, D.; Krieger, F.W.; Lewandowski, G.E. (1991) Recent declines in breastfeeding in the United States, 1984-1989. Pediatrics. 88:719-727.

Ryan, A.S. (1997) The resurgence of breastfeeding in the United States. 99(4):e12.

Table 2-1. Daily Intakes of Breast Milk

Age	Number of Infants Surveyed at Each Time Period	Mean Intake (mL/day) [a]	Range of Daily Intake (mL/day)
Completely Breast-fed			
1 month	11	600 ± 159	426 - 989
3 months	2	833	645 - 1,000
6 months	1	682	616 - 786
Partially Breast-fed			
1 month	4	485 ± 79	398 - 655
3 months	11	467 ± 100	242 - 698
6 months	6	395 ± 175	147 - 684
9 months	3	<554	451 - 732

[a]Data expressed as mean ± standard deviation.

Source: Pao et al. (1980).

Table 2-2. Breast Milk Intake for Infants Aged 1 to 6 Months

Age (months)	Number of Infants	Mean (mL/day)	SD (mL/day) [a]	Range (mL/day)
1	16	673	192	341-1,003
2	19	756	170	449-1,055
3	16	782	172	492-1,053
4	13	810	142	593-1,045
5	11	805	117	554-1,045
6	11	896	122	675-1,096

[a]Standard deviation.

Source: Dewey and Lönnerdal (1983).

Table 2-3. Breast Milk Intake among Exclusively Breast-fed Infants During the First 4 Months of Life

Age (months)	Number of Infants	Breast Milk Intake[a] (g/day)	Breast Milk Intake[a] (g/kg-day)	Body Weight[b] (kg)
1	37	751.0 ± 130.0	159.0 ± 24.0	4.7
2	40	725.0 ± 131.0	129.0 ± 19.0	5.6
3	37	723.0 ± 114.0	117.0 ± 20.0	6.2
4	41	740.0 ± 128.0	111.0 ± 17.0	6.7

[a]Data expressed as mean ± standard deviation.
[b]Calculated by dividing 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	Mean (g/day)	Standard Deviation (g/day)	Range (g/day)
1	7	44	71	-31-149 [a]
2	10	182	86	44-355
3	11	371	153	209-688
4	11	451	176	164-694
5	12	498	129	323-736
6	10	508	167	315-861
7	8	573	167	406-842
8	9	581	159	410-923
9	10	580	76	470-720
10	10	589	132	366-866
11	8	615	168	398-934
14	10	653	154	416-922
21	10	651	84	554-786
28	13	770	179	495-1144
35	12	668	117	465-930
42	12	711	111	554-896
49	10	709	115	559-922
56	13	694	98	556-859
90	12	734	114	613-942
120	13	711	100	570-847
150	13	838	134	688-1173
180	13	766	121	508-936
210	12	721	154	486-963
240	10	622	210	288-1002
270	12	618	220	223-871
300	11	551	234	129-894
330	9	554	240	120-860
360	9	403	250	65-770

[a]Negative value due to insensible water loss correction.

Source: Neville et al. (1988).

Table 2-5. Breast Milk Intake Estimated by the Darling Study

Age (months)	Number of Infants	Mean Intake (g/day)	Standard Deviation (g/day)
3	73	812	133
6	60	769	171
9	50	646	217
12	42	448	251

Source: Dewey et al. (1991b).

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) [a]	Lipid Content (percent) [b]	Lipid Intake (g/day) [a]	Lipid Intake (g/kg-day) [a]
1	37	36.2 ± 7.5	3.6	28.0 ± 8.5	5.9 ± 1.7
2	40	34.4 ± 6.8	3.4	25.2 ± 7.1	4.4 ± 1.2
3	37	32.2 ± 7.8	3.2	23.6 ± 7.2	3.8 ± 1.2
4	41	34.8 ± 10.8	3.5	25.6 ± 8.6	3.8 ± 1.3

[a]Data expressed as means ± standard deviations.
[b]Percents calculated from lipid content reported in mg/g.

Source: Butte, et al. (1984).

Table 2-7. Predicted Lipid Intakes for Breast-fed Infants under 12 Months of Age

Statistic	Value
Number of Observations in Simulation	1,113
Minimum Lipid Intake	1.0 g/day
Maximum Lipid Intake	51.5 g/day
Arithmetic Mean Lipid Intake	26.8 g/day
Standard Deviation Lipid Intake	7.4 g/day

Source: Maxwell and Burmaster (1993).

Table 2-8. Number of Meals per Day

Age (months)	Bottle-fed Infants (meals/day) [a]	Breast-fed (meals/day) [a]
1	5.4 (4-7)	5.8 (5-7)
2	4.8 (4-6)	5.3 (5-7)
3	4.7 (3-6)	5.1 (4-8)

[a]Data expressed as mean with range in parentheses.

Source: Hofvander et al. (1982).

Table 2-9. Percentage of Mothers Breast-feeding Newborn Infants in the Hospital and Infants at 5 or 6 Months Of Age in the United States in 1989[a], by Ethnic Background and Selected Demographic Variables[b]

	Total		White		Black		Hispanic[c]	
Category	Newborns	5-6 Mo Infants	Newborns	5-6 Mo Infants	Newborns	5-6 Mo Infants	Newborns	5-6 Mo Infants
All mothers	52.2	19.6	58.5	22.7	23.0	7.0	48.4	15.0
Parity								
Primiparous	52.6	16.6	58.3	18.9	23.1	5.9	49.9	13.2
Multiparous	51.7	22.7	58.7	26.8	23.0	7.9	47.2	16.5
Marital status								
Married	59.8	24.0	61.9	25.3	35.8	12.3	55.3	18.8
Unmarried	30.8	7.7	40.3	9.8	17.2	4.6	37.5	8.6
Maternal age								
<20 yr	30.2	6.2	36.8	7.2	13.5	3.6	35.3	6.9
20-24 yr	45.2	12.7	50.8	14.5	19.4	4.7	46.9	12.6
25-29 yr	58.8	22.9	63.1	25.0	29.9	9.4	56.2	19.5
30-34 yr	65.5	31.4	70.1	34.8	35.4	13.6	57.6	23.4
≥35 yr	66.5	36.2	71.9	40.5	35.6	14.3	53.9	24.4
Maternal education								
No college	42.1	13.4	48.3	15.6	17.6	5.5	42.6	12.2
College[d]	70.7	31.1	74.7	34.1	41.1	12.2	66.5	23.4
Family income								
<$7,000	28.8	7.9	36.7	9.4	14.5	4.3	35.3	10.3
$7,000-$14,999	44.0	13.5	49.0	15.2	23.5	7.3	47.2	13.0
$15,000-$24,999	54.7	20.4	57.7	22.3	31.7	8.7	52.6	16.5
≥$25,000	66.3	27.6	67.8	28.7	42.8	14.5	65.4	23.0
Maternal employment								
Full time	50.8	10.2	54.8	10.8	30.6	6.9	50.4	9.5
Part time	59.4	23.0	63.8	25.5	26.0	6.6	59.4	17.7
Not employed	51.0	23.1	58.7	27.5	19.3	7.2	46.0	16.7
U.S. census region								
New England	52.2	20.3	53.2	21.4	35.6	5.0	47.6	14.9
Middle Atlantic	47.4	18.4	52.4	21.8	30.6	9.7	41.4	10.8
East North Central	47.6	18.1	53.2	20.7	21.0	7.2	46.2	12.6
West North Central	55.9	19.9	58.2	20.7	27.7	7.9	50.8	22.8
South Atlantic	43.8	14.8	53.8	18.7	19.6	5.7	48.0	13.8
East South Central	37.9	12.4	45.1	15.0	14.2	3.7	23.5	5.0
West South Central	46.0	14.7	56.2	18.4	14.5	3.8	39.2	11.4
Mountain	70.2	30.4	74.9	33.0	31.5	11.0	53.9	18.2
Pacific	70.3	28.7	76.7	33.4	43.9	15.0	58.5	19.7

[a]Mothers were surveyed when their infants were 6 months of age. They were asked to recall the method of feeding the infant when in the hospital, at age 1 week, at months 1 through 5, and on the day preceding completion of the survey. Numbers in the columns labeled “5-6 Mo Infants” are an average of the 5-month and previous day responses.
[b]Based on data from Ross Laboratories.
[c]Hispanic is not exclusive of white or black.
[d]College includes all women who reported completing at least 1 year of college.
Source: NAS (1991).

Table 2-10. Confidence in Breast Milk Intake Recommendations

Considerations	Rationale	Rating
Study Elements		
Level of peer review	All key studies are from peer review literature.	High
Accessibility	Papers are widely available from peer review journals.	High
Reproducibility	Methodology used was clearly presented.	High
Focus on factor of interest	The focus of the studies was on estimating breast milk intake.	High
Data pertinent to U.S.	Subpopulations of the U.S. were the focus of all the key studies.	High
Primary data	All the studies were based on primary data.	High
Currency	Studies were conducted between 1980-1986. Although incidence of breast feeding may change with time, breast milk intake among breastfed infants may not.	Medium
Adequacy of data collection period	Infants were not studied long enough to fully characterize day to day variability.	Medium
Validity of approach	Methodology uses changes in body weight as a surrogate for total ingestion. This is the best methodology there is to estimate breast milk ingestion. Mothers were instructed in the use of infant scales to minimize measurement errors. Three out of the 5 studies corrected data for insensible water loss.	Medium
Study size	The sample sizes used in the key studies were fairly small (range 13-73).	Low
Representativeness of the population	Population is not representative of the U.S.; only mid-upper class, well nourished mothers were studied. Socioeconomic factors may affect the incidence of breastfeeding. Mother's nourishment may affect milk production.	Low
Characterization of variability	Not very well characterized. Infants under 1 month not captured, mothers committed to breast feeding over 1 year not captured.	Low
Lack of bias in study design (high rating is desirable)	Bias in the studies was not characterized. Three out of 5 studies corrected for insensible water loss. Not correcting for insensible water loss may underestimate intake. Mothers selected for the studies were volunteers; therefore response rate does not apply. Population studied may introduce some bias in the results (see above).	Low
Measurement error	All mothers were well educated and trained in the use of the scale which helped minimize measurement error.	Medium
Other Elements		
Number of studies	There are 5 key studies.	High
Agreement between researchers	There is good agreement among researchers.	High
Overall Rating	Studies were well designed. Results were consistent. Sample size was fairly low and not representative of U.S. population or population of nursing mothers. Variability cannot be characterized due to limitations in data collection period.	**Medium**

Table 2-11. Breast Milk Intake Rates Derived from Key Studies

Mean (mL/day)	N	Upper Percentile (mL/day) (mean plus 2 standard deviations)	Reference
Age: 1 Month			
600	11	918	Pao et al., 1980
729	37	981	Butte et al., 1984
747	13	1,095	Neville et al., 1988
673	16	1,057	Dewey and Lönnerdal, 1983
weighted avg = 702		1,007[a]	
Age: 3 Months			
833	2	---	Pao et al., 1980
702	37	923	Butte et al., 1984
712	12	934	Neville et al., 1988
782	16	1,126	Dewey and Lönnerdal, 1983
788	73	1,046	Dewey et al., 1991b
weighted avg = 759		1,025[a]	
Age: 6 Months			
682	1	---	Pao et al., 1980
744	13	978	Neville et al., 1988
896	11	1,140	Dewey and Lönnerdal, 1983
747	60	1,079	Dewey et al., 1991b
weighted avg = 765		1,059[a]	
Age: 9 Months			
600	12	1,027	Neville et al., 1988
627	50	1,049	Dewey et al., 1991b
avg = 622		1,038	
Age: 12 Months			
391	9	877	Neville et al., 1988
435	42	923	Dewey et al., 1991a; 1991b
weighted avg = 427		900	
12-MONTH TIME WEIGHTED AVERAGE			
688		Range 900-1,059 (middle of the range 980)	

[a]Middle of the range.

Table 2-12. Summary of Recommended Breast Milk And Lipid Intake Rates

Age	Mean	Upper Percentile
Breast Milk		
1-6 Months	742 mL/day	1,033 mL/day
12 Month Average	688 mL/day	980 mL/day
Lipids[a]		
<1 Year	26.0 mL/day	40.4 mL/day

[a]The recommended value for the lipid content of breastmilk is 4.0 percent.

TABLE OF CONTENTS

3. FOOD INTAKE 3-1

3.1 INTRODUCTION 3-1

3.2 INTAKE RATE DISTRIBUTIONS FOR VARIOUS FOOD TYPES 3-3

3.3 FISH INTAKE RATES 3-6

3.3.1 General Population Studies 3-6

3.3.2 Freshwater Recreational Study 3-12

3.3.3 Native American Subsistence Study 3-14

3.4 FAT INTAKE 3-15

3.5 TOTAL DIETARY INTAKE AND CONTRIBUTIONS TO DIETARY INTAKE 3-17

3.6 INTAKE OF HOME-PRODUCED FOODS 3-18

3.7 SERVING SIZE STUDY BASED ON THE USDA NFCS 3-23

3.8 CONVERSION BETWEEN AS CONSUMED AND DRY WEIGHT INTAKE RATES 3-23

3.9 FAT CONTENT OF MEAT AND DAIRY PRODUCTS 3-24

3.10 RECOMMENDATIONS 3-25

3.11 REFERENCES FOR CHAPTER 3 3-27

APPENDIX 3a Calculations Used in the 1994-96 CSFII Analysis to Correct for Mixtures

APPENDIX 3b Food Codes and Definitions Used in Analysis of the 1994-96 Usda CSFII Data

APPENDIX 3c Sample Calculation of Mean Daily Fat Intake Based On cdc (1994) Data

APPENDIX 3d Food Codes and Definitions Used in Analysis of the 1987-88 USDA NFCS Data

LIST OF TABLES

Table 3-1. Weighted and Unweighted Number of Observations, 1994/96 CSFII Analysis . . 3-29

Table 3-2. Per Capita Intake of the Major Food Groups (g/kg-day as consumed) 3-30

Table 3-3. Per Capita Intake of Individual Foods (g/kg-day as consumed) 3-31

Table 3-4. Per Capita Intake of USDA Categories of Vegetables and Fruits (g/kg-day as consumed) 3-33

Table 3-5. Per Capita Intake of Exposed/Protected Fruit and Vegetable Categories (g/kg-day as consumed) 3-34

Table 3-6. Per Capita Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - As Consumed 3-35

Table 3-7. Consumers Only Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - As Consumed 3-36

Table 3-8. Per Capita Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - Uncooked Fish Weight 3-37

Table 3-9. Per Capita Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - Uncooked Fish Weight 3-38

Table 3-10. Mean and 95th Percentile of Fish Consumption (g/day) by Sex and Age[a] 3-39

Table 3-11. Best Fits of Lognormal Distributions Using the Nonlinear Optimization (Nlo) Method 3-40

Table 3-12. Number of Respondents Reporting Consumption of a Specified Number of Servings of Seafood in 1 Month and Source of Seafood Eaten 3-40

Table 3-13. Mean Fish Intake Among Individuals Who Eat Fish and Reside in Households With Recreational Fish Consumption 3-41

Table 3-14. Children's 5 and Under Fish Consumption Rates - Throughout Year 3-41

Table 3-15. Fat Intake Among Children Based on Data from the Bogalusa Heart Study, 1973-1982 (g/day) 3-42

Table 3-16. Fat Intake Among Children Based on Data from the Bogalusa Heart Study, 1973-1982 (g/kg/day) 3-43

Table 3-17. Mean Total Daily Dietary Fat Intake (g/day) Grouped by Age and Gender[a] . . . 3-44

Table 3-18. Per Capita Total Dietary Intake 3-45

Table 3-19. Per Capita Intake of Major Food Groups (g/day, as consumed) 3-46
Table 3-20. Per Capita Intake of Major Food Groups (g/kg/day, as consumed) 3-48
Table 3-21. 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 3-50
Table 3-22. 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 3-52
Table 3-23. 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 3-54
Table 3-24. 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 3-56
Table 3-25. 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 3-58
Table 3-26. 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 3-60
Table 3-27. Weighted and Unweighted Number of Observations (Individuals) for NFCS Data Used in Analysis of Food Intake 3-62
Table 3-28. Consumer Only Intake of Homegrown Foods (g/kg-day)[a] - All Regions Combined 3-63
Table 3-29. Percent Weight Losses from Food Preparation 3-64
Table 3-30. Quantity (as consumed) of Food Groups Consumed Per Eating Occasion and the Percentage of Individuals Using These Foods in Three Days 3-65
Table 3-31. Mean Moisture Content of Selected Food Groups Expressed as Percentages of Edible Portions 3-67
Table 3-32. Percent Moisture Content for Selected Fish Species[a] 3-71

Table 3-35. Summary of Recommended Values for Per Capita Intake of Foods, As Consumed 3-79
Table 3-36. Confidence Intake Recommendations for Various Foods, Including Fish (General Population) 3-81
Table 3-37. Confidence Intake Recommendations for Fish Consumption - Recreational Freshwater Angler Population 3-82
Table 3-38. Confidence Intake Recommendations for Fish Consumption - Native American Subsistence Population 3-83

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.

Exposure to children 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 adults. The most common foods eaten by children include milk, nonfat solids; apple juice; apples, fresh; orange juice; pears, fresh; milk, fat, solids; peaches, fresh; carrots; beef, lean; milk sugar (lactose); bananas, fresh; rice, milled; peas, succulent, garden; beans, succulent, garden; oats; soybean oil; coconut oil; and wheat flour (Goldman, 1995).

The primary source of recent information on consumption rates of foods among children is the U.S. Department of Agriculture's (USDA) Nationwide Food Consumption Survey (NFCS) and the USDA Continuing Survey of Food Intakes by Individuals (CSFII). Data from the 1989-91 and 1994-96 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 USDA’s Nationwide Food Consumption Survey (NFCS) from 1977/78 or 1987/88. Because data from the 1989-91 and 1994-96 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 1987/88 NFCS, and serving size information, which is based on the 1977/78 NFCS. Older USDA data analyses can be found in *Exposure Factors Handbook* (U.S. EPA 1997).

It should be noted that a variety of terms may be used to define intake. These terms (e.g., consumer-only intake, per capita intake, as consumed intake, dry weight intake) 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 non-users). 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 both children who ate the foods during the survey period and 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 that 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.

Estimating source-specific exposures to toxic chemicals in fruits and vegetables may also require information on the amount of fruits and vegetables that are exposed to or protected from contamination as a result of cultivation practices or the physical nature of the food product itself (i.e., those having protective coverings that are removed before eating would be considered protected), or the amount grown beneath the soil (i.e., most root crops such as potatoes). The percentages of foods grown above and below ground will be useful when the concentrations of contaminants in foods are estimated from concentrations in soil, water, and air. For example, vegetables grown below ground may be more likely to be contaminated by soil pollutants, but leafy above ground vegetables may be more likely to be contaminated by deposition of air pollutants on plant surfaces.

The purpose of this section is to provide: (1) intake data for individual 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

U.S. EPA (2000) - Analysis of USDA 1994-96 CSFII Data to Generate Intake Rates for Major Food Groups and Individual Foods - EPA's National Center for Environmental Assessment (NCEA) analyzed three 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, D.C. were surveyed. Individuals provided 2 non-consecutive days of data, based on 24-hour recall. The 2-day response rate for the 1994-96 CSFII was approximately 76 percent. 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 three 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; and 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 data base according to USDA-defined food codes. Appendix 3B presents the codes used to determine the various food groups. Intake rates for these food items/groups represent intake of all forms of the product (i.e., home produced and commercially produced).

Individual identifiers in the database were used throughout the analysis to categorize populations according to demographics. These identifiers included identification number, age, body weight, weighting factor, and number of days that data were reported. Distributions of intake were determined for children who provided data for two days of the survey. Individuals who did not provide information on body weight, or for which identifying information was unavailable, were excluded from the analysis. 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 g/kg-day. The data were also weighted according to the two-day weights provided in the 1994-96 CSFII. USDA sample weights are calculated to account for inherent biases in the sample selection process, and to adjust the sample population to reflect the national population. Summary statistics for individual intake rates were generated on a per capita basis. That is, both users and non-users of the food item were included in the analysis. Mean consumer only intake rates may be calculated by dividing the mean per capita intake rate by the percent of the population consuming the food item of interest. 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, 1, 5, 10, 25, 50, 75, 90, 95, 99, and 100th percentile). Data were provided for the total population using the food item being evaluated and for several 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 3-1. The food analysis was accomplished using the SAS statistical programming system (SAS, 1990).

The results of this analysis are presented in Table 3-2 for total fruits, total vegetables, total grains, total meats, total fish, and total dairy products. Table 3-3 provides data for individual foods, and Table 3-4 for the various USDA categories. The data for exposed/protected and root food items are presented in Table 3-5. These tables are presented at the end of this Chapter. The results are presented in units of g/kg-day. Thus, use of these data in calculating potential dose does not require the body weight factor to be included in the denominator of the average daily dose (ADD) equation. It should be noted that converting these intake rates into units of g/day by multiplying by a single average body weight is inappropriate, because individual intake rates were indexed to the 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 document should be used.

Short-term data are suitable for estimating mean average daily intake rates representative of both short-term and long-term consumption. However, the *distribution* of average daily intake rates generated using short-term data (e.g., 2-day) do not necessarily reflect the long-term *distribution* of average daily intake rates. The distributions generated from short-term and long-term data will differ to the extent that each individual's intake varies from day to day; the distributions will be similar to the extent that individual's intakes are constant from day to day.

Day to day variation in intake among individuals will be great for food item/groups that are highly seasonal and for items/groups that are eaten year around but that are not typically eaten every day. For these foods, the intake distribution generated from short-term data will not be a good reflection of the long-term distribution. On the other hand, for broad categories of foods (e.g., vegetables) which are eaten on a daily basis throughout the year with minimal seasonality, the short-term distribution may be a reasonable approximation of the true long-term distribution, although it will show somewhat more variability. 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 1949-96 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 United States. The data set includes three years of intake data combined and are based on a two-day survey period. Short-term dietary data may not accurately reflect long-term eating patterns. This is particularly true for the tails (extremes) of the distribution of food intake. In addition, the adjustment for including mixtures adds uncertainty to the intake rate distributions. The calculation for including mixtures assumes that intake of any mixture includes all of the foods identified in Appendix Table 3A-1 in the proportions specified in that table. This may under- or over-estimate intake of certain foods among some individuals.

3.3 FISH INTAKE RATES

3.3.1 General Population Studies

U.S. EPA (1996) - Daily Average Per Capita Fish Consumption Estimates Based on the Combined USDA 1989, 1990, and 1991 CSFII—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 utilized to convert, for each fish containing food, the as-eaten fish weight consumed into an uncooked equivalent weight of fish. Analyses of fish intake were performed on both an as-eaten and uncooked basis.

Each (fish-related) food code was assigned by EPA a habitat type of either freshwater/ estuarine or marine. Food codes were also designated as finfish or shellfish. Average daily individual consumption (g/day) for a given fish type-by-habitat category (e.g., marine finfish) was calculated by summing the amount of fish consumed by the individual across the three reporting days for all fish-related food codes in the given fish-by-habitat category and then dividing by 3. Individual consumption per day consuming fish (g/day) was calculated similarly except that total fish consumption was divided by the 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 body-weight of the individual was used to convert consumption in g/day to consumption in g/kg-day.

There were a total of 11,912 respondents in the combined data set who had three-day dietary intake data. 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-percent interval estimates for the 90th, 95th, and 99th percentiles. The 90-percent 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 non-parametric distribution of the given point estimate (U.S. EPA, 1996). 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 3-6 presents data for daily average per capita fish consumption by age and gender in g/day and in mg/kg/day, as consumed. Table 3-7 provides consumer only data in units of g/day and mg/kg/day, as consumed. Tables 3-8 and 3-9 provide similar data on an uncooked basis. These data are presented by selected age groupings (4 and under and 15-44) 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 National Food Consumption Surveys (NFCSs) which 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.

EPA, 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 1994-96 CSFII by EPA/NCEA (see Section 3.2). The EPA, Office of Water data will be in this Handbook when available.

Tuna Research Institute Survey - The Tuna Research Institute (TRI) funded a study of fish consumption which was performed by the National Purchase Diary (NPD) during the period of September, 1973 to August, 1974. The data tapes from this survey were obtained by the National Marine Fisheries Service (NMFS), which later, along with the FDA, USDA and TRI, conducted an intensive effort to identify and correct errors in the data base. Javitz (1980) summarized the TRI survey methodology and used the corrected tape to generate fish intake distributions for various sub-populations.

The TRI survey sample included 6,980 families who were currently participating in a syndicated national purchase diary panel, 2,400 additional families where the head of household was female and under 35 years old; and 210 additional black families (Javitz, 1980). Of the 9,590 families in the total sample, 7,662 families (25,162 individuals) completed the questionnaire, a response rate of 80 percent. The survey was weighted to represent the U.S. population based on a number of census-defined controls (i.e., census region, household size, income, presence of children, race and age). The calculations of means, percentiles, etc. were performed on a weighted basis with each person contributing in proportion to his/her assigned survey weight.

The survey population was divided into 12 different sample segments and, for each of the 12 survey months, data were collected from a different segment. Each survey household was given a diary in which they recorded, over a one month period, the date of any fish meals consumed and the following accompanying information: the species of fish consumed, whether the fish was commercially or recreationally caught, the way the fish was packaged (canned, frozen fresh, dried, smoked), the amount of fish prepared and consumed, and the number of servings consumed by household members and guests. Both meals eaten at home and away from home were recorded. The amount of fish prepared was determined as follows (Javitz, 1980): “For fresh fish, the weight was recorded in ounces and may have included the weight of the head and tail. For frozen fish, the weight was recorded in packaged ounces, and it was noted whether the fish was breaded or combined with other ingredients (e.g., TV dinners). For canned fish, the weight was recorded in packaged ounces and it was noted whether the fish was canned in water, oil, or with other ingredients (e.g., soups)”.

Javitz (1980) reported that the corrected survey tapes contained data on 24,652 individuals who consumed fish in the survey month and that tabulations performed by NPD indicated that these fish consumers represented 94 percent of the U.S. population. For this population of "fish consumers," Javitz (1980) calculated means and percentiles of fish consumption by age (Table 3-10). The overall mean fish intake rate among fish consumers was calculated at 6.2 g/day for ages 0-9 years and 10.1 g/day for ages 10-19 years. the 95th percentile fish ingestion rates were 16.5 g/day for ages 0-9 years and 26.8 g/day for ages 10-19 years.

The TRI survey data were also utilized by Rupp et al. (1980) to generate fish intake distributions for three age groups (<11, 12-18, and 19+ years) within each of the 9 census regions and for the entire United States. Separate distributions were derived for freshwater finfish, saltwater finfish and shellfish; thus, a total of 90 (3*3*10) different distributions were derived, each corresponding to intake of a specific category of fish for a given age group within a given region. The analysis of Rupp et al. (1980) included only those respondents with known age. This amounted to 23,213 respondents.

Ruffle et al. (1994) used the percentiles data of Rupp et al. (1980) to estimate the best fitting lognormal parameters for each distribution. Three methods (non-linear optimization, first probability plot and second probability plot) were used to estimate optimal parameters. Ruffle et al. (1994) determined that, of the three methods, the non-linear optimization method (NLO) generally gave the best results. For some of the distributions fitted by the NLO method, however, it was determined that the lognormal model did not adequately fit the empirical fish intake distribution. Ruffle et al. (1994) used a criterion of minimum sum of squares (min SS) less than 30 to identify which distributions provided adequate fits. Of the 90 distributions studied, 77 were seen to have min SS < 30; for these, Ruffle et al. (1994) concluded that the NLO modeled lognormal distributions are "well suited for risk assessment". Of the remaining 13 distributions, 12 had min SS > 30; for these Ruffle et al. (1994) concluded that modeled lognormal distributions "may also be appropriate for use when exercised with due care and with sensitivity analyses". One distribution, that of freshwater finfish intake for children < 11 years of age in New England, could not be modeled due to the absence of any reported consumption.

Table 3-11 presents the optimal lognormal parameters, the mean (μ), standard deviation (s), and min SS, for all 89 modeled distributions. These parameters can be used to determine percentiles of the corresponding distribution of average daily fish consumption rates through the relation DFC(p)=exp[μ+ z(p)s] where DFC(p) is the pth percentile of the distribution of average daily fish consumption rates and z(p) is the z-score associated with the pth percentile (e.g., z(50)=0). The mean average daily fish consumption rate is given by exp[μ + 0.5s^2].

The analyses of Javitz (1980) and Ruffle et al. (1994) were based on consumers only, who are estimated to represent 94.0 percent of the U.S. population. U.S. EPA estimated the mean intake in the general population by multiplying the fraction consuming, 0.94, by the mean among consumers reported by Javitz (1980) of 14.3 g/day; the resulting estimate is 13.4 g/day. The 95th percentile estimate of Javitz (1980) of 41.7 g/day among consumers would be essentially unchanged when applied to the general population; 41.7 g/day would represent the 95.3 percentile (i.e., 100*[0.95*0.94+0.06]) among the general population.

Advantages of the TRI data survey are that it was a large, nationally representative survey with a high response rate (80 percent) and was conducted over an entire year. In addition, consumption was recorded in a daily diary over a one month period; this format should be more reliable than one based on one-month recall. The upper percentiles presented are derived from one month of data, and are likely to overestimate the corresponding upper percentiles of the long-term (i.e., one year or more) average daily fish intake distribution. Similarly, the standard deviation of the fitted lognormal distribution probably overestimates the standard deviation of the long-term distribution. However, the period of this survey (one month) is considerably longer than those of many other consumption studies, including the USDA National Food Consumption Surveys, which report consumption over a 3 day to one week period.

Another obvious limitation of this data base is that it is now over twenty years out of date. Ruffle et al. (1994) considered this shortcoming and suggested that one may wish to shift the distribution upward to account for the recent increase in fish consumption. Adding ln(1+x/100) to the log mean μ will shift the distribution upward by x percent (e.g., adding 0.22 = ln(1.25) increases the distribution by 25 percent). Although the TRI survey distinguished between recreationally and commercially caught fish, Javitz (1980), Rupp et al. (1980), and Ruffle et al. (1994) (which was based on Rupp et al., 1980) did not present analyses by this variable.

Tsang and Klepeis (1996) - National Human Activity Pattern Survey (NHAPS) - The U.S. EPA collected information for the general population on the duration and frequency of time spent in selected activities and time spent in selected microenvironments via 24-hour diaries. Over 9,000 individuals from 48 contiguous states participated in NHAPS. Approximately

4,700 participants also provided information on seafood consumption. Over 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 the (1) number of people that ate seafood in the last month, (2) the number of servings of seafood consumed, and (3) whether the seafood consumed was caught or purchased (Tsang and Klepeis, 1996). The participant responses were weighted according to selected demographics such as age, gender, and race to ensure that results were representative of the U.S. population. Of the 900 children who participated in the survey, approximately 43 percent reportedly ate 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 3-12). The highest number of respondents for all ages of children had 1-2 servings per month. Most of the respondents purchased the seafood they ate (Table 3-12).

Intake data were not provided in the survey. However, intake of fish can be estimated using the information on the number of servings of fish eaten from this study and serving size data for each age group from other studies (e.g., Pao et al., 1982). Using this mean value for serving size and assuming that the average child eats 1-2 servings per month, the age-specific amount of seafood eaten per month can be estimated.

The advantages of NHAPS is that the data were collected for a large number of individuals and are representative of the U.S. general population. However, evaluation of seafood intake was not the primary purpose of the study and the data do not reflect the actual amount of seafood that was eaten. However, using the assumption described above, the estimated seafood intake from this study are comparable to those observed in the EPA CSFII analysis. It should be noted that an all inclusive description for seafood was not presented in Tsang and Klepeis (1996). It is not known if processed or canned seafood and seafood mixtures are included in the seafood category.

3.3.2 Freshwater Recreational Study

West et al. (1989) - Michigan Sport Anglers Fish Consumption Survey, 1989 - surveyed a stratified random sample of Michigan residents with fishing licences. The sample was divided into 18 cohorts, with one cohort receiving a mail questionnaire each week between January and May 1989. The survey included both a short term recall component recording respondents' fish intake over a seven day period and a usual frequency component. For the short-term component, respondents were asked to identify all household members and list all fish meals consumed by each household member during the past seven days. The source of the fish for each meal was requested (self-caught, gift, market, or restaurant). Respondents were asked to categorize serving size by comparison with pictures of 8 oz. fish portions; serving sizes could be designated as either "about the same size", "less", or "more" than the 8 oz. picture. Data on fish species, locations of self-caught fish and methods of preparation and cooking were also obtained.

The usual frequency component of the survey asked about the frequency of fish meals during each of the four seasons and requested respondents to give the overall percentage of household fish meals that come from recreational sources. A sample of 2,600 individuals were selected from state records to receive survey questionnaires. A total of 2,334 survey questionnaires were deliverable and 1,104 were completed and returned, giving a response rate of 47.3 percent among individuals receiving questionnaires.

In the analysis of the survey data by West et. al. (1989), the authors did not attempt to generate the distribution of recreationally caught fish intake in the survey population. EPA obtained the raw data of this survey for the purpose of generating fish intake distributions and other specialized analyses.

As described elsewhere in this handbook, percentiles of the distribution of average daily intake reflective of long-term consumption patterns can not in general be estimated using short-term (e.g., one week) data. Such data can be used to estimate mean average daily intake rates (reflective of short or long term consumption); in addition, short term data can serve to validate estimates of usual intake based on longer recall.

EPA first analyzed the short term data with the intent of estimating mean fish intake rates. In order to compare these results with those based on usual intake, only respondents with information on both short term and usual intake were included in this analysis. For the analysis of the short term data, EPA modified the serving size weights used by West et al. (1989), which were 5, 8 and 10 oz., respectively, for portions that were less, about the same, and more than the 8 oz. picture. EPA examined the percentiles of the distribution of fish meal sizes reported in Pao et al. (1982) derived from the 1977-1978 USDA National Food Consumption Survey and observed that a lognormal distribution provided a good visual fit to the percentile data. Using this lognormal distribution, the mean values for serving sizes greater than 8 oz. and for serving sizes at least 10 percent greater than 8 oz. were determined. In both cases a serving size of 12 oz. was consistent with the Pao et al. (1982) distribution. The weights used in the EPA analysis then were 5, 8, and 12 oz. for fish meals described as less, about the same, and more than the 8 oz. picture, respectively. It should be noted that the mean serving size from Pao et al. (1982) was about 5 oz., well below the value of 8 oz. most commonly reported by respondents in the West et al. (1989) survey.

Table 3-13 displays the mean number of total and recreational fish meals for each household member between age 1 and 20 years based on the seven day recall data. Also shown are mean fish intake rates derived by applying the weights described above to each fish meal. Intake was calculated on both a grams/day and grams/kg body weight/day basis. This analysis was restricted to individuals who eat fish and who reside in households reporting some recreational fish consumption during the previous year. About 75 percent of survey respondents (i.e., licensed anglers) and about 84 percent of respondents who fished in the prior year reported some household recreational fish consumption.

The 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 percent, was relatively low. This study was conducted in the winter and spring months of 1989. This period does not include the summer months when peak fishing activity can be anticipated, leading to the possibility that intake results based on the 7 day recall data may understate individuals' usual (annual average) fish consumption.

3.3.3 Native American Subsistence Study

Columbia River Inter-Tribal Fish Commission (CRITFC) (1994) - A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin - CRITFC (1994) conducted a fish consumption survey among four Columbia River Basin 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 percent.

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 (CRITFC, 1994). Foam sponge food models approximating four, eight, and twelve ounce fish fillets were provided to help respondents estimate average fish meal size. Fish intake rates were calculated by multiplying the annual frequency of fish meals by the average serving size per fish meal.

The study was designed to give essentially equal sample sizes for each tribe. However, since the population sizes of the tribes were highly unequal, it was necessary to weight the data (in proportion to tribal population size) in order that the survey results represent the overall population of the four tribes. Such weights were applied to the analysis of adults; however, because the sample size for children was considered small, only an unweighted analysis was performed for this population (CRITFC, 1994).

A total of 49 percent 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 percent reported that they obtained fish from either self-harvesting, family or friends, at tribal ceremonies or from tribal distributions. Of all fish consumed, 41 percent came from self or family harvesting, 11 percent from the harvest of friends, 35 percent from tribal ceremonies or distribution, 9 percent from stores and 4 percent from other sources (CRITFC, 1994).

The analysis of seasonal intake showed that May and June tended to be high consumption months and December and January low consumption months. Table 3-14 gives the fish intake distribution for children under 5 years of age. The mean intake rate was 19.6 g/d and the 95th percentile was approximately 70 g/d.

The authors noted that some non-response bias may have occurred in the survey since respondents were more likely to live near the reservation and were more likely to be female than non-respondents. In addition, they hypothesized that non fish consumers may have been more likely to be non-respondents than fish consumers since non consumers may have thought their contribution to the survey would be meaningless; if such were the case, this study would 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, thereby the reliability of some of these data is questioned.

Although the authors have noted these limitations, this study does present information on fish consumption patterns and habits for a Native American subpopulation. It should be noted that the number of surveys that address subsistence subpopulations is very limited.

3.4 FAT INTAKE

Cresenta et al. (1988), Nicklas (1993), and Frank et al. (1986) analyzed dietary fat intake data as part of the Bogalusa heart study. The Bogalusa study "is an epidemiologic investigation of cardiovascular risk-factor variables and environmental determinants in a population that began 20 years ago" (Nicklas, 1995). The Bogalusa study has collected dietary data on subjects residing in Bogalusa, Louisiana, 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 during 1973 to 1982 are presented in Tables 3-15 and 3-16 (Frank et al., 1986). Data are presented for total fats, animal fats, vegetable fats, and fish fats in units of g/day and g/kg/day, respectively.

Total fat intake and intake of individual fat products was also estimated by EPA/NCEA using data from the 1994/96 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 Center for Disease Control (CDC) (1994) used data from NHANES III to calculate daily total food energy intake (TFEI), total dietary fat intake, and saturated fat intake for the U.S. population during 1988 to 1991. The sample population comprised 20,277 individuals ages 2 months and above, of which 14,001 respondents (73 percent response rate) provided dietary information based on a 24-hour recall. TFEI was defined as "all nutrients (i.e., protein, fat, carbohydrate, and alcohol) derived from consumption of foods and beverages (excluding plain drinking water) measured in kilocalories (kcal)." Total dietary fat intake was defined as "all fat (i.e., saturated and unsaturated) derived from consumption of foods and beverages measured in grams."

CDC (1994) estimated and provided data on the mean daily TFEI and the mean percentages of TFEI from total dietary fat grouped by age and gender. The overall mean daily TFEI was 2,095 kcal for the total population and 34 percent (or 82 g) of their TFEI was from total dietary fat (CDC, 1994). Based on this information, the mean daily fat intake was calculated for the various age groups and genders (see Appendix 3C for detailed calculation). Table 3-17 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

U.S. EPA (2000) - 1994-96 CSFII Total Diet Analysis. Using data from the 1994-1996 CSFII, total dietary intake was also evaluated. Total dietary intake was defined as intake of the sum of all foods in the following major food groups: dairy, eggs, meats, fish, fats, grains, vegetables, and fruits, using the same foods codes as those described in Appendix 3B, and the same method for allocation of mixtures as described in Appendix 3A. Beverages; sugar, candy, and 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 10th percentile of total intake), a central group (i.e., the 45th to 55th

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, mean intake of each of the major food groups, and the fraction 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, survey 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 fraction 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 3-18 in units of g/day and g/kg/day. Tables 3-19 and 3-20 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. Tables 3-21 through 3-26 present the contributions of the major food groups to total dietary intake for individuals (in the various age groups) at the low-end, central, 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.

3.6 INTAKE OF HOME-PRODUCED FOODS

U.S. EPA (1997) - EPA's Analysis of the 1987/88 NFCS to Estimate Homegrown Intake Rates. 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 seven-day period on the socioeconomic and demographic characteristics of households, and the types, amount, value, and sources of foods consumed by the household (USDA, 1994). The individual intake component collected information on food intakes of individuals within each household over a three-day period (USDA, 1993). The sample size for the 1987-88 survey was approximately 4,300 households (over 10,000 individuals). This is a decrease over the previous survey conducted in 1977-78 which sampled approximately 15,000 households (over 36,000 individuals) (USDA, 1994). The sample size was lower in the 1987-88 survey as a result of budgetary constraints and low response rate (i.e., 38 percent for the household survey and 31 percent for the individual survey) (USDA, 1993). However, NFCS data from 1987-88 were used to generate homegrown intake rates because they were the most recent data available and were believed to be more reflective of current eating patterns among the U.S. population.

The USDA data were adjusted by applying the sample weights calculated by USDA to the data set prior to analysis. The USDA sample weights were designed to "adjust for survey non-response and other vagaries of the sample selection process" (USDA, 1987-88). Also, the USDA weights are calculated "so that the weighted sample total equals the known population total, in thousands, for several characteristics thought to be correlated with eating behavior" (USDA, 1987-88).

For the purposes of this study, home produced foods were defined as homegrown fruits and vegetables, meat and dairy products derived from consumer-raised livestock or game meat, and home caught fish. The food items/groups selected for analysis included major food groups such as total fruits, total vegetables, total meats, total dairy, total fish and shellfish. Individual food items for which >30 households reported eating the home produced form of the item, fruits and vegetables categorized as exposed, protected, and roots, and various USDA fruit and vegetable subcategories (i.e., dark green vegetables, citrus fruits, etc.) 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 numbers of observations for children eating individual homegrown foods in the data set. Food items/groups were identified in the NFCS data base according to NFCS-defined food codes. Appendix 3D presents the codes used to determine the various food groups.

Although the individual intake component of the NFCS gives the best measure of the amount of each food 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 which incorporated data from both the household and individual survey components was developed to estimate individual home produced food intake. The USDA household data were used to determine (1) the amount of each home produced food item used during a week by household members and (2) the number of meals eaten in the household by each household member during a week. Note that the household survey reports the total amount of each food item used in the household (whether by guests or household members); the amount used by household members was derived by multiplying the total amount used in the household by the proportion of all meals served in the household (during the survey week) that were consumed by household members.

The individual survey data were used to generate average sex- and age-specific serving sizes for each food item. The age categories used in the analysis were as follows: 1 to 2 years; 3 to 5 years; 6 to 11 years; 12 to 19 years (intake rates were not calculated for children under 1; the rationale for this is discussed below). These serving sizes were used during subsequent analyses to generate homegrown food intake rates for individual household members. Assuming that the proportion of the household quantity of each homegrown food item/group was a function of the number of meals and the mean sex- and age-specific serving size for each family member, individual intakes of home produced food were calculated for all members of the survey population using SAS programming in which the following general equation was used:

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

where:

- w_i = Homegrown amount of food item/group attributed to member i during the week (g/week);
- W_f = Total quantity of homegrown food item/group used by the family members (g/week);
- m_i = Number of meals of household food consumed by member i during the week (meals/week); and

q_i = Serving size for an individual within the age and sex category of the member (g/meal).

Daily intake of a homegrown food item/group was determined by dividing the weekly value (w_i) by seven. Intake rates were indexed to the self-reported body weight of the survey respondent and reported in units of g/kg-day. Intake rates were not calculated for children under one year of age because their diet differs markedly from that of other household members, and thus the assumption that all household members share all foods would be invalid for this age group.

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 one week survey period. Finally, the percentages of total intake of the food items/groups consumed within survey households that can be attributed to home production were tabulated. The percentage of intake that was homegrown was calculated as the ratio of total intake of the homegrown food item/group by the survey population to the total intake of all forms of the food by the survey population. As 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 and 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:

$$P^{th}_{overall} = 100 \text{ x } \frac{\left(\frac{P}{100} \text{ x } N_c + \left(N_T - N_c\right)\right)}{N_T} \qquad \text{(Eqn. 3-2)}$$

Table 3-27 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 3-27 (9,852) is somewhat lower than the number of observations reported by USDA because this study only used observations for family members for which age and body weight were specified.

Table 3-28 present homegrown intake rates for fruits, vegetables, meats, and fish, respectively. As mentioned above, the intake rates derived in this section are based on the amount of household food consumption. As measured by the NFCS, the amount of food “consumed” by the household is a measure of consumption in an economic sense, i.e., a measure of the weight of food brought into the household that has been consumed (used up) in some manner. In addition to food being consumed by persons, food may be used up by spoiling, by being discarded (e.g., inedible parts), through cooking processes, etc.

USDA estimated preparation losses for various foods (USDA, 1975). For meats, a net cooking loss, which includes dripping and volatile losses, and a net post cooking loss, which involves losses from cutting, bones, excess fat, scraps and juices, were derived for a variety of cuts and cooking methods. For each meat type (e.g., beef) EPA has averaged these losses across all cuts and cooking methods to obtain a mean net cooking loss and a mean net post cooking loss. Mean values for all meats and fish are provided in Table 3-29. 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 3-29.

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

$$I_A = I \times \left(1 - L_1\right) \times \left(1 - L_2\right) \qquad \text{(Eqn. 3-3)}$$

where I_A is the adjusted intake rate, I is the tabulated intake rate, L_1 is the cooking or preparation loss, and L_2 is the post-cooking loss. For fruits, corrections based on postcooking 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 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

Pao et al. (1982) - Foods Commonly Eaten by Individuals - Using data gathered in the 1977-78 USDA NFCS, Pao et al. (1982) calculated distributions for the quantities of individual fruit and vegetables consumed per eating occasion by members of the U.S. population (i.e., serving sizes), over a 3-day period. The data were collected during NFCS home interviews of 37,874 respondents, who were asked to recall food intake for the day preceding the interview, and record food intake the day of the interview and the day after the interview.

Serving size data are presented on an as consumed (g/day) basis in Table 3-30 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 1977-78 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 1977-78.

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/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 3-31 and Table 3-32 and the following equation:

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

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

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

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:

$$\frac{\text{residue level}}{\text{g-product}} = \frac{\text{residue level}}{\text{g-fat}} \times \frac{\text{g-fat}}{\text{g-product}} \qquad \text{(Eqn. 3-6)}$$

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 3-33 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-ounce (85.05 g) cooked serving size, and the corresponding percent fat content values for several categories of meats (Table 3-34). NLMB (1993) also reported that 0.17 grams of fat are consumed per gram of meat (i.e., beef, pork, lamb, veal, game, processed meats, and variety meats) (17 percent) and 0.08 grams of fat are consumed per gram of poultry (8 percent).

3.10 RECOMMENDATIONS

The 1994-96 CSFII data described in this section were used in selecting recommended intake rates for most food groups for general population children. For fish intake among general population children, the 1989-91 CSFII analyses were used to recommend intake rates. For recreational fish intake and intake among Native American populations, the data for children are limited. Fat intake data are also limited. The studies that address these populations should be used in exposure assessments where these populations are of interest (see Tables 3-13 and 3-17). Table 3-35 presents a summary of the recommended values for food intake and Table 3-36 presents the confidence ratings for the food intake (including fish) recommendations for general population children. Table 3-37 present the confidence ratings for fish intake recommendations for the freshwater recreational population and Table 3-38 for Native American subsistence populations. 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.

3.11 REFERENCES FOR CHAPTER 3

CDC. (1994) Dietary fat and total food-energy intake. Third National Health and Nutrition Examination Survey, Phase 1, 1988-91. Morbidity and Mortality Weekly Report, February 25, 1994: 43(7)118-125.

Columbia River Inter-Tribal Fish Commission (CRITFC). (1994) A fish consumption survey of the Umatilla, Nez Perce, Yakama and Warm Springs tribes of the Columbia River Basin. Technical Report 94-3. Portland, OR: CRIFTC.

Cresanta, J.L.; Farris, R.P.; Croft, J.B.; Frank, G.C.; Berenson, G.S. (1988) Trends in fatty acid intakes of 10-year-old children, 1973-1982. Journal of American Dietetic Association. 88:178-184.

Frank, G.C.; Webber, L.S.; Farris, R.P.; Berenson, G.S. (1986) Dietary databook: quantifying dietary intakes of infants, children, and adolescents, the Bogalusa heart study, 1973-1983. National Research and Demonstration Center - Arteriosclerosis, Louisiana State University Medical Center, New Orleans, Louisiana.

Goldman, L. (1995) Children - unique and vulnerable. Environmental risks facing children and recommendations for response. Environmental Health Perspectives. 103(6):13-17.

Javitz, H. (1980) Seafood consumption data analysis. SRI International. Final report prepared for EPA Office of Water Regulations and Standards. EPA Contract 68-01-3887.

National Livestock and Meat Board (NLMB). (1993) Eating in America today: A dietary pattern and intake report. National Livestock and Meat Board. Chicago, IL.

Nicklas, T.A. (1995) Dietary studies of children: The Bogalusa Heart Study experience. Journal of the American Dietetic Association. 95:1127-1133.

Nicklas, T.A.; Webber, L.S.; Srinivasan, S.R.; Berenson, G.S. (1993) Secular trends in dietary intakes and cardiovascular risk factors in 10-y-old children: the Bogalusa heart study (1973-1988). American Journal of Clinical Nutrition. 57:930-937.

Pao, E.M.; Fleming, K.H.; Guenther, P.M.; Mickle, S.J. (1982) Foods commonly eaten by individuals: amount per day and per eating occasion. U.S. Department of Agriculture. Home Economics Report No. 44.

Ruffle, B.; Burmaster, D.; Anderson, P.; Gordon, D. (1994) Lognormal distributions for fish consumption by the general U.S. population. Risk Analysis 14(4):395-404.

Rupp, E.; Miler, F.L.; Baes, C.F. III. (1980) Some results of recent surveys of fish and shellfish consumption by age and region of U.S. residents. Health Physics 39:165-175.

SAS Institute, Inc. (1990) SAS Procedures Guide, Version 6, Third Edition, Cary, NC: SAS Institute, Inc., 1990, 705 pp.

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

USDA. (1975) Food yields summarized by different stages of preparation. Agricultural Handbook No. 102. Washington, DC: U.S. Department of Agriculture, Agriculture Research Service.

USDA. (1979-1986) Agricultural Handbook No. 8. United States Department of Agriculture.

USDA. (1987-88) Dataset: Nationwide Food Consumption Survey 1987/88 Household Food Use. U.S. Department of Agriculture. Washington, D.C. 1987/88 NFCS Database.

USDA. (1992) Changes in food consumption and expenditures in American households during the 1980's. U.S. Department of Agriculture. Washington, D.C. Statistical Bulletin No. 849.

USDA. (1993) Food and nutrient intakes by individuals in the United States, 1 Day, 1987-88. Nationwide Food Consumption Survey 1987-88, NFCS Report No. 87-I-1.

USDA. (1994) Food consumption and dietary levels of households in the United States, 1987-88. U.S. Department of Agriculture, Agricultural Research Service. Report No. 87-H-1.

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

USDA. (1998) 1994-96 Continuing Survey of Food Intakes by Individuals (CSFII) and 1994-96 Diet and Health Knowledge Survey (DKHS). CD-ROM. U.S. Department of Agriculture, Agricultural Research Service. Available from the National Technical Information Service, Springfield, VA.

U.S. EPA. (1996) Daily average per capita fish consumption estimates based on the combined USDA 1989, 1990 and 1991 continuing survey of food intakes by individuals (CSFII) 1989-91 data. Volumes I and II. Preliminary Draft Report. Washington, DC: Office of Water.

U.S. EPA. (1997) Exposure Factors Handbook. Washington, DC: Office of Research and Development. EPA/600/P-95/002F.

U.S. EPA. (2000) CSFII analysis of food intake. Report prepared for U.S. EPA, Office of Research and Development, National Center for Environmental Assessment by Versar, Inc.

West, P.C.; Fly, M.J.; Marans, R.; Larkin, F. (1989) Michigan sport anglers fish consumption survey. A report to the Michigan Toxic Substance Control Commission. Michigan Department of Management and Budget Contract No. 87-20141.

Table 3-1. Weighted and Unweighted Number of Observations, 1994/96 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 3-2. Per Capita Intake of the Major Food Groups (g/kg-day as consumed)

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Fruits													
Age (years)													
< 01	56.8%	13.18	1.106	0	0	0	0	7.559	22.67	35.69	41.18	63.73	110.2
1-2	85.5%	19.31	0.521	0	0	0	6.351	15.52	27.45	41.62	53.9	77.26	125.3
3-5	79.0%	11.02	0.341	0	0	0	2.273	8.102	16.34	26.44	32.68	52.99	105.2
6-11	71.2%	5.393	0.2	0	0	0	0	3.351	7.874	13.63	17.95	28.45	44.57
12-19	60.7%	2.771	0.133	0	0	0	0	1.371	4.116	7.978	10.97	16.64	32.23
Vegetables													
Age (years)													
< 01	50.1%	6.902	0.721	0	0	0	0	2.337	12.23	17.86	24.18	36.28	102.6
1-2	95.4%	9.528	0.213	0	0.471	1.929	4.534	8.013	12.58	18.72	23.28	33.46	83.29
3-5	92.7%	7.295	0.159	0	0	1.348	3.411	6.231	9.69	13.93	18.27	28.99	45.54
6-11	93.2%	5.337	0.118	0	0	1.12	2.48	4.334	7.103	10.44	13.54	21.21	52.27
12-19	97.9%	4.034	0.085	0	0.633	1.121	2.14	3.404	5.145	7.399	9.346	14.68	42.43
Grains													
Age (years)													
< 01	64.9%	4.124	0.416	0	0	0	0	1.575	5.438	12.97	20.24	26.61	40.13
1-2	95.6%	11.21	0.202	0	1.686	3.594	6.434	9.807	14.27	21.04	24.71	34.67	47.99
3-5	93.1%	10.29	0.197	0	0	3.674	6.292	9.177	13.13	17.77	21.07	33.64	120.9
6-11	93.4%	7.2	0.122	0	0	2.452	4.285	6.656	9.413	12.92	15.55	19.89	36.3
12-19	98.2%	4.401	0.08	0	1.13	1.543	2.452	3.788	5.541	7.899	9.702	14.08	34.57
Meats													
Age (years)													
< 01	32.3%	1.132	0.198	0	0	0	0	0	1.383	3.87	5.853	10.59	12.37
1-2	94.0%	4.422	0.094	0	0	0.759	1.909	3.845	6.195	8.869	10.16	14.66	24.44
3-5	92.2%	4.144	0.08	0	0	0.768	2.125	3.814	5.624	7.847	9.436	13.1	20.74
6-11	92.4%	2.919	0.06	0	0	0.523	1.418	2.52	3.996	5.555	6.802	10.23	17.6
12-19	97.3%	2.158	0.046	0	0.266	0.527	1.106	1.947	2.835	3.93	4.865	7.459	26.75
Fish													
Age (years)													
< 01	20.9%	0.108	0.047	0	0	0	0	0	0	0.325	0.527	1.562	4.685
1-2	58.2%	0.368	0.037	0	0	0	0	0.08	0.286	0.783	1.791	4.687	14.42
3-5	56.4%	0.316	0.03	0	0	0	0	0.069	0.245	0.661	1.736	4.567	9.553
6-11	57.5%	0.259	0.025	0	0	0	0	0.058	0.178	0.479	1.346	4.234	6.686
12-19	62.9%	0.204	0.017	0	0	0	0	0.055	0.172	0.417	1.1	2.499	5.354
Dairy Products													
Age (years)													
< 01	83.6%	111.4	4.855	0	0	2.522	63.89	102.2	158.6	197.8	235.3	318.3	576.3
1-2	95.7%	37.48	0.779	0	0.412	6.677	17.75	31.76	51.44	73.89	90.15	132.8	182.8
3-5	92.9%	20.91	0.402	0	0	3.473	10.18	18.73	29.16	41.24	48.75	66.16	89.72
6-11	93.3%	13.92	0.276	0	0	2.167	6.438	12.35	19.25	27.34	33.46	43.43	80.78
12-19	96.9%	6.119	0.16	0	0.168	0.413	1.832	4.467	8.803	13.49	17.79	27.84	38.01

Note: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analyses of the 1994-96 CSFII

Table 3-3. Per Capita Intake of Individual Foods (g/kg-day as consumed)

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%	7.03	0.977	0.0%	0	0	21.4%	1.153	0.342	0.6%	0.032	0.247	1.1%	0.017	0.11
01-02	55.1%	8.02	0.448	0.7%	0.014	0.082	35.0%	1.688	0.138	0.4%	0.004	0.035	8.6%	0.242	0.095
03-05	47.7%	4.103	0.273	0.7%	0.009	0.041	20.8%	0.713	0.095	0.6%	0.012	0.051	7.8%	0.137	0.06
06-11	34.1%	1.437	0.135	0.8%	0.014	0.065	14.2%	0.353	0.073	0.3%	0.003	0.033	6.8%	0.108	0.055
12-19	20.0%	0.582	0.093	0.3%	0.003	0.022	9.4%	0.119	0.037	0.2%	0.001	0.015	5.8%	0.064	0.036
	Cabbage			Carrots			Corn			Cucumbers			Lettuce		
Age (years)															
< 01	0.6%	0.023	0.209	12.3%	0.678	0.348	2.2%	0.164	0.355	0.3%	0	0.011	0.0%	0	0
01-02	3.8%	0.071	0.07	14.5%	0.343	0.177	18.5%	0.462	0.097	6.9%	0.089	0.054	11.0%	0.109	0.035
03-05	5.7%	0.099	0.06	15.1%	0.182	0.043	19.2%	0.426	0.071	11.2%	0.13	0.059	18.9%	0.166	0.029
06-11	6.7%	0.074	0.04	17.8%	0.153	0.032	21.0%	0.316	0.046	14.7%	0.123	0.038	24.7%	0.184	0.027
12-19	5.8%	0.039	0.024	13.1%	0.057	0.019	12.8%	0.144	0.036	15.2%	0.094	0.037	35.6%	0.177	0.018
	Lima Beans			Okra			Onions			Other Berries			Peaches		
Age (years)															
< 01	0.3%	0	0.008	0.0%	0	0	0.3%	0.007	0.135	0.3%	0.005	0.068	12.8%	0.856	0.393
01-02	1.6%	0.037	0.074	1.0%	0.01	0.041	4.1%	0.019	0.021	1.5%	0.073	0.229	9.7%	0.447	0.145
03-05	0.8%	0.01	0.044	0.3%	0.006	0.084	4.7%	0.022	0.021	1.7%	0.034	0.084	7.2%	0.248	0.117
06-11	1.0%	0.018	0.057	0.8%	0.008	0.03	6.7%	0.026	0.017	1.8%	0.029	0.057	5.6%	0.125	0.077
12-19	0.5%	0.007	0.062	0.7%	0.003	0.018	12.9%	0.044	0.015	1.4%	0.016	0.043	4.0%	0.064	0.051
	Pears			Peas			Peppers			Pumpkins			Snap Beans		
Age (years)															
< 01	14.8%	1.354	0.49	9.2%	0.603	0.313	0.3%	0.001	0.014	7.5%	0.433	0.383	11.7%	0.624	0.267
01-02	8.5%	0.393	0.159	12.3%	0.257	0.072	1.5%	0.007	0.015	1.0%	0.054	0.172	19.4%	0.49	0.086
03-05	5.0%	0.178	0.114	9.1%	0.163	0.054	3.1%	0.018	0.023	0.3%	0.003	0.034	15.3%	0.239	0.05
06-11	5.2%	0.114	0.07	7.8%	0.111	0.049	4.7%	0.018	0.015	0.1%	0.001	0.017	12.2%	0.16	0.057
12-19	1.7%	0.023	0.039	5.6%	0.06	0.037	7.4%	0.018	0.01	0.1%	0.002	0.039	7.9%	0.063	0.024
	Strawberries			Tomatoes			White Potatoes			Breads			Breakfast Foods (Grains)		
Age (years)															
< 01	0.6%	0.007	0.086	28.7%	0.518	0.119	27.6%	0.537	0.151	15.0%	0.256	0.114	1.7%	0.048	0.162
01-02	4.4%	0.116	0.091	88.8%	2.139	0.076	77.4%	2.245	0.1	76.9%	1.95	0.063	19.5%	0.429	0.066
03-05	4.4%	0.096	0.081	87.7%	1.741	0.059	77.6%	2.027	0.085	85.6%	2.289	0.054	21.5%	0.391	0.055
06-11	4.5%	0.064	0.053	89.4%	1.217	0.037	79.0%	1.51	0.058	87.0%	1.698	0.04	21.9%	0.37	0.045
12-19	3.8%	0.032	0.026	94.8%	1.01	0.025	84.3%	1.243	0.049	86.4%	1.068	0.026	12.7%	0.13	0.031
	Cereals (Baby)			Cereals (Cooked)			Cereals (Ready-to-Eat)			Pasta			Rice		

Table 3-3. Per Capita Intake of Individual Foods (g/kg-day as consumed) (continued)

Population Group	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE	Percent Consuming	Mean	SE
Age (years)															
< 01	52.9%	1.595	0.265	5.6%	0.931	0.819	8.6%	0.059	0.048	2.5%	0.066	0.149	3.9%	0.167	0.283
1-2	6.5%	0.162	0.095	16.6%	1.618	0.286	65.0%	0.965	0.039	16.2%	0.795	0.152	19.1%	0.905	0.166
3-5	0.3%	0.004	0.055	14.7%	1.26	0.283	68.5%	1.1	0.038	12.5%	0.552	0.128	16.3%	0.795	0.179
6-11	0.1%	0	0.002	8.7%	0.471	0.171	63.1%	0.794	0.031	12.3%	0.488	0.115	16.1%	0.492	0.098
12-19	0.0%	0	0	5.9%	0.164	0.09	44.6%	0.36	0.023	12.1%	0.264	0.088	17.2%	0.462	0.105
	Snacks (Grains)			Sweets (Grains)			Beef			Eggs			Game		
Age (years)															
< 01	13.9%	0.135	0.063	10.6%	0.158	0.096	29.0%	0.508	0.111	29.0%	0.405	0.142	0.0%	0	0
1-2	57.5%	0.738	0.039	53.9%	1.155	0.066	88.9%	1.389	0.045	88.8%	1.174	0.055	0.5%	0.009	0.067
3-5	54.5%	0.701	0.042	62.1%	1.342	0.064	86.1%	1.311	0.042	84.5%	0.65	0.037	0.6%	0.009	0.054
6-11	51.0%	0.461	0.03	63.4%	1.151	0.055	87.7%	1.073	0.035	85.3%	0.4	0.025	1.0%	0.013	0.053
12-19	45.6%	0.287	0.022	54.6%	0.621	0.033	92.9%	0.917	0.033	91.0%	0.286	0.015	0.8%	0.006	0.027
	Pork			Poultry			Butter			Margarine			Dressing		
Age (years)															
< 01	29.0%	0.092	0.03	30.4%	0.35	0.1	1.1%	0.002	0.007	2.2%	0.004	0.011	0.8%	0.003	0.02
01-02	86.7%	0.4	0.025	89.7%	1.408	0.051	12.9%	0.034	0.01	30.1%	0.073	0.009	11.7%	0.062	0.02
03-05	84.5%	0.375	0.024	88.1%	1.307	0.047	13.7%	0.04	0.01	31.6%	0.085	0.009	18.3%	0.084	0.016
06-11	85.0%	0.265	0.016	87.8%	0.829	0.032	14.9%	0.03	0.008	31.4%	0.062	0.007	23.1%	0.094	0.013
12-19	90.2%	0.209	0.011	93.3%	0.619	0.022	11.6%	0.015	0.005	24.0%	0.034	0.005	24.2%	0.08	0.011
	Mayonnaise			Sauce			Vegetable Oil								
Age (years)															
< 01	0.6%	0.001	0.005	0.0%	0	0	0.6%	0.005	0.057						
01-02	9.1%	0.024	0.01	0.4%	0.004	0.025	0.4%	0.001	0.014						
03-05	14.8%	0.036	0.008	0.8%	0.003	0.016	0.7%	0.002	0.007						
06-11	16.4%	0.028	0.006	0.7%	0.003	0.013	0.4%	0.001	0.008						
12-19	21.5%	0.032	0.005	1.3%	0.005	0.012	0.5%	0	0.002						

NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analyses of the 1989-91 CSFII

Table 3-4. Per Capita Intake of USDA Categories of Vegetables and Fruits (g/kg-day as consumed)

Population Group	Percent Consuming	MEAN	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Dark Green Vegetables													
Age (years)													
< 01	1.7%	0.045	0.219	0	0	0	0	0	0	0	0	0.678	9.77
1-2	12.5%	0.328	0.098	0	0	0	0	0	0	0.845	2.315	6.513	20.94
3-5	10.9%	0.197	0.063	0	0	0	0	0	0	0.224	1.488	4.127	12.72
6-11	9.9%	0.154	0.054	0	0	0	0	0	0	0.162	1.042	3.655	6.761
12-19	9.4%	0.124	0.041	0	0	0	0	0	0	0.15	0.935	2.792	4.333
Deep Yellow Vegetables													
Age (years)													
< 01	4.5%	0.162	0.217	0	0	0	0	0	0	0	0.372	5.708	7.862
1-2	15.2%	0.276	0.065	0	0	0	0	0	0	0.728	2.131	4.235	11.72
3-5	16.9%	0.243	0.051	0	0	0	0	0	0	0.716	1.729	4.299	8.268
6-11	19.3%	0.18	0.035	0	0	0	0	0	0	0.658	1.18	2.45	10.84
12-19	14.3%	0.071	0.021	0	0	0	0	0	0	0.152	0.506	1.387	4.85
Citrus Fruits													
Age (years)													
< 01	4.5%	0.213	0.392	0	0	0	0	0	0	0	0	8.578	30.25
1-2	37.7%	4.018	0.341	0	0	0	0	0	5.741	12.87	18.71	37.07	113.4
3-5	38.9%	2.946	0.22	0	0	0	0	0	4.704	9.308	13.03	21.21	66.54
6-11	35.0%	1.9	0.163	0	0	0	0	0	2.745	6.329	9.465	16.74	27.94
12-19	36.1%	1.409	0.121	0	0	0	0	0	1.92	4.652	7.16	12.87	17.93
Other Fruits													
Age (years)													
< 01	55.4%	12.93	1.11	0	0	0	0	7.266	22.67	35.38	41.18	63.42	110.2
1-2	79.6%	15.27	0.496	0	0	0	2.817	10.69	23	35.16	48.17	70.31	105.5
3-5	71.4%	8.071	0.311	0	0	0	0	4.92	11.76	20.53	27.38	44.08	84.57
6-11	62.0%	3.493	0.163	0	0	0	0	1.901	5.102	9.341	12.81	22.22	38.47
12-19	43.1%	1.362	0.104	0	0	0	0	0	1.833	4.153	6.261	12.71	32.23
Other Vegetables													
Age (years)													
< 01	10.9%	0.466	0.293	0	0	0	0	0	0	0.565	2.853	11.07	14.76
1-2	62.4%	2.161	0.125	0	0	0	0	0.75	2.961	6.35	8.871	16.07	53.61
3-5	64.5%	1.726	0.091	0	0	0	0	0.706	2.239	4.693	7.206	13.35	21.71
6-11	66.3%	1.328	0.067	0	0	0	0	0.62	1.836	3.639	4.858	9.762	28.58
12-19	68.8%	0.804	0.042	0	0	0	0	0.33	1.127	2.086	2.961	6.27	12.56

Table 3-5. Per Capita Intake of Exposed/Protected Fruit and Vegetable Categories (g/kg-day as consumed)

Population Group	Percent Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Exposed Fruits													
Age (years)													
< 01	49.9%	10.02	0.995	0	0	0	0	4.449	16.53	30.09	38.78	58.46	69.61
01-02	68.6%	10.9	0.469	0	0	0	0	5.695	15.68	29.37	38.99	65.81	101.3
03-05	60.7%	5.637	0.277	0	0	0	0	2.717	8.096	15.84	22.18	34.98	77.08
06-11	49.3%	2.197	0.136	0	0	0	0	0	3.075	6.338	8.777	17.55	32.2
12-19	31.9%	0.872	0.087	0	0	0	0	0	1.07	2.857	4.85	8.787	14.91
Protected Fruits													
Age (years)													
< 01	27.0%	1.719	0.392	0	0	0	0	0	1.957	6.013	8.344	16.61	30.25
01-02	62.1%	6.449	0.309	0	0	0	0	3.59	9.186	17.84	24.18	39.03	113.4
03-05	54.5%	4.356	0.223	0	0	0	0	2.062	6.721	12.14	17.16	27.9	66.54
06-11	49.0%	2.702	0.165	0	0	0	0	0.165	3.817	8.074	11.44	19.81	31.71
12-19	46.4%	1.809	0.124	0	0	0	0	0	2.612	5.417	8.402	15.43	27.02
Exposed Vegetables													
Age (years)													
< 01	18.1%	1.189	0.371	0	0	0	0	0	0	4.991	7.353	14.65	19.04
1-2	63.4%	1.996	0.114	0	0	0	0	0.591	2.678	5.753	8.551	14.87	45.03
3-5	68.2%	1.63	0.083	0	0	0	0	0.674	2.241	4.442	6.378	12.79	25.07
6-11	70.6%	1.235	0.058	0	0	0	0	0.601	1.58	3.417	4.836	8.102	19.6
12-19	76.4%	0.966	0.041	0	0	0	0.055	0.53	1.338	2.53	3.61	5.767	13.02
Protected Vegetables													
Age (years)													
< 01	18.9%	1.281	0.371	0	0	0	0	0	0	5.42	7.785	11.9	23.1
01-02	41.4%	1.469	0.125	0	0	0	0	0	1.863	4.422	7.042	14.16	27.81
03-05	38.8%	1.079	0.09	0	0	0	0	0	1.402	3.52	5.417	10.3	17.99
06-11	38.7%	0.778	0.065	0	0	0	0	0	1.042	2.583	3.894	7.496	26.51
12-19	31.2%	0.462	0.055	0	0	0	0	0	0.437	1.517	2.348	5.766	21.55
Root Vegetables													
Age (years)													
< 01	30.4%	1.812	0.355	0	0	0	0	0	2.307	6.944	9.582	15.59	32.92
01-02	68.2%	2.572	0.134	0	0	0	0	1.447	3.562	6.774	8.331	16.78	83.29
03-05	71.1%	2.191	0.091	0	0	0	0	1.355	3.215	5.512	7.125	14.06	32.05
06-11	73.7%	1.62	0.063	0	0	0	0	1.034	2.315	4.171	5.325	9.492	20.59
12-19	76.2%	1.263	0.053	0	0	0	0.094	0.823	1.747	3.015	3.992	7.661	22.47

NOTE: SE = Standard error
P = Percentile of the distribution
Source: Based on EPA's analyses of the 1989-91 CSFII

Table 3-6. Per Capita Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - As Consumed

Age (years)	Sample Size	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	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 3-7. Consumers Only Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - As Consumed

Age (years)	Sample Size	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	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	371	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	153.2	176.9	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	88.8	170.01	212.56	361.04	1414.54	2726.46	3740.83	6703.25
Males									
14 or under	429	79.72	161.62	190	308.59	2568.93	4714.97	5818.08	9350.89
15 - 44	702	124.78	230.77	296.66	397.7	1545.93	2854.49	3773.51	5254.04
Both Sexes									
14 or under	807	74.8	153.7	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 3-8. Per Capita Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - Uncooked Fish Weight

Age (years)	Sample Size	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	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 3-9. Per Capita Distribution of Fish (Finfish and Shellfish) Intake by Age and Gender - Uncooked Fish Weight

Age (years)	Sample Size	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	48.3	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	101.5	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	488.9	1897.40	3674.88	4709.78	7276.18

Source: U.S. EPA, 1996.

Table 3-10. Mean and 95th Percentile of Fish Consumption (g/day) by Sex and Age[a]

		Total Fish	
	Age (years)	Mean	95th Percentile
Female	0 - 9	6.1	17.3
	10 - 19	9.0	25.0
Male	0 - 9	6.3	15.8
	10 - 19	11.2	29.1
Male & Female	0-9	6.2	16.5
	10-19	10.1	26.8

[a] The calculations in this table are based upon respondents who consumed fish in the month of the survey. These respondents are estimated to represent 94.0% of the U.S. population.
Source: Javitz, 1980.

Table 3-11. Best Fits of Lognormal Distributions Using the Nonlinear Optimization (Nlo) Method

	Teenagers	Children
Shellfish		
μ	-0.183	0.854
σ	1.092	0.730
(min SS)	1.19	16.06
Finfish (freshwater)		
μ	0.578	-0.559
σ	0.822	1.141
(min SS)	23.51	2.19
Finfish (saltwater)		
μ	1.691	0.881
σ	0.830	0.970
(min SS)	0.33	4.31

The following equations may be used with the appropriate μ and σ values to obtain an average Daily Consumption Rate (DCR), in grams, and percentiles of the DCR distribution.

$DCR50 = \exp(\mu)$
$DCR90 = \exp[\mu + z(0.90) \cdot \sigma]$
$DCR99 = \exp[\mu + z(0.99) \cdot \sigma]$
$DCR_{avg} = \exp[\mu + 0.5 \cdot \sigma^2]$

Source: Ruffle et al., 1994.

Table 3-12. Number of Respondents Reporting Consumption of a Specified Number of Servings of Seafood in 1 Month and Source of Seafood Eaten

Population Group	Total N	Number of Servings in a Month								
		1-2	3-5	6-10	11-19	20+	DK	Mostly Purchased	Mostly Caught	DK
Age (years)										
1-4	102	55	29	12	2	*	4	94	8	*
5-11	166	72	57	21	6	4	6	153	9	4
12-17	137	68	54	9	2	1	3	129	6	2

Note: * = Missing data; DK = Don't know; % = Row percentage; N = Sample size; Refused = Respondent refused to answer.
Source: Tsang and Klepeis, 1996.

Table 3-13. Mean Fish Intake Among Individuals Who Eat Fish and Reside in Households With Recreational Fish Consumption

Group	All Fish meals/week	Recreational Fish meals/week	n	Total Fish grams/day	Recreational Fish grams/day	Total Fish grams/ kg/day	Recreational Fish grams/ kg/day
Age Groups (years)							
1-5	0.463	0.223	121	11.4	5.63	0.737	0.369
6 to 10	0.49	0.278	151	13.6	7.94	0.481	0.276
1 to 20	0.407	0.229	349	12.3	7.27	0.219	0.123

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

Table 3-14. Children's 5 and Under Fish Consumption Rates - Throughout Year

Number of Grams/Day	Unweighted Cumulative Percent
0.0	21.1%
0.4	21.6%
0.8	22.2%
1.6	24.7%
2.4	25.3%
3.2	28.4%
4.1	32.0%
4.9	33.5%
6.5	35.6%
8.1	47.4%
9.7	48.5%
12.2	51.0%
13.0	51.5%
16.2	72.7%
19.4	73.2%
20.3	74.2%
24.3	76.3%
32.4	87.1%
48.6	91.2%
64.8	94.3%
72.9	96.4%
81.0	97.4%
97.2	98.5%
162.0	100%

N = 194
Unweighted Mean = 19.6 grams/day
Unweighted SE = 1.94
Source: CRITFC, 1994.

Table 3-15. Fat Intake Among Children Based on Data from the Bogalusa Heart Study, 1973-1982 (g/day)

Age (years)	N	Mean	St. Dev.	P10	P25	P50	P75	P90	Minimum	Maximum
				Total Fat Intake						
6 Mo.	125	37.1	17.5	18.7	25.6	33.9	46.3	60.8	3.4	107.6
1	99	59.1	26.0	29.1	40.4	56.1	71.4	94.4	21.6	152.7
2	135	86.7	41.3	39.9	55.5	79.2	110.5	141.1	26.5	236.4
3	106	91.6	38.8	50.2	63.6	82.6	114.6	153.0	32.6	232.5
4	219	98.6	56.1	46.0	66.8	87.0	114.6	163.3	29.3	584.6
10	871	93.2	50.8	45.7	60.5	81.4	111.3	154.5	14.6	529.5
13	148	107.0	53.9	53.0	69.8	90.8	130.7	184.1	9.8	282.2
15	108	97.7	48.7	46.1	65.2	85.8	124.0	165.2	10.0	251.3
17	159	107.8	64.3	41.4	59.7	97.3	140.2	195.1	8.5	327.4
				Total Animal Fat						
6 Mo.	125	18.4	16.0	0.7	4.2	13.9	28.4	42.5	0.0	61.1
1	99	36.5	20.0	15.2	23.1	33.0	45.9	65.3	0.0	127.1
2	135	49.5	28.3	20.1	28.9	42.1	66.0	81.4	10.0	153.4
3	106	50.1	29.4	21.3	29.1	42.9	64.4	88.9	14.1	182.6
4	219	50.8	31.7	21.4	28.1	42.6	66.4	92.6	5.9	242.2
10	871	54.1	39.6	20.3	30.6	45.0	64.6	97.5	0.0	412.3
13	148	56.2	39.8	19.8	28.5	44.8	72.8	109.4	4.7	209.6
15	108	53.8	35.1	15.9	28.3	44.7	67.9	105.8	0.6	182.1
17	159	64.4	48.5	15.2	30.7	51.6	86.6	128.8	2.6	230.3
				Total Vegetable Fat Intake						
6 Mo.	125	9.2	12.8	0.6	1.2	2.8	11.6	29.4	0.0	53.2
1	99	15.4	14.3	3.7	6.1	11.3	18.1	38.0	0.2	70.2
2	135	19.3	16.3	3.8	7.9	14.8	26.6	42.9	0.7	96.6
3	106	21.1	15.5	3.9	8.6	18.7	26.6	45.2	1.0	70.4
4	219	24.5	18.6	5.7	10.4	21.8	33.3	48.5	0.9	109.0
10	871	23.7	21.6	4.3	9.5	18.3	30.6	49.0	0.6	203.7
13	148	34.3	27.4	8.4	17.9	31.2	44.6	57.5	0.0	238.3
15	108	27.3	22.8	5.1	11.9	22.6	38.1	54.4	0.7	132.2
17	159	25.7	21.3	4.2	11.7	20.8	32.9	47.6	0.0	141.5
				Total Fish Fat Intake						
6 Mo.	125	0.046	0.130	0.000	0.000	0.000	0.000	0.140	0.000	0.900
1	99	0.047	0.233	0.000	0.000	0.000	0.000	0.000	0.000	1.900
2	135	0.036	0.229	0.000	0.000	0.000	0.000	0.000	0.000	1.900
3	106	0.100	0.591	0.000	0.000	0.000	0.000	0.000	0.000	4.500
4	219	2.255	31.05	0.000	0.000	0.000	0.000	0.000	0.000	459.2
10	871	0.292	1.452	0.000	0.000	0.000	0.000	0.000	0.000	19.2
13	148	0.269	2.151	0.000	0.000	0.000	0.000	0.000	0.000	25.4
15	108	0.431	1.467	0.000	0.000	0.000	0.000	0.000	0.000	9.500
17	159	0.465	2.010	0.000	0.000	0.000	0.000	0.000	0.000	15.3

Source: Frank et al., 1986.

Table 3-16. Fat Intake Among Children Based on Data from the Bogalusa Heart Study, 1973-1982 (g/kg/day)

Age (years)	N	Mean	St. Dev.	P10	P25	P50	P75	P90	Minimum	Maximum
					Total Fat Intake					
6 Mo.	125	4.94	2.32	2.41	3.28	4.67	6.19	7.97	0.39	13.16
1	99	6.12	2.75	3.03	4.11	5.66	7.47	9.53	2.27	16.38
2	132	6.98	3.34	3.37	4.45	6.15	8.56	11.94	2.14	18.69
3	106	6.40	2.67	3.61	4.56	5.50	8.16	9.93	2.18	16.73
4	218	6.05	3.66	2.88	3.96	5.24	6.97	9.98	2.03	38.21
10	861	2.70	1.52	1.23	1.68	2.35	3.32	4.54	0.33	13.86
13	147	2.28	1.30	1.03	1.47	1.99	2.80	3.81	0.21	10.19
15	105	1.73	0.84	0.84	1.18	1.54	2.14	3.13	0.15	4.73
17	149	1.77	1.02	0.69	0.92	1.62	2.24	3.10	0.16	6.23
					Total Animal Fat					
6 Mo.	125	2.43	2.13	0.08	0.60	2.03	3.74	5.47	0.00	8.99
1	99	3.78	2.12	1.70	2.37	3.39	4.90	6.48	0.00	13.64
2	132	3.99	2.31	1.73	2.29	3.36	5.22	6.69	0.67	13.40
3	106	3.50	2.01	1.56	2.07	3.13	4.18	6.05	0.90	13.14
4	218	3.12	2.05	1.26	1.73	2.64	4.04	5.38	0.39	15.43
10	861	1.56	1.16	0.55	0.84	1.28	1.92	2.83	0.00	10.79
13	147	1.19	0.86	0.40	0.59	0.94	1.59	2.28	0.08	5.19
15	105	0.95	0.62	0.32	0.54	0.81	1.25	1.90	0.01	3.07
17	149	1.04	0.77	0.26	0.51	0.83	1.38	1.97	0.05	4.15
					Total Vegetable Fat Intake					
6 Mo.	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 Mo.	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 3-17. Mean Total Daily Dietary Fat Intake (g/day) Grouped by Age and Gender[a]

	Total		Males		Females	
Age (yrs)	N	Mean Fat Intake (g/day)	N	Mean Fat Intake (g/day)	N	Mean Fat Intake (g/day)
2-11 (months)	871	37.52	439	38.31	432	36.95
1-2	1,231	49.96	601	51.74	630	48.33
3-5	1,647	60.39	744	70.27	803	61.51
6-11	1,745	74.17	868	79.45	877	68.95
12-16	711	85.19	338	101.94	373	71.23
16-19	785	100.50	308	123.23	397	77.46

[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 3-18. Per Capita Total Dietary Intake

Population Group	Percent Consuming	Mean	Adjusted SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
(g/day, as consumed)													
Age (years)													
Age < 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
Age 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
Age 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
Age 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
Age 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)													
Age (years)													
Age < 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
Age 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
Age 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
Age 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
Age 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

Note: SE = Standard error.
P = percentile of the distribution.
Source: Based on EPA's analysis of the 1994-96 CSFII.

Table 3-19. Per Capita Intake of Major Food Groups (g/day, as consumed)

Food Group	Percent Consuming	MEAN	Adjusted SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
						Age <1 Year							
Total Dietary Intake	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
Total Dairy Intake	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
Total Meat Intake	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
Total Egg Intake	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
Total Fish Intake	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
Total Grain Intake	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
Total Vegetable Intake	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
Total Fruit Intake	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
Total Fat Intake[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
						Ages 1-2 Years							
Total Dietary Intake	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
Total Dairy Intake	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
Total Meat Intake	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
Total Egg Intake	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
Total Fish Intake	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
Total Grain Intake	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
Total Vegetable Intake	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
Total Fruit Intake	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
Total Fat Intake[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
						Ages 3-5 Years							
Total Dietary Intake	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
Total Dairy Intake	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
Total Meat Intake	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
Total Egg Intake	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
Total Fish Intake	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
Total Grain Intake	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
Total Vegetable Intake	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
Total Fruit Intake	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
Total Fat Intake[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
						Ages 6-11 Years							
Total Dietary Intake	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
Total Dairy Intake	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
Total Meat Intake	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
Total Egg Intake	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
Total Fish Intake	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
Total Grain Intake	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
Total Vegetable Intake	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
Total Fruit Intake	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
Total Fat Intake[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
						Ages 12-19 Years							
Total Dietary Intake	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

Table 3-19. Per Capita Intake of Major Food Groups (g/day, as consumed) (continued)

Food Group	Percent Consuming	MEAN	Adjusted SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total Dairy Intake	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
Total Meat Intake	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
Total Egg Intake	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
Total Fish Intake	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
Total Grain Intake	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
Total Vegetable Intake	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
Total Fruit Intake	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
Total Fat Intake[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.

Note: SE = Standard error.
P = percentile of the distribution.
Source: Based on EPA's analysis of the 1994-96 CSFII.

Table 3-20. Per Capita Intake of Major Food Groups (g/kg/day, as consumed)

Food Group	Percent Consuming	MEAN	Adjusted SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
						Age <1 Year							
Total Dietary Intake	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
Total Dairy Intake	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
Total Meat Intake	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
Total Egg Intake	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
Total Fish Intake	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
Total Grain Intake	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
Total Vegetable Intake	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
Total Fruit Intake	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
Total Fat Intake[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
						Ages 1-2 Years							
Total Dietary Intake	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
Total Dairy Intake	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
Total Meat Intake	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
Total Egg Intake	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
Total Fish Intake	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
Total Grain Intake	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
Total Vegetable Intake	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
Total Fruit Intake	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
Total Fat Intakea	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
						Ages 3-5 Years							
Total Dietary Intake	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
Total Dairy Intake	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
Total Meat Intake	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
Total Egg Intake	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
Total Fish Intake	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
Total Grain Intake	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
Total Vegetable Intake	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
Total Fruit Intake	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
Total Fat Intake[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
						Ages 6-11 Years							
Total Dietary Intake	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
Total Dairy Intake	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
Total Meat Intake	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
Total Egg Intake	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
Total Fish Intake	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
Total Grain Intake	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
Total Vegetable Intake	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
Total Fruit Intake	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
Total Fat Intake[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
						Ages 12-19 Years							
Total Dietary Intake	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

Table 3-20. Per Capita Intake of Major Food Groups (g/kg/day, as consumed) (continued)

Food Group	Percent Consuming	MEAN	Adjusted SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
Total Dairy Intake	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
Total Meat Intake	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
Total Egg Intake	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
Total Fish Intake	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
Total Grain Intake	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
Total Vegetable Intake	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
Total Fruit Intake	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
Total Fat Intake[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.

Note: SE = Standard error.
P = percentile of the distribution.
Source: Based on EPA's analysis of the 1994-96 CSFII.

Table 3-21. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
	Age <1 Year (g/day, as consumed)						Age <1 Year (g/kg/day, as consumed)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total Foods	4.8E+02	100.0%	1.1E+03	100.0%	1.9E+03	100.0%	1.9E+01	100%	8.1E+01	100.0%	1.6E+02	100.0%
Total Dairy	1.6E+02	33.3%	4.5E+02	42.5%	9.2E+02	49.1%	6.0E+00	31%	3.4E+01	42.5%	8.3E+01	52.3%
Total Meats	4.8E+01	10.0%	5.9E+01	5.6%	7.0E+01	3.7%	2.0E+00	11%	4.8E+00	5.9%	5.6E+00	3.5%
Total Fish	2.4E+00	0.5%	5.6E+00	0.5%	6.9E+00	0.4%	8.9E-02	0%	5.5E-01	0.7%	5.0E-01	0.3%
Total Eggs	1.2E+01	2.5%	1.5E+01	1.5%	2.3E+01	1.2%	6.7E-01	3%	1.4E+00	1.7%	1.6E+00	1.0%
Total Grains	1.0E+02	21.0%	1.5E+02	14.5%	1.8E+02	9.8%	4.2E+00	22%	1.1E+01	13.6%	1.5E+01	9.2%
Total Vegetables	7.4E+01	15.3%	1.2E+02	11.5%	1.9E+02	10.0%	3.2E+00	17%	1.0E+01	12.5%	1.5E+01	9.6%
Total Fruits	8.0E+01	16.7%	2.5E+02	23.3%	4.7E+02	25.3%	2.8E+00	14%	1.8E+01	22.6%	3.8E+01	23.7%
Total Fats[a]	3.7E+00	0.8%	5.7E+00	0.5%	7.5E+00	0.4%	1.6E-01	1%	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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					

Table 3-21. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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 3-22. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
	Age <1 Year (g/day, as consumed)						Age <1 Year (g/kg/day, as consumed)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total Foods	1.0E+03	100.0%	1.0E+03	100.0%	1.2E+03	100.0%	5.6E+01	100%	8.4E+01	100.0%	1.0E+02	100.0%
Total Dairy	5.9E+02	56.9%	4.8E+02	45.8%	4.3E+02	35.6%	3.2E+01	57%	3.6E+01	42.9%	3.9E+01	38.9%
Total Meats	5.9E+00	0.6%	5.2E+01	5.0%	1.5E+02	12.5%	1.6E-01	0%	3.9E+00	4.7%	1.1E+01	11.3%
Total Fish	3.3E+00	0.3%	5.5E+00	0.5%	7.9E+00	0.6%	9.8E-02	0%	4.0E-01	0.5%	7.0E-01	0.7%
Total Eggs	1.0E+01	1.0%	1.5E+01	1.4%	2.2E+01	1.8%	4.0E-01	1%	1.4E+00	1.7%	1.4E+00	1.4%
Total Grains	1.0E+02	9.7%	1.4E+02	13.6%	1.7E+02	14.3%	4.7E+00	8%	1.1E+01	13.4%	1.4E+01	13.8%
Total Vegetables	1.0E+02	9.8%	1.1E+02	10.8%	1.7E+02	13.7%	6.1E+00	11%	9.7E+00	11.5%	1.3E+01	13.4%
Total Fruits	2.2E+02	21.6%	2.3E+02	22.4%	2.5E+02	20.8%	1.2E+01	22%	2.1E+01	24.7%	2.0E+01	19.9%
Total Fats[a]	2.4E+00	0.2%	5.4E+00	0.5%	7.9E+00	0.7%	8.4E-02	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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					

Table 3-22. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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 3-23. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
	Age <1 Year (g/day, as consumed)						Age <1 Year (g/kg/day, as consumed)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total Foods	7.2E+02	100.0%	1.1E+03	100.0%	1.7E+03	100.0%	3.2E+01	100%	8.3E+01	100.0%	1.5E+02	100.0%
Total Dairy	7.4E+01	10.3%	4.2E+02	39.6%	1.1E+03	66.4%	2.4E+00	7%	3.2E+01	38.3%	9.7E+01	66.7%
Total Meats	4.9E+01	6.7%	6.2E+01	5.8%	5.9E+01	3.5%	1.9E+00	6%	5.0E+00	6.0%	4.9E+00	3.4%
Total Fish	3.7E+00	0.5%	5.7E+00	0.5%	4.4E+00	0.3%	7.6E-02	0%	3.5E-01	0.4%	4.0E-01	0.3%
Total Eggs	2.0E+01	2.8%	1.6E+01	1.5%	1.5E+01	0.9%	1.1E+00	3%	1.3E+00	1.6%	1.3E+00	0.9%
Total Grains	1.6E+02	22.8%	1.6E+02	14.8%	1.3E+02	7.9%	7.5E+00	24%	1.2E+01	14.3%	1.1E+01	7.7%
Total Vegetables	1.2E+02	16.9%	1.2E+02	11.0%	1.3E+02	7.6%	5.5E+00	17%	1.1E+01	12.7%	1.2E+01	8.0%
Total Fruits	2.8E+02	39.3%	2.8E+02	26.2%	2.2E+02	13.0%	1.3E+01	41%	2.2E+01	26.2%	1.9E+01	12.7%
Total Fats[a]	4.6E+00	0.6%	5.8E+00	0.5%	5.3E+00	0.3%	2.1E-01	1%	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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					

Table 3-23. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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 3-24. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
	Age <1 Year (g/day, as consumed)						Age <1 Year (g/kg/day, as consumed)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total Foods	1.1E+03	100.0%	9.5E+02	100.0%	1.2E+03	100.0%	8.4E+01	100%	7.8E+01	100.0%	9.4E+01	100.0%
Total Dairy	4.5E+02	41.1%	4.5E+02	48.0%	4.6E+02	39.1%	3.6E+01	43%	3.8E+01	48.7%	3.7E+01	40.0%
Total Meats	5.5E+01	5.0%	4.7E+01	5.0%	7.4E+01	6.3%	4.0E+00	5%	3.8E+00	4.9%	6.1E+00	6.5%
Total Fish	0.0E+00	0.0%	1.2E+00	0.1%	3.7E+01	3.1%	0.0E+00	0%	7.9E-02	0.1%	2.8E+00	2.9%
Total Eggs	1.6E+01	1.4%	1.2E+01	1.3%	1.6E+01	1.4%	1.1E+00	1%	9.2E-01	1.2%	1.3E+00	1.3%
Total Grains	1.6E+02	14.4%	1.3E+02	13.7%	1.6E+02	13.5%	1.2E+01	14%	1.0E+01	12.9%	1.3E+01	13.5%
Total Vegetables	1.2E+02	10.6%	1.1E+02	11.4%	1.4E+02	12.0%	8.5E+00	10%	8.7E+00	11.2%	1.1E+01	12.1%
Total Fruits	3.0E+02	27.0%	1.9E+02	20.0%	2.8E+02	24.0%	2.3E+01	27%	1.6E+01	20.7%	2.2E+01	23.1%
Total Fats[a]	5.2E+00	0.5%	4.5E+00	0.5%	6.7E+00	0.6%	3.8E-01	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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					

Table 3-24. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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 3-25. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
	Age <1 Year (g/day, as consumed)						Age <1 Year (g/kg/day, as consumed)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					

Table 3-25. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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 3-26. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
Age <1 Year (g/day, as consumed)							Age <1 Year (g/kg/day, as consumed)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total 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)					

Table 3-26. 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	Low-end consumers		Mid-range consumers		High-end consumers		Low-end consumers		Mid-range consumers		High-end consumers	
	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent	Intake	Percent
Total 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%
Total 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%
Total 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%
Total 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%
Total 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%
Total Grains	2.0E+02	28.4%	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%
Total 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%
Total 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%
Total 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 3-27. Weighted and Unweighted Number of Observations (Individuals) for NFCS Data Used in Analysis of Food Intake

	All Regions		Northeast		Midwest		South		West	
	wgtd	unwgtd	wgtd	unwgtd	wgtd	unwgtd	wgtd	unwgtd	wgtd	unwgtd
Age (years)										
< 01	2814000	156	545000	29	812000	44	889000	51	568000	32
01-02	5699000	321	1070000	56	1757000	101	1792000	105	1080000	59
03-05	8103000	461	1490000	92	2251000	133	2543000	140	1789000	95
06-11	16711000	937	3589000	185	4263000	263	5217000	284	3612000	204
12-19	20488000	1084	4445000	210	5490000	310	6720000	369	3833000	195

Table 3-28. Consumer Only Intake of Homegrown Foods (g/kg-day)[a] - All Regions Combined

Age (years)	Nc wgtd	Nc unwgtd	% Consuming	Mean	SE	P1	P5	P10	P25	P50	P75	P90	P95	P99	P100
							Homegrown Fruits								
01-02	360000	23	6.32	8.74E+00	3.10E+00	9.59E-01	1.09E+00	1.30E+00	1.64E+00	3.48E+00	7.98E+00	1.93E+01	6.06E+01	6.06E+01	6.06E+01
03-05	550000	34	6.79	4.07E+00	1.48E+00	1.00E-02	1.00E-02	3.62E-01	9.77E-01	1.92E+00	2.73E+00	6.02E+00	8.91E+00	4.83E+01	4.83E+01
06-11	1044000	75	6.25	3.59E+00	6.76E-01	1.00E-02	1.91E-01	4.02E-01	6.97E-01	1.31E+00	3.08E+00	1.18E+01	1.58E+01	3.22E+01	3.22E+01
12-19	1189000	67	5.80	1.94E+00	3.66E-01	8.74E-02	1.27E-01	2.67E-01	4.41E-01	6.61E-01	2.35E+00	6.76E+00	8.34E+00	1.85E+01	1.85E+01
							Homegrown Vegetables								
01-02	951000	53	16.69	5.20E+00	8.47E-01	2.32E-02	2.45E-01	3.82E-01	1.23E+00	3.27E+00	5.83E+00	1.31E+01	1.96E+01	2.70E+01	2.70E+01
03-05	1235000	76	15.24	2.46E+00	2.79E-01	0.00E+00	4.94E-02	3.94E-01	7.13E-01	1.25E+00	3.91E+00	6.35E+00	7.74E+00	1.06E+01	1.28E+01
06-11	3024000	171	18.10	2.02E+00	2.54E-01	5.95E-03	1.00E-01	1.60E-01	4.00E-01	8.86E-01	2.21E+00	4.64E+00	6.16E+00	1.76E+01	2.36E+01
12-19	3293000	183	16.07	1.48E+00	1.35E-01	0.00E+00	6.46E-02	1.45E-01	3.22E-01	8.09E-01	1.83E+00	3.71E+00	6.03E+00	7.71E+00	9.04E+00
							Home Produced Meats								
01-02	276000	22	4.84	3.65E+00	6.10E-01	3.85E-01	9.49E-01	9.49E-01	1.19E+00	2.66E+00	4.72E+00	8.68E+00	1.00E+01	1.15E+01	1.15E+01
03-05	396000	26	4.89	3.61E+00	5.09E-01	8.01E-01	8.01E-01	1.51E+00	2.17E+00	2.82E+00	3.72E+00	7.84E+00	9.13E+00	1.30E+01	1.30E+01
06-11	1064000	65	6.37	3.65E+00	4.51E-01	3.72E-01	6.52E-01	7.21E-01	1.28E+00	2.09E+00	4.71E+00	8.00E+00	1.40E+01	1.53E+01	1.53E+01
12-19	1272000	78	6.21	1.70E+00	1.68E-01	1.90E-01	3.20E-01	4.70E-01	6.23E-01	1.23E+00	2.35E+00	3.66E+00	4.34E+00	6.78E+00	7.51E+00
							Home Caught Fish								
01-02	82000	6	1.44	*	*	*	*	*	*	*	*	*	*	*	*
03-05	142000	11	1.75	*	*	*	*	*	*	*	*	*	*	*	*
06-11	382000	29	2.29	2.78E+00	8.40E-01	1.60E-01	1.60E-01	1.84E-01	2.28E-01	5.47E-01	1.03E+00	3.67E+00	7.05E+00	7.85E+00	2.53E+01
12-19	346000	21	1.69	1.52E+00	4.07E-01	1.95E-01	1.95E-01	1.95E-01	1.95E-01	3.11E-01	9.84E-01	1.79E+00	4.68E+00	6.67E+00	8.44E+00

NOTE: SE = standard error
P = percentile of the distribution
Nc wgtd = weighted number of consumers; Nc unwgtd = unweighted number of consumers in survey.
* = Less than 20 observations
[a] Data are not provided for intake of Home Produced Dairy because intake data were not provided for subpopulations for which there were less than 20 observations.

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

Table 3-29. Percent Weight Losses from Food Preparation

	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. (Derived from USDA, 1975.)

Table 3-30. Quantity (as consumed) of Food Groups Consumed Per Eating Occasion and the Percentage of Individuals Using These Foods in Three Days

	Quantity consumed per eating occasion (g)																							
	Under 1 year			1-2 years			3-5 years			6-8 years			9-14 years						15-18 years					
	Male and Female			Male and Female			Male and Female			Male and Female			Male			Female			Male			Female		
Food category	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	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, black-eyed 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	100
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	62
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	64
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	51
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	78
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	84
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	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	139
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	113
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	66
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	57
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	45

Table 3-30. Quantity (as consumed) of Food Groups Consumed Per Eating Occasion and the Percentage of Individuals Using These Foods in Three Days (continued)

	Quantity consumed per eating occasion (g)																							
	Under 1 year			1-2 years			3-5 years			6-8 years			9-14 years						15-18 years					
	Male and Female			Male and Female			Male and Female			Male and Female			Male			Female			Male			Female		
Food category	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD	PC	Ave.	SD
Grain Products																								
Yeast Breads	17.6	20	11	88.0	28	16	95.1	36	17	97.2	40	19	96.9	49	28	96.4	44	23	96.2	59	35	93.7	44	21
Pancakes	3.0	39	27	12.2	59	50	12.7	76	52	11.9	96	59	13.5	118	72	10.7	101	89	9.8	161	110	9.8	121	93
Waffles	0.6	30	13	3.4	56	45	5.7	69	41	5.9	69	45	5.2	87	62	4.1	80	68	3.5	125	70	2.4	79	55
Tortillas	0.8	16	7	3.9	26	11	5.1	36	16	4.7	55	29	4.0	74	31	4.3	66	33	3.4	100	48	4.0	69	33
Cakes and Cupcakes	1.6	53	37	17.4	51	38	25.3	61	45	34.4	66	42	36.4	80	56	35.2	77	55	31.0	93	71	26.5	80	59
Cookies	11.9	15	13	46.3	21	15	48.1	25	22	53.2	28	21	44.4	36	36	43.1	32	29	37.9	45	50	34.9	31	26
Pies	0.5	53	30	4.7	88	50	7.1	106	48	8.1	116	58	10.2	133	55	10.6	129	62	13.6	144	66	9.2	126	47
Doughnuts	0.8	36	22	6.6	47	26	8.6	54	28	10.9	60	30	12.0	67	39	12.9	62	36	13.2	91	74	12.9	63	34
Crackers	13.8	10	9	38.1	14	14	32.8	18	20	26.2	20	19	22.1	24	24	22.1	20	16	18.0	32	29	19.6	23	21
Popcorn	0.1	72	0	5.7	9	12	8.5	12	11	9.5	14	9	9.6	18	17	9.1	17	15	6.1	20	20	7.8	18	20
Pretzels	0.7	4	4	3.2	18	18	3.1	21	20	3.3	25	21	4.1	29	25	3.5	30	26	2.9	52	50	3.1	25	16
Corn-based Salty Snacks	0.6	8	2	6.6	24	20	8.6	27	22	10.3	29	26	9.9	33	29	11.3	32	30	8.3	46	44	10.7	34	22
Pasta	3.4	58	42	14.1	82	59	14.7	99	58	14.5	116	74	14.0	162	102	14.5	145	89	11.2	198	133	10.8	158	99
Rice	4.3	53	42	20.9	81	50	22.2	95	58	23.4	120	77	18.9	149	86	22.4	138	77	20.9	195	117	19.0	160	89
Cooked Cereals	16.3	116	82	33.1	149	87	26.0	177	97	21.3	198	104	19.5	223	126	17.3	212	107	14.3	259	132	12.1	229	106
Ready-to-Eat Cereals	68.7	13	11	68.0	23	14	75.8	29	17	76.8	33	19	69.8	41	28	64.0	36	21	50.4	49	31	43.7	37	22
Meat, Poultry, and Dairy Products																								
Meat[a]	23.2	58	42	78.2	53	40	82.8	66	46	84.6	82	55	87.1	103	71	84.2	94	69	87.9	123	90	82.6	102	73
Beef	15.6	56	41	60.1	64	38	65.5	79	43	67.2	97	52	69.0	124	66	68.2	111	70	70.3	152	87	65.9	123	73
Pork	10.1	66	44	44.2	37	36	46.0	47	44	46.7	57	49	48.8	68	65	47.0	64	57	56.1	79	75	46.2	68	60
Lamb	2.6	52	29	1.4	72	46	0.6	90	59	0.5	139	86	0.9	171	80	0.7	127	68	0.5	156	81	1.0	112	43
Veal	3.2	54	37	1.2	80	28	1.6	75	33	2.0	115	72	1.5	124	75	1.5	96	46	1.5	170	87	2.1	131	62
Poultry	18.2	60	38	42.2	73	44	42.6	90	50	45.1	103	56	44.3	131	75	44.0	112	58	43.8	153	85	43.7	123	68
Chicken	15.6	62	39	38.8	73	43	39.3	92	50	41.4	106	55	39.8	136	77	39.6	115	57	38.9	160	87	39.5	128	70
Turkey	5.1	53	34	4.4	73	59	4.5	74	39	5.7	74	44	6.5	103	56	6.2	90	54	7.5	120	68	6.2	89	47
<u>Dairy Products</u>																								
Eggs	17.7	49	30	61.3	59	27	55.2	66	34	48.5	70	37	49.1	85	47	44.3	75	40	52.3	101	49	44.4	79	41
Butter	5.2	6	4	29.2	7	6	28.7	9	10	31.7	10	11	32.4	12	15	30.9	10	9	32.4	14	12	32.0	13	14
Margarine	8.5	5	4	43.8	6	6	46.1	8	8	42.9	9	8	44.8	12	12	40.7	11	12	41.4	16	14	38.6	11	9
Milk[b]	89.0	170	71	96.9	179	80	97.0	198	83	98.5	227	89	97.4	265	125	95.1	242	103	93.2	314	164	88.0	244	113
Cheese[c]	6.1	25	21	35.9	31	19	37.0	31	17	35.3	35	23	31.2	39	22	34.9	35	23	39.0	46	30	39.8	37	23

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

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

Table 3-31. Mean Moisture Content of Selected Food Groups Expressed as Percentages of Edible Portions

Food	Moisture Content (Percent) Raw	Moisture Content (Percent) Cooked	Comments
Fruit			
Apples - dried	31.76	84.13*	sulfured; *without added sugar
Apples 83.93*	84.46**		*with skin; **without skin
Apples - juice		87.93	canned or bottled
Applesauce		88.35*	*unsweetened
Apricots	86.35	86.62*	*canned juice pack with skin
Apricots - dried	31.09	85.56*	sulfured; *without added sugar
Bananas	74.26		
Blackberries	85.64		
Blueberries	84.61	86.59*	*frozen unsweetened
Boysenberries	85.90		frozen unsweetened
Cantaloupes - unspecified	89.78		
Casabas	91.00		
Cherries - sweet	80.76	84.95*	*canned, juice pack
Crabapples	78.94		
Cranberries	86.54		
Cranberries - juice cocktail	85.00		bottled
Currants (red and white)	83.95		
Elderberries	79.80		
Grapefruit	90.89		
Grapefruit - juice	90.00	90.10*	*canned unsweetened
Grapefruit - unspecified	90.89		pink, red, white
Grapes - fresh	81.30		American type (slip skin)
Grapes - juice	84.12		canned or bottled
Grapes - raisins	15.42		seedless
Honeydew melons	89.66		
Kiwi fruit	83.05		
Kumquats	81.70		
Lemons - juice	90.73	92.46*	*canned or bottled
Lemons - peel	81.60		
Lemons - pulp	88.98		
Limes - juice	90.21	92.52*	*canned or bottled
Limes - unspecified	88.26		
Loganberries	84.61		
Mulberries	87.68		
Nectarines	86.28		
Oranges - unspecified	86.75		all varieties
Peaches	87.66	87.49*	*canned juice pack
Pears - dried	26.69	64.44*	sulfured; *without added sugar
Pears - fresh	83.81	86.47*	*canned juice pack
Pineapple	86.50	83.51*	*canned juice pack
Pineapple - juice		85.53	canned
Plums		85.20	
Quinces	83.80		
Raspberries	86.57		
Strawberries	91.57	89.97*	*frozen unsweetened
Tangerine - juice	88.90	87.00*	*canned sweetened
Tangerines	87.60	89.51*	*canned juice pack
Watermelon	91.51		
Vegetables			
Alfalfa sprouts	91.14		
Artichokes - globe & French	84.38	86.50	boiled, drained
Artichokes - Jerusalem	78.01		

Table 3-31. Mean Moisture Content of Selected Food Groups Expressed as Percentages of Edible Portions (continued)

Food	Moisture Content (Percent)		Comments
	Raw	Cooked	
Asparagus	92.25	92.04	boiled, drained
Bamboo shoots	91.00	95.92	boiled, drained
Beans - dry			
Beans - dry - blackeye peas (cowpeas)	66.80	71.80	boiled, drained
Beans - dry - hyacinth (mature seeds)	87.87	86.90	boiled, drained
Beans - dry - navy (pea)	79.15	76.02	boiled, drained
Beans - dry - pinto	81.30	93.39	boiled, drained
Beans - lima	70.24	67.17	boiled, drained
Beans - snap - Italian - green - yellow	90.27	89.22	boiled, drained
Beets	87.32	90.90	boiled, drained
Beets - tops (greens)	92.15	89.13	boiled, drained
Broccoli	90.69	90.20	boiled, drained
Brussel sprouts	86.00	87.32	boiled, drained
Cabbage - Chinese/celery, including bok choy	95.32	95.55	boiled, drained
Cabbage - red	91.55	93.60	boiled, drained
Cabbage - savoy	91.00	92.00	boiled, drained
Carrots	87.79	87.38	boiled, drained
Cassava (yucca blanca)	68.51		
Cauliflower	92.26	92.50	boiled, drained
Celeriac	88.00	92.30	boiled, drained
Celery	94.70	95.00	boiled, drained
Chili peppers	87.74	92.50*	*canned solids & liquid
Chives	92.00		
Cole slaw	81.50		
Collards	93.90	95.72	boiled, drained
Corn - sweet	75.96	69.57	boiled, drained
Cress - garden - field	89.40	92.50	boiled, drained
Cress - garden	89.40	92.50	boiled, drained
Cucumbers	96.05		
Dandelion - greens	85.60	89.80	boiled, drained
Eggplant	91.93	91.77	boiled, drained
Endive	93.79		
Garlic	58.58		
Kale	84.46	91.20	boiled, drained
Kohlrabi	91.00	90.30	boiled, drained
Lambsquarter	84.30	88.90	boiled, drained
Leeks	83.00	90.80	boiled, drained
Lentils - whole	67.34	68.70	stir-fried
Lettuce - iceberg	95.89		
Lettuce - romaine	94.91		
Mung beans (sprouts)	90.40	93.39	boiled, drained
Mushrooms	91.81	91.08	boiled, drained
Mustard greens	90.80	94.46	boiled, drained
Okra	89.58	89.91	boiled, drained
Onions	90.82	92.24	boiled, drained
Onions - dehydrated or dried	3.93		
Parsley	88.31		
Parsley roots	88.31		
Parsnips	79.53	77.72	boiled, drained
Peas (garden) - mature seeds - dry	88.89	88.91	boiled, drained
Peppers - sweet - garden	92.77	94.70	boiled, drained
Potatoes (white) - peeled	78.96	75.42	baked

Table 3-31. Mean Moisture Content of Selected Food Groups Expressed as Percentages of Edible Portions (continued)

Food	Moisture Content (Percent) Raw	Cooked	Comments
Potatoes (white) - whole	83.29	71.20	baked
Pumpkin	91.60	93.69	boiled, drained
Radishes - roots	94.84		
Rhubarb	93.61	67.79	frozen, cooked with added sugar
Rutabagas - unspecified	89.66	90.10	boiled, drained
Salsify (oyster plant)	77.00	81.00	boiled, drained
Shallots	79.80		
Soybeans - sprouted seeds	69.05	79.45	steamed
Spinach	91.58	91.21	boiled, drained
Squash - summer	93.68	93.70	all varieties; boiled, drained
Squash - winter	88.71	89.01	all varieties; baked
Sweetpotatoes (including yams)	72.84	71.85	baked in skin
Swiss chard	92.66	92.65	boiled, drained
Tapioca - pearl	10.99		dry
Taro - greens	85.66	92.15	steamed
Taro - root	70.64	63.80	
Tomatoes - juice		93.90	canned
Tomatoes - paste		74.06	canned
Tomatoes - puree		87.26	canned
Tomatoes - raw	93.95		
Tomatoes - whole	93.95	92.40	boiled, drained
Towelgourd	93.85	84.29	boiled, drained
Turnips - roots	91.87	93.60	boiled, drained
Turnips - tops	91.07	93.20	boiled, drained
Water chestnuts	73.46		
Yambean - tuber	89.15	87.93	boiled, drained
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 3-31. Mean Moisture Content of Selected Food Groups Expressed as Percentages of Edible Portions (continued)

Food	Moisture Content (Percent) Raw	Cooked	Comments
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	90.80		1%

Source: USDA, 1979-1986.

Table 3-32. Percent Moisture Content for Selected Fish Species[a]

Species	Moisture Content (%)	Comments
	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 & Pacific	77.92	Raw
	71.69	Cooked, dry heat
Halibut, Greenland	70.27	Raw
Herring, Atlantic & 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 & 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 3-32. Percent Moisture Content for Selected Fish Species[a] (continued)

Species	Moisture Content (%)	Comments
Pollock, Alaska & 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 & 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 3-32. Percent Moisture Content for Selected Fish Species[a] (continued)

Species	Moisture Content (%)	Comments
	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

[a] Data are reported as in the Handbook
NA = Not available

Source: USDA, 1979-1984 - U.S. Agricultural Handbook No. 8

Table 3-33. Percentage Lipid Content (Expressed as Percentages of 100 Grams of Edible Portions) of Selected Meat, Dairy, and Fish Products[a]

Product	Fat Percentage	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
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

Table 3-33. Percentage Lipid Content (Expressed as Percentages of 100 Grams of Edible Portions) of Selected Meat, Dairy, and Fish Products[a] (continued)

Product	Fat Percentage	Comment
Butter	76.93	Regular
Cheese		
American	29.63	Pasteurized
Cheddar	31.42	
Swiss	26.02	
Cream	33.07	
Parmesan	24.50; 28.46	Hard; grated
Cottage	1.83	Lowfat, 2% fat
Colby	30.45	
Blue	27.26	
Provolone	25.24	
Mozzarella	20.48	
Yogurt	1.47	Plain, lowfat
Eggs	8.35	Chicken, whole raw, fresh or frozen
	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 & Pacific	1.812	Raw
	2.324	Cooked, dry heat
Halibut, Greenland	12.164	Raw
Herring, Atlantic & Turbot, domestic species	7.909	Raw
	10.140	Cooked, dry heat
	10.822	Kippered
	16.007	Pickled

Table 3-33. Percentage Lipid Content (Expressed as Percentages of 100 Grams of Edible Portions) of Selected Meat, Dairy, and Fish Products[a] (continued)

Product	Fat Percentage	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 & 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 & 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 & 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 3-33. Percentage Lipid Content (Expressed as Percentages of 100 Grams of Edible Portions) of Selected Meat, Dairy, and Fish Products[a] (continued)

Product	Fat Percentage	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

NA = Not available

[a] Based on the lipid content in 100 grams, edible portion. Total Fat Content - saturated, monosaturated and polyunsaturated.
Source: USDA, 1979-1984.

Table 3-34. Fat Content of Meat Products

Meat Product 3-oz cooked serving (85.05 g)	Total Fat (g)	Percent Fat Content (%)
Beef, retail composite, lean only	8.4	9.9
Pork, retail composite, lean only	8.0	9.4
Lamb, retail composite, lean only	8.1	9.5
Veal, retail composite, lean only	5.6	6.6
Broiler chicken, flesh only	6.3	7.4
Turkey, flesh only	4.2	4.9

Source: National Livestock and Meat Board, 1993

Table 3-35. Summary of Recommended Values for Per Capita Intake of Foods, As Consumed

Age	Mean	95th Percentile	Multiple Percentiles	Study
Total Fruit Intake				
< 1 year	13.2 g/kg-day	41.2 g/kg-day	see Table 3-2	EPA Analysis of CSFII 1994-96 Data
1-2 years	19.3 g/kg-day	53.9 g/kg-day		
3-5 years	11.0 g/kg-day	32.7 g/kg-day		
6-11 years	5.4 g/kg-day	18.0 g/kg-day		
12-19 years	2.8 g/kg-day	11.0 g/kg-day		
Total Vegetable Intake				
< 1 year	6.9 g/kg-day	24.2 g/kg-day	see Table 3-2	EPA Analysis of CSFII 1994-96 Data
1-2 years	9.5 g/kg-day	23.3 g/kg-day		
3-5 years	7.3 g/kg-day	18.3 g/kg-day		
6-11 years	5.3 g/kg-day	13.5 g/kg-day		
12-19 years	4.0 g/kg-day	9.3 g/kg-day		
Total Grain Intake				
< 1 year	4.1 g/kg-day	20.2 g/kg-day	See Table 3-2	EPA Analysis of CSFII 1994-96 Data
1-2 years	11.2 g/kg-day	24.7 g/kg-day		
3-5 years	10.3 g/kg-day	21.1 g/kg-day		
6-11 years	7.2 g/kg-day	15.6 g/kg-day		
12-19 years	4.4 g/kg-day	9.7 g/kg-day		
Total Meat Intake				
< 1 year	1.1 g/kg-day	5.9 g/kg-day	See Table 3-2	EPA Analysis of CSFII 1994-96 Data
1-2 years	4.4 g/kg-day	10.2 g/kg-day		
3-5 years	4.1 g/kg-day	9.4 g/kg-day		
6-11 years	2.9 g/kg-day	6.8 g/kg-day		
12-19 years	2.2 g/kg-day	4.9 g/kg-day		
Total Dairy Intake				
< 1 year	111 g/kg-day	235 g/kg-day	See Table 3-2	EPA Analysis of CSFII 1994-96 Data
1-2 years	37.5 g/kg-day	90.2 g/kg-day		
3-5 years	20.9 g/kg-day	48.8 g/kg-day		
6-11 years	13.9 g/kg-day	33.5 g/kg-day		
12-19 years	6.1 g/kg-day	17.8 g/kg-day		
Total Fish Intake				
< 1 year	0.11 g/kg-day	0.53 g/kg-day	See Table 3-2	EPA Analysis of CSFII 1994-96 Data
1-2 years	0.37 g/kg-day	1.79 g/kg-day		
3-5 years	0.32 g/kg-day	1.74 g/kg-day		
6-11 years	0.26 g/kg-day	1.35 g/kg-day		
12-19 years	0.20 g/kg-day	1.10 g/kg-day		
Individual Foods Intake	see Table 3-3	---	---	EPA Analysis of CSFII 1994-96 Data

Table 3-35. 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	370 mg/kg-day	—	See Table 3-13	EPA Analysis of West et al.1989 Data
6-10 years	280 mg/kg-day	—		
Native American Subsistence Fish Intake				
<5 years	11 g/kg-day	—	—	CRITFC, 1994
Total Fat Intake				
	See Table 3-15	See Table 3-15	See Table 3-15	Frank et al.,1996
Homeproduced Food Intake				
	See Table 3-28	See Table 3-28	See Table 3-28	EPA Analysis of 1987/88 NFCS

Table 3-36. 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. Javitz (1980) is a contractor report to EPA (CSFII)	High Medium (Javitz)
• 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	Were 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	1 for most foods, 2 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 key study for most foods, the results are in good agreement with earlier data.	High
Overall Rating	The survey is representative of U.S. population. Although there was only one study considered key, these data are the most recent and are in agreement with earlier data. The approach used to analyzed the data was adequate. However, due to the limitations of the survey design estimation of long-term percentile values (especially the upper percentiles) is uncertain.	**High** confidence in the average; **Low** confidence in the long-term upper percentiles

Table 3-37. 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 the 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 one week recall of fish consumption study. 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 percent.	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 1 study.	Low
• Agreement between researchers	There is only 1 study. EPA performed an analyses using these data.	Low
Overall Rating	The study is not nationally representative and not representative of long-term consumption.	**Low**

Table 3-38. Confidence Intake Recommendations for Fish Consumption - Native American Subsistence Population

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	Study is in a technical report.	Medium
• Accessibility	CRITFC is a technical report, that is publicly available	Medium
• Reproducibility	The study was adequately detailed and enough information is available to reproduce results.	High
• Focus on factor of interest	Study focused on fish ingestion among Native American Tribes.	High
• Data pertinent to U.S.	The study was specific in the U.S.	High
• Primary data	The study used primary data.	High
• Currency	Data were from 1991-1992.	High
• Adequacy of data collection period	Data were collected for 1 study.	High Low confidence for long term percentile distribution
• Validity of approach	Individual intake measured directly, but some respondents provided in same information for the children as themselves.	Low
• Study size	The sample population was 204 children < 5 years old.	Medium
• Representativeness of the population	Only one state was represented; population < 5 years old only.	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 percent in the study..	Medium
• Measurement error	The weight of the fish was estimated.	Medium
Other Elements		
• Number of studies	There was only one study.	Low - Medium
• Agreement between researchers	There was only one study.	Medium
Overall Rating	Study is not nationally representative.	**Low**

APPENDIX 3A

CALCULATIONS USED IN THE 1994-96 CSFII ANALYSIS TO CORRECT FOR MIXTURES

APPENDIX 3A
Calculations Used in the 1994-96 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 example for meats below.

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

where:

$IR_{meat\text{-}adjusted}$	=	adjusted individual intake rate for total meat;
$IR_{gr\ mixtures}$	=	individual intake rate for grain mixtures;
$IR_{mt\ mixtures}$	=	individual intake rate for meat mixtures;
IR_{meat}	=	individual intake rate for meats;
$Fr_{meat/gr}$	=	fraction of grain mixture that is meat; and
$Fr_{meat/mt}$	=	fraction of meat mixture that is meat.

Population distributions for mixture-adjusted intakes were based on adjusted intake rates for the population of interest.

TABLE 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 3B

FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 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 (i.e., 13.48 percent) and the average portion of meat mixtures (i.e., 5.56 percent) 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 (i.e., 7.87 percent) and the average portion of meat mixtures (i.e., 31.11 percent) made up by meats.
Total Fish	26-	Fish, all types	Also includes the average portion of meat mixtures (i.e., 4.44 percent) made up by fish.
Eggs	3-	Eggs eggs egg mixtures egg substitutes eggs baby food froz. meals with egg as main ingred.	Includes baby foods. Also includes the average portion of grain mixtures (i.e., 1.12 percent) and the average portion of meat mixtures (i.e., 1.11 percent) 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 (i.e., 31.46 percent) and the average portion of meat mixtures (i.e., 13.33 percent) 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 & PR starchy dark green vegetables deep yellow vegetables tomatoes and tom. mixtures other vegetables veg. and mixtures/baby food veg. 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 (i.e., 25.84 percent) and the average portion of meat mixtures (i.e., 30.00 percent) made up by vegetables.
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 (i.e., 2.25 percent) and the average portion of meat mixtures (i.e., 2.22 percent) made up by meats.

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA (CONTINUED)

	Food Product	Food Codes		
1	**INDIVIDUAL MEATS**			
2	Beef	21-	Beef beef, nfs beef steak beef oxtails, neckbones, ribs roasts, stew meat, corned, brisket, sandwich steaks ground beef, patties, meatballs other beef items beef baby food	Also includes the average portion of grain mixtures (i.e., 4.49 percent) and the average portion of meat mixtures (i.e., 20.0 percent) made up by beef.
3	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 (i.e., 1.12 percent) and the average portion of meat mixtures (i.e., 2.22 percent) made up by pork.
4	Game	233-	Game	
5	Poultry	24-	Poultry chicken turkey duck other poultry poultry baby food	Also includes the average portion of grain mixtures (i.e., 1.12 percent) and the average portion of meat mixtures (i.e., 7.78 percent) made up by poultry.
6	**INDIVIDUAL GRAINS**			
7	Breads	51- 52-	breads, rolls, muffins, bagel, biscuits, corn bread tortillas	
8	Sweets	53-	cakes, cookies, pies, pastries, doughnuts, breakfast bars, coffee cakes	
9	Snacks	54-	crackers, salty snacks, popcorn, pretzels	
10	Breakfast Foods	55-	pancakes, waffles, french toast	
11	Pasta	561-	macaroni, noodles, spaghetti	
12	Cooked Cereals	56200- 56201- 56202- 56203- 56206- 56207- 56208- 56209- 56210-		Includes grits, oatmeal, cornmeal mush, millet, etc.
13	Rice	56204- 56205-		Includes all varieties of rice.
14	Ready-to-eat Cereals	570- 571- 572- 573- 574- 576-		Includes all varieties of ready-to-eat cereals.
15	Baby Cereals	578-	baby cereals	

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA (CONTINUED)

	Food Product	Food Codes	
1	**FRUIT CATEGORIES**		
2	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.
3	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).
4	Apples	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 6210130 Apple chips 6310100 Apples, raw 6310111 Applesauce, NS 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 NS 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, ns as to strained or junior 6710101 Apple-raspberry, baby, strained 6710102 Apple-raspberry, baby, junior 6710200 Applesauce baby fd., NS as to str. or jr. 6710201 Applesauce baby food, strained 6710202 Applesauce baby food, junior 67104- Applesauce & other fruit, baby 67113- Apples & 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 & cranberries w/tapioca, baby 6740407 Apple yogurt dessert, baby, strained 67412- Dutch apple dessert, baby 675- Apples & meat, baby Includes some mixtures.
5	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
6	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
7	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
8	Strawberries	6322- Strawberries 6413250 Strawberry Juice	
9	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

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA (CONTINUED)

Food Product	Food Codes			
Exposed Fruits	621011-	Apple, dried	6710102	Apple-raspberry, baby, junior
	621012-	Apple, dried	67102-	Applesauce, baby
	6210130	Apple chips	6710400	Applesauce & apricots, baby, ns as to str or jr
	62104-	Apricot, dried	6710401	Applesauce & apricots, baby, strained
	62108-	Currants, dried	6710402	Applesauce & apricots, baby, junior
	6210910	Cranberries, dried	6710407	Applesauce w/cherries, baby, strained
	62110-	Date, dried	6710408	Applesauce w/cherries, baby, junior
	62116-	Peaches, dried	6710409	Applesauce w/cherries, baby, ns str/jr
	62119-	Pears, dried	67108-	Peaches, baby
	62121-	Plum, dried	67109-	Pears, baby
	62122-	Prune, dried	6711000	Prunes, baby
	62125-	Raisins	6711300	Apples & pears, baby, ns as to str or jr
	63101-	Apples/applesauce	6711301	Apples & pears, baby, strained
	63102-	Wi-apple	6711302	Apples & pears, baby, junior
	63103-	Apricots	6711450	Peaches, baby, dry
	63111-	Cherries, maraschino	6711455	Pears, baby, dry
	63112-	Acerola	67202-	Apple Juice, baby
	63113-	Cherries, sour	6720340	Apple-cherry juice, baby
	63115-	Cherries, sweet	6720345	Apple-cranberry juice, baby
	63117-	Currants, raw	6720350	Apple-grape juice, baby
	63123-	Grapes	6720360	Apple-peach juice, baby
	6312601	Juneberry	6720370	Apple-prune juice, baby
	63131-	Nectarine	6720380	White Grape Juice, baby
	63135-	Peach	67212-	Pear Juice, baby
	63137-	Pear	6723000	Apple-sweet potato juice, baby food
	63139-	Persimmons	6725005	Apple juice w/lowfat yogurt, baby food
	63143-	Plum	6725020	Pear-peach juice w/lowfat yogurt, baby food
	63146-	Quince	6730100	Apples & cranberries w/tapioca, baby, ns str/jr
	63147-	Rhubarb/Sapodillo	6730101	Apples & cranberries w/tapioca, baby, strained
	632-	Berries	6730102	Apples & cranberries w/tapioca, baby, junior
	6340101	Apple salad w/dressing (include waldorf salad)	6730400	Plums w/tapioca, baby, ns as to str/jr
	6340102	Apple & cabbage salad w/dressing	6730401	Plums w/tapioca, baby, strained
	6340103	Apple & fruit salad w/dressing	6730402	Plums w/tapioca, baby, junior
	6340106	Apple, candied (include caramel apples)	6730403	Plums, bananas & rice, baby, strained
	6340203	Prune whip	6730450	Prunes w/oatmeal, baby, strained
	6341101	Cranberry salad, congealed	6730501	Prunes w/tapioca, baby, strained
	6341201	Pear salad w/dressing	6730600	Ciruelas w/tapioca, baby
	6341500	Soup, sour cherry	6730700	Apricots w/tapioca, baby, ns as to str/jr
	64101-	Apple Cider	6730701	Apricots w/tapioca, baby, strained
	64104-	Apple Juice	6730702	Apricots w/tapioca, baby, junior
	6410409	Apple juice with calcium	6740407	Apple yogurt dessert, baby, strained
	64105-	Cranberry Juice	6740430	Blueberry yogurt dessert, baby, strained
	64116-	Grape Juice	6740455	Cherry cobbler, baby, junior
	64122-	Peach Juice	6740500	Peach cobbler, baby, ns as to str/jr
	6412300	Pear-white-grape-passion fruit juice, w/added Vit. C	6740501	Peach cobbler, baby, strained
			6740502	Peach cobbler, baby, junior
	64132-	Prune/Strawberry Juice	6741000	Cherry vanilla pudding, baby
	6420101	Apricot Nectar	6741200	Dutch apple dessert, baby, ns as to str/jr
	64205-	Peach Nectar	6741201	Dutch apple dessert, baby, strained
	64215-	Pear Nectar	6741202	Dutch apple dessert, baby, junior
	6710030	Applesauce, baby toddler	6741370	Peach yogurt dessert, baby, strained
	6710100	Apple-raspberry, baby, ns as to strained or junior	675-	Apples & meat
	6710101	Apple-raspberry, baby, strained		

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA (CONTINUED)

	Food Product	Food Codes	
1	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
2	**VEGETABLE CATEGORIES**		
3	Asparagus	7510080 Asparagus, raw 75202- Asparagus, cooked 7540101 Asparagus, creamed or with cheese	756010 Asparagus soup Does not include vegetables with meat mixtures.
4	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.
5	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.
6	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.
7	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.

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA (CONTINUED)

	Food Product	Food Codes	
1	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, yell., canned, low sod., fat not add 7521632 Corn, yell., 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.
2	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.
3	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.
4	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.
5	Okra	7522000 Okra, cooked, NS as to fat 7522001 Okra, cooked, fat not added 7522002 Okra, cooked, fat added 7522010 Lufta, cooked (Chinese Okra)	7541450 Okra, fried 7550700 Okra, pickled Does not include vegetable with meat mixtures.
6	Onions	7510950 Chives, raw 7511150 Garlic, raw 7511250 Leek, raw 7511701 Onions, young green, raw 7511702 Onions, mature 7521550 Chives, dried 7521740 Garlic, cooked 7521840 Leek, cooked 7522100 Onions, mature cooked, NS as to fat added 7522101 Onions, mature cooked, fat not added 7522102 Onions, mature cooked, fat added	7522103 Onions, pearl cooked 7522104 Onions, young green cooked, NS as to fat 7522105 Onions, young green cooked, fat not added 7522106 Onions, young green cooked, fat added 7522110 Onion, dehydrated 7541501 Onions, creamed 7541502 Onion rings 75605- Leek soup 75608- Onion soup Does not include vegetable with meat mixtures.

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA (CONTINUED)

	Food Product	Food Codes	
1	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.
2	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.
3	Pumpkin	732- Pumpkin (all forms) 733- Winter squash (all forms) 76205- Squash, baby	Does not include vegetable with meat mixtures.
4	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 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	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 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.
5	Tomatoes	74- Tomatoes and Tomato Mixtures raw, cooked, juices, sauces, mixtures, soups, sandwiches	Also includes the average portion of grain mixtures (i.e., 16.85 percent) and the average portion of meat mixtures (i.e., 11.11 percent) made up by tomatoes.
6	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 (i.e., 3.33 percent) made up by meats.
7 8	Dark Green Vegetables	72- Dark Green Vegetables all forms leafy, nonleafy, dk. gr. veg. soups	

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA (CONTINUED)

Food Product	Food Codes			
Deep Yellow Vegetables	73-	Deep Yellow Vegetables all forms carrots, pumpkin, squash, sweet potatoes, dp. yell. veg. soups		
Other Vegetables	75-	Other Vegetables all forms		
Exposed Vegetables	721-	Dark Green Leafy Veg.	7514800	Cob salad w/dressing
	722-	Dark Green Nonleafy Veg.	7520060	Algae, dried
	7230200	Broccoli soup (include cream of broccoli soup)	75201-	Artichoke, cooked
	7230210	Broccoli cheese soup, prep w/milk	75202-	Asparagus, cooked
	7230500	Escarole soup	75203-	Bamboo shoots, cooked
	7230600	Watercress broth w/shrimp	752049-	Beans, string, cooked
	7230700	Spinach soup	75205-	Beans, green, cooked/canned
	7230800	Dark-green leafy vegetable soup w/meat, oriental	75206-	Beans, yellow, cooked/canned
	7230850	Dark-green leafy vegetable soup, meatless, oriental	75207-	Bean Sprouts, cooked
	74-	Tomatoes and Tomato Mixtures	752085-	Breadfruit
	7510050	Alfalfa Sprouts	752087-	Broccoflower, cooked
	7510075	Artichoke, Jerusalem, raw	752090-	Brussel Sprouts, cooked
	7510080	Asparagus, raw	75210-	Cabbage, Chinese, cooked
	75101-	Beans, sprouts and green, raw	75211-	Cabbage, green, cooked
	7510260	Broccoflower, raw	75212-	Cabbage, red, cooked
	7510275	Brussel Sprouts, raw	752130-	Cabbage, savoy, cooked
	7510280	Buckwheat Sprouts, raw	75214-	Cauliflower
	7510300	Cabbage, raw	75215-	Celery, Chives, Christophine (chayote)
	7510400	Cabbage, Chinese, raw	752167-	Cucumber, cooked
	7510500	Cabbage, Red, raw	752170-	Eggplant, cooked
	7510700	Cauliflower, raw	752171-	Fern shoots
	7510900	Celery, raw	752172-	Fern shoots
	7510950	Chives, raw	752173-	Flowers of sesbania, squash or lily
	7510955	Cilantro, raw	7521801	Kohlrabi, cooked
	7511100	Cucumber, raw	75219-	Mushrooms, cooked
	7511120	Eggplant, raw	75220-	Okra/lettuce, cooked
	7511200	Kohlrabi, raw	7522116	Palm Hearts, cooked
	75113-	Lettuce, raw	7522121	Parsley, cooked
	7511500	Mushrooms, raw	75226-	Peppers, pimento, cooked
	7511900	Parsley	75230-	Sauerkraut, cooked/canned
	7512100	Pepper, hot chili	75231-	Snowpeas, cooked
	75122-	Peppers, raw	75232-	Seaweed
	7512400	Pepper, banana, raw	75233-	Summer Squash
	7512750	Seaweed, raw	7530201	Beans, green string w/tomatoes (assume w/o fat)
	7512775	Snowpeas, raw	7530202	Beans, green string w/onions, no fat added
	75128-	Summer Squash, raw	7530203	Beans, green string w/chickpeas, cooked, no fat added
	7513210	Celery Juice		
	7514050	Broccoli salad w/cauliflower, cheese, bacon, dressing	7530204	Beans, green string w/almonds, cooked, no fat added
	7514100	Cabbage or cole slaw	7530205	Beans, green & potatoes, cooked, no fat added
	7514110	Cabbage salad or coleslaw w/apples/raisins, dressing	7530206	Beans, green w/pinto beans, cooked, no fat added
	7514120	Cabbage salad or coleslaw w/pineapple, dressing	7530207	Beans, green w/spaetzel, cooked, no fat added
	7514130	Chinese Cabbage Salad	7530208	Bean salad, yellow &/or green string beans
	7514150	Celery with cheese	7530220	Beans, green string w/onions, ns as to added fat
	75142-	Cucumber salads	7530221	Beans, green string w/onions, fat added
	75143-	Lettuce salads	7530250	Beans, green & potatoes, ns as to added fat
	7514410	Lettuce, wilted with bacon dressing	7530251	Beans, green & potatoes, fat added
	7514500	Seven-layer salad (lettuce, mayo, cheese, egg, peas)	7530601	Eggplant in tom sauce, cooked, no fat added
	7514600	Greek salad	7530700	Green peppers & onions, cooked, fat added in cooking
	7514700	Spinach salad		

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA (CONTINUED)

Food Product	Food Codes			
Exposed Vegetables (continued)	7531600	Squash, summer & onions, cooked, no fat added	7550314	Cucumber pickles, sweet, reduced salt
	7531601	Zucchini w/tom sauce, cooked, no fat added in cooking	7550500	Mushrooms, pickled
	7531602	Squash, summer & onions, cooked, fat added	7550700	Okra, pickled
	7540050	Artichokes, stuffed	75510-	Olives
	7540101	Asparagus, creamed or with cheese	7551101	Peppers, hot
	75403-	Beans, green with sauce	7551102	Peppers, pickled
	75404-	Beans, yellow with sauce	7551104	Peppers, hot pickled
	7540601	Brussel Sprouts, creamed	7551301	Seaweed, pickled
	7540701	Cabbage, creamed	7553500	Zucchini, pickled
	75409-	Cauliflower, creamed	756010-	Asparagus soup
	75410-	Celery/Chiles, creamed	756012-	Cabbage soup
	75412-	Eggplant, fried, with sauce, etc.	756020-	Cauliflower soup, cream of, w/milk
	75413-	Kohlrabi, creamed	756030-	Celery soup
	75414-	Mushrooms, Okra, fried, stuffed, creamed	7560451	Cucumber soup, cream of, w/milk
	754180-	Squash, baked, fried, creamed, etc.	756046-	Gazpacho
	7541822	Christophine, creamed	75607-	Mushroom soup
	7550011	Beans, pickled	7561201	Zucchini soup, cream of, prep w/milk
	7550051	Celery, pickled	7564700	Seaweed soup
	7550201	Cauliflower, pickled	76102-	Dark Green Veg., baby
	755025-	Cabbage, pickled	76401-	Beans, baby (excl. most soups & mixtures)
	7550301	Cucumber pickles, dill	7660400	Broccoli & chicken, baby, strained
	7550302	Cucumber pickles, relish	7661150	Green beans & turkey, baby, strained
	7550303	Cucumber pickles, sour	7731601	Stuffed cabbage w/meat, p.r. (repollo relleno con carne)
	7550304	Cucumber pickles, sweet	7731651	Stuffed cabbage w/meat & rice, syrian dish, puerto rican style
	7550305	Cucumber pickles, fresh	7731660	Eggplant and meat casserole
	7550307	Cucumber, Kim Chee	7756301	Puerto rican stew (sancocho)
	7550308	Eggplant, pickled	Does not include vegetable with meat mixtures.	
	7550311	Cucumber pickles, dill, reduced salt		
Protected Veg.	411-, 412-, 413-	Beans and lentils	7531502	Peas & corn, cooked, fat added
	414-	Soy products	7531510	Peas & onions, cooked, ns as to added fat
	415-, 416-	Bean meals	7531511	Peas & onions, cooked, fat not added
	7185-, 7190-	Plantains soups etc.	7531512	Peas & onions, cooked, fat added
	732-	Pumpkin	7531521	Peas w/mushrooms, cooked, no fat added
	733-	Winter Squash	7531525	Cowpeas w/snap beans, cooked, no fat added in cooking
	7510200	Lima Beans, raw	7531530	Peas & potatoes, cooked, no fat added in cooking
	7510550	Cactus, raw	75402-	Lima Beans with sauce
	7510960	Corn, raw	75411-	Corn, scalloped, fritter, with cream
	7512000	Peas, raw	7541650	Pea salad
	7520070	Aloe vera juice	7541660	Pea salad with cheese
	752040-	Lima Beans, cooked	75417-	Peas, with sauce or creamed
	752041-	Lima Beans, canned	7550101	Corn relish
	7520829	Bitter Melon	7560401	Corn soup, cream of, w/milk
	752083-	Bitter Melon, cooked	7560402	Corn soup, cream of, prepared w/water
	7520950	Burdock	7560900	Pea soup, nfs
	752131-	Cactus	7560901	Pea soup, prep w/milk
	752160-	Corn, cooked	7560802	Pea soup, prepared w/water
	752161-	Corn, yellow, cooked	7560905	Pea soup, prepared w/water, low sodium
	752162-	Corn, white, cooked	7560906	Pea soup, prepared w/lowfat milk
	752163-	Corn, canned	76205-	Squash, yellow, baby
	7521749	Hominy	76405-	Corn, baby
	752175-	Hominy	76409-	Peas, baby
	75223-	Peas, cowpeas, field or blackeye, cooked	76411-	Peas, creamed, baby
	75224-	Peas, green, cooked	7650200	Peas and brown rice, baby
	75225-	Peas, pigeon, cooked	7720121	Green plantain w/cracklings, p.r. (Mofongo)
	75301-	Succotash	7720511	Ripe plantain fritters, p.r. (Pionono)
	7531500	Peas & corn, cooked, ns as to added fat	7720561	Ripe plantainmeat pie, p.r. (Pinon)
	7531501	Peas & corn, cooked, no fat added	Does not include vegetable with meat mixtures.	

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA (CONTINUED)

	Food Product	Food Codes	
1	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.
2	**FAT CATEGORIES**		
3	Animal Fat	81201- Bacon grease 81202- Lard 812032- Shortening, animal 8133011 Lard	
4	Butter	811005- Butter 81101- Butter 81105- Butter 81204- Clarified butter 8132200 Honey butter	
5	Dressing	83100- 83101- 83102- 83103- 83104- 83105- 83106- 8311- 83200- 83201-	83202- 83203- 83205- 83206- 83207- 83208- 83209- 83210- 83220-
6	Margarine	81102- 81103- 81104- 81106-	
7	Mayonnaise	83204- 83107- 83108-	
8	Sauce	81301– Lemon butter sauce 81302- Sauces, various 81312- Tartar sauce	

TABLE 3B-1 FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1994-96 USDA CSFII DATA (CONTINUED)

Food Product	Food Codes			
Vegetable Oil	812031-	Shortening, vegetable	82104-	Olive oil
	81324-	Lechithin	82105-	Peanut, rapeseed, & canola oil
	8133021	Adobo fresco	82106-	Safflower oil
	82101-	Vegetable oil	82107-	Sesame oil
	82102-	Corn oil	82108-	Soy and sunflower oil
	82103-	Cottonseed & flax seed oil	82109-	Wheat germ oil

APPENDIX 3C

SAMPLE CALCULATION OF MEAN DAILY FAT INTAKE BASED ON CDC (1994) DATA

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 percent (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 and their percent TFEI from total dietary fat (33 percent) 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 3D

FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1987-88 USDA NFCS DATA

APPENDIX 3D. FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1987-88 USDA NFCS DATA

Food Product	Household Code/Definition	Individual Code
	MAJOR FOOD GROUPS	
Total Fruits	50- Fresh Fruits citrus other vitamin-C rich other fruits 512- Commercially Canned Fruits 522- Commercially Frozen Fruits 533- Canned Fruit Juice 534- Frozen Fruit Juice 535- Aseptically Packed Fruit Juice 536- Fresh Fruit Juice 542- Dried Fruits (includes baby foods)	6- Fruits citrus fruits and juices dried fruits other fruits fruits/juices & nectar fruit/juices baby food (includes baby foods)
Total Vegetables	48- Potatoes, Sweetpotatoes 49- Fresh Vegetables dark green deep yellow tomatoes light green other 511- Commercially Canned Vegetables 521- Commercially Frozen Vegetables 531- Canned Vegetable Juice 532- Frozen Vegetable Juice 537- Fresh Vegetable Juice 538- Aseptically Packed Vegetable Juice 541- Dried Vegetables (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures/dinners)	7- Vegetables (all forms) white potatoes & PR starchy dark green vegetables deep yellow vegetables tomatoes and tom. mixtures other vegetables veg. and mixtures/baby food veg. with meat mixtures (includes baby foods; mixtures, mostly vegetables)
Total Meats	44- Meat beef pork veal lamb mutton goat game lunch meat mixtures 451- Poultry (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	20- Meat, type not specified 21- Beef 22- Pork 23- Lamb, veal, game, carcass meat 24- Poultry 25- Organ meats, sausages, lunchmeats, meat spreads (excludes meat, poultry, and fish with non-meat items; frozen plate meals; soups and gravies with meat, poultry and fish base; and gelatin-based drinks; includes baby foods)
Total Dairy	40- Milk Equivalent fresh fluid milk processed milk cream and cream substitutes frozen desserts with milk cheese dairy-based dips (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners)	1- Milk and Milk Products milk and milk drinks cream and cream substitutes milk desserts, sauces, and gravies cheeses (includes regular fluid milk, human milk, imitation milk products, yogurt, milk-based meal replacements, and infant formulas)
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)

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
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	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

1 **APPENDIX 3D. FOOD CODES AND DEFINITIONS USED IN ANALYSIS**
2 **OF THE 1987-88 USDA NFCS DATA (cont'd)**

	Food Product	Household Code/Definition	Individual Code
3 4	**Food Product**	**Household Code/Definition**	**Individual Code**
5	Corn (cont.)	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)	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)
6	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)
7	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

3 4	Food Product	Household Code/Definition	Individual Code
5	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)
6	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)
7	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)
8	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)

1 APPENDIX 3D. FOOD CODES AND DEFINITIONS USED IN ANALYSIS
2 OF THE 1987-88 USDA NFCS DATA (cont'd)

	Food Product	Household Code/Definition	Individual Code
3 4			
5	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)
6	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)
7	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)
8	Carrots	4921- Fresh Carrots (and home canned/froz.) 51121- Comm. Canned Carrots 5115101 Carrots, Low Sodium, Comm. Canned 52121- Comm. Frozen Carrots 5312103 Comm. Canned Carrot Juice 5372102 Carrot Juice Fresh 5413502 Carrots, Dried Baby Food (does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)	7310- Carrots (all forms) 7311140 Carrots in Sauce 7311200 Carrot Chips 76201- Carrots, baby (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby foods except mixtures)
9	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)
10	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)
11	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- ima Beans, canned 75402- Lima Beans with sauce (does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; does not include succotash)

1 APPENDIX 3D. FOOD CODES AND DEFINITIONS USED IN ANALYSIS
2 OF THE 1987-88 USDA NFCS DATA (cont'd)

	Food Product	Household Code/Definition	Individual Code
3 4	**Food** **Product**	**Household Code/Definition**	**Individual Code**
5	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)
6	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)
7	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)
8	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)
9	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)

Food Product	Household Code/Definition		Individual Code	
Beets	4954-	Fresh Beets (and home canned/froz.)	7510250	Beets, raw
	51145-	Comm. Canned Beets (incl. baby)	752080-	Beets, cooked
	5115305	Low Sodium Beets (canned)	752081-	Beets, canned
	5213714	Comm. Frozen Beets	7540501	Beets, harvard
	5312104	Beet Juice	7550021	Beets, pickled
	(does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)		76403-	Beets, baby
			(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures; includes baby foods except mixtures)	
Strawberries	5022-	Fresh Strawberries	6322-	Strawberries
	5122801	Comm. Canned Strawberries with sugar	6413250	Strawberry Juice
	5122802	Comm. Canned Strawberries without sugar	(includes baby food; except mixtures)	
	5122803	Canned Strawberry Pie Filling		
	5222-	Comm. Frozen Strawberries		
	(does not include ready-to-eat dinners; includes baby foods except mixtures)			
Other Berries	5033-	Fresh Berries Other than Strawberries	6320-	Other Berries
	5122804	Comm. Canned Blackberries with sugar	6321-	Other Berries
	5122805	Comm. Canned Blackberries without sugar	6341101	Cranberry salad
	5122806	Comm. Canned Blueberries with sugar	6410460	Blackberry Juice
	5122807	Comm. Canned Blueberries without sugar	64105-	Cranberry Juice
	5122808	Canned Blueberry Pie Filling	(includes baby food; except mixtures)	
	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)			
Peaches	5036-	Fresh Peaches	62116-	Dried Peaches
	51224-	Comm. Canned Peaches (incl. baby)	63135-	Peaches
	5223601	Comm. Frozen Peaches	6412203	Peach Juice
	5332405	Home Canned Peach Juice	6420501	Peach Nectar
	5423105	Dried Peaches (baby)	67108-	Peaches,baby
	5423106	Dried Peaches	6711450	Peaches, dry, baby
	(does not include ready-to-eat dinners; includes baby foods except mixtures)		(includes baby food; except mixtures)	
Pears	5037-	Fresh Pears	62119-	Dried Pears
	51225-	Comm. Canned Pears (incl. baby)	63137-	Pears
	5332403	Comm. Canned Pear Juice, baby	6341201	Pear salad
	5362204	Fresh Pear Juice	6421501	Pear Nectar
	5423107	Dried Pears	67109-	Pears, baby
	(does not include ready-to-eat dinners; includes baby foods except mixtures)		6711455	Pears, dry, baby
			(includes baby food; except mixtures)	
EXPOSED/PROTECTED FRUITS/VEGETABLES, ROOT VEGETABLES				
Exposed Fruits	5022-	Strawberries, fresh	62101-	Apple, dried
	5023101	Acerola, fresh	62104-	Apricot, dried
	5023401	Currants, fresh	62108-	Currants, dried
	5031-	Apples/Applesauce, fresh	62110-	Date, dried
	5033-	Berries other than Strawberries, fresh	62116-	Peaches, dried
	5034-	Cherries, fresh	62119-	Pears, dried
	5036-	Peaches, fresh	62121-	Plum, dried

Food Product	Household Code/Definition		Individual Code	
Exposed Fruits (cont.)	5037-	Pears, fresh	62122-	Prune, dried
	50381-	Apricots, Nectarines, Loquats, fresh	62125-	Raisins
	5038305	Dates, fresh	63101-	Apples/applesauce
	50384-	Grapes, fresh	63102-	Wi-apple
	50386-	Plums, fresh	63103-	Apricots
	50387-	Rhubarb, fresh	63111-	Cherries, maraschino
	5038805	Persimmons, fresh	63112-	Acerola
	5038901	Sapote, fresh	63113-	Cherries, sour
	51221-	Apples/Applesauce, canned	63115-	Cherries, sweet
	51222-	Apricots, canned	63117-	Currants, raw
	51223-	Cherries, canned	63123-	Grapes
	51224-	Peaches, canned	6312601	Juneberry
	51225-	Pears, canned	63131-	Nectarine
	51228-	Berries, canned	63135-	Peach
	5122903	Grapes with sugar, canned	63137-	Pear
	5122904	Grapes without sugar, canned	63139-	Persimmons
	5122905	Plums with sugar, canned	63143-	Plum
	5122906	Plums without sugar, canned	63146-	Quince
	5122907	Plums, canned, baby	63147-	Rhubarb/Sapodillo
	5122911	Prunes, canned, baby	632- Berries	
	5122912	Prunes, with sugar, canned	64101-	Apple Cider
	5122913	Prunes, without sugar, canned	64104-	Apple Juice
	5122914	Raisin Pie Filling	64105-	Cranberry Juice
	5222-	Frozen Strawberries	64116-	Grape Juice
	52231-	Apples Slices, frozen	64122-	Peach Juice
	52233-	Berries, frozen	64132-	Prune/Strawberry Juice
	52234-	Cherries, frozen	6420101	Apricot Nectar
	52236-	Peaches, frozen	64205-	Peach Nectar
	52239-	Rhubarb, frozen	64215-	Pear Nectar
	53321-	Canned Apple Juice	67102-	Applesauce, baby
	53322-	Canned Grape Juice	67108-	Peaches, baby
	5332402	Canned Prune Juice	67109-	Pears, baby
	5332403	Canned Pear Juice	6711450	Peaches, baby, dry
	5332404	Canned Blackberry Juice	6711455	Pears, baby, dry
	5332405	Canned Peach Juice	67202-	Apple Juice, baby
	53421-	Frozen Grape Juice	6720380	White Grape Juice, baby
	5342201	Frozen Apple Juice, comm. fr.	67212-	Pear Juice, baby
	5342202	Frozen Apple Juice, home fr.	(includes baby foods/juices except mixtures; excludes fruit mixtures)	
	5352101	Apple Juice, asep. packed		
	5352201	Grape Juice, asep. packed		
	5362101	Apple Juice, fresh		
	5362202	Apricot Juice, fresh		
	5362203	Grape Juice, fresh		
	5362204	Pear Juice, fresh		
	5362205	Prune Juice, fresh		
	5421-	Dried Prunes		
	5422-	Raisins, Currants, dried		
	5423101	Dry Apples		
	5423102	Dry Apricots		
	5423103	Dates without pits		
	5423104	Dates with pits		
	5423105	Peaches, dry, baby		
	5423106	Peaches, dry		
	5423107	Pears, dry		
	5423114	Berries, dry		
	5423115	Cherries, dry		
	(includes baby foods)			
Protected Fruits	501- Citrus Fruits, fresh		61- Citrus Fr., Juices (incl. cit. juice mixtures)	
	5021-	Cantaloupe, fresh	62107-	Bananas, dried
	5023201	Mangoes, fresh	62113-	Figs, dried
	5023301	Guava, fresh	62114-	Lychees/Papayas, dried

APPENDIX 3D. FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1987-88 USDA NFCS DATA (cont'd)

Food Product	Household Code/Definition	Individual Code
Protected	5023601 Kiwi, fresh	62120- Pineapple, dried
Fruits	5023701 Papayas, fresh	62126- Tamarind, dried
(cont.)	5023801 Passion Fruit, fresh	63105- Avocado, raw
	5032- Bananas, Plantains, fresh	63107- Bananas
	5035- Melons other than Cantaloupe, fresh	63109- Cantaloupe, Carambola
	50382- Avocados, fresh	63110- Cassaba Melon
	5038301 Figs, fresh	63119- Figs
	5038302 Figs, cooked	63121- Genip
	5038303 Figs, home canned	63125- Guava/Jackfruit, raw
	5038304 Figs, home frozen	6312650 Kiwi
	50385- Pineapple, fresh	6312651 Lychee, raw
	5038801 Pomegranates, fresh	6312660 Lychee, cooked
	5038902 Cherimoya, fresh	63127- Honeydew
	5038903 Jackfruit, fresh	63129- Mango
	5038904 Breadfruit, fresh	63133- Papaya
	5038905 Tamarind, fresh	63134- Passion Fruit
	5038906 Carambola, fresh	63141- Pineapple
	5038907 Longan, fresh	63145- Pomegranate
	5121- Citrus, canned	63148- Sweetsop, Soursop, Tamarind
	51226- Pineapple, canned	63149- Watermelon
	5122901 Figs with sugar, canned	64120- Papaya Juice
	5122902 Figs without sugar, canned	64121- Passion Fruit Juice
	5122909 Bananas, canned, baby	64124- Pineapple Juice
	5122910 Bananas and Pineapple, canned, baby	64133- Watermelon Juice
	5122915 Litchis, canned	6420150 Banana Nectar
	5122916 Mangos with sugar, canned	64202- Cantaloupe Nectar
	5122917 Mangos without sugar, canned	64203- Guava Nectar
	5122918 Mangos, canned, baby	64204- Mango Nectar
	5122920 Guava with sugar, canned	64210- Papaya Nectar
	5122921 Guava without sugar, canned	64213- Passion Fruit Nectar
	5122923 Papaya with sugar, canned	64221- Soursop Nectar
	5122924 Papaya without sugar, canned	6710503 Bananas, baby
	52232- Bananas, frozen	6711500 Bananas, baby, dry
	52235- Melon, frozen	6720500 Orange Juice, baby
	52237- Pineapple, frozen	6721300 Pineapple Juice, baby
	5331- Canned Citrus Juices	(includes baby foods/juices except mixtures; excludes fruit mixtures)
	53323- Canned Pineapple Juice	
	5332408 Canned Papaya Juice	
	5332410 Canned Mango Juice	
	5332501 Canned Papaya Concentrate	
	5341- Frozen Citrus Juice	
	5342203 Frozen Pineapple Juice	
	5351- Citrus and Citrus Blend Juices, asep. packed	
	5352302 Pineapple Juice, asep. packed	
	5361- Fresh Citrus and Citrus Blend Juices	
	5362206 Papaya Juice, fresh	
	5362207 Pineapple-Coconut Juice, fresh	
	5362208 Mango Juice, fresh	
	5362209 Pineapple Juice, fresh	
	5423108 Pineapple, dry	
	5423109 Papaya, dry	
	5423110 Bananas, dry	
	5423111 Mangos, dry	
	5423117 Litchis, dry	
	5423118 Tamarind, dry	
	5423119 Plantain, dry	
	(includes baby foods)	
Exposed	491- Fresh Dark Green Vegetables	721- Dark Green Leafy Veg.
Vegetable	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

APPENDIX 3D. FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1987-88 USDA NFCS DATA (cont'd)

Food Product	Household Code/Definition	Individual Code
Exposed Vegetable (cont.)	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 Brussel 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- Brussel 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
	51152- Tomatoes, canned, low sod.	752130- Cabbage, savoy, cooked
	5115301 Asparagus, canned, low sod.	75214- Cauliflower
	5115302 Beans, Green, canned, low sod.	75215- Celery, Chives, Christophine (chayote)
	5115303 Beans, Yellow, canned, low sod.	752167- Cucumber, cooked
	5115309 Mushrooms, canned, low sod.	752170- Eggplant, cooked
	51154- Greens, canned, low sod.	752171- Fern shoots
	5115501 Sauerkraut, low sodium	752172- Fern shoots
	5211- Dark Gr. Veg., comm. frozen (all exp.)	752173- Flowers of sesbania, squash or lily
	52131- Asparagus, comm. froz.	7521801 Kohlrabi, cooked
	52133- Beans, snap, green, yellow, comm. froz.	75219- Mushrooms, cooked
	5213407 Peapods, comm froz.	75220- Okra/lettuce, cooked
	5213408 Peapods, with sauce, comm froz.	7522116 Palm Hearts, cooked
	5213409 Peapods, with other veg., comm froz.	7522121 Parsley, cooked
	5213701 Brussel Sprouts, comm. froz.	75226- Peppers, pimento, cooked
	5213702 Brussel Sprouts, comm. froz. with cheese	75230- Sauerkraut, cooked/canned
	5213703 Brussel Sprouts, comm. froz. with other veg.	75231- Snowpeas, cooked
	5213705 Cauliflower, comm. froz.	75232- Seaweed

APPENDIX 3D. FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1987-88 USDA NFCS DATA (cont'd)

Food Product	Household Code/Definition		Individual Code	
Exposed Vegetable (cont.)	5213706	Cauliflower, comm. froz. with sauce	75233-	Summer Squash
	5213707	Cauliflower, comm. froz. with other veg.	7540050	Artichokes, stuffed
	5213708	Caul., comm. froz. with other veg. & sauce	7540101	Asparagus, creamed or with cheese
	5213709	Summer Squash, comm. froz.	75403-	Beans, green with sauce
	5213710	Summer Squash, comm. froz. with other veg.	75404-	Beans, yellow with sauce
	5213716	Eggplant, comm. froz.	7540601	Brussel Sprouts, creamed
	5213718	Mushrooms with sauce, comm. froz.	7540701	Cabbage, creamed
	5213719	Mushrooms, comm. froz.	75409-	Cauliflower, creamed
	5213720	Okra, comm. froz.	75410-	Celery/Chiles, creamed
	5213721	Okra, comm. froz., with sauce	75412-	Eggplant, fried, with sauce, etc.
	5311-	Canned Tomato Juice and Tomato Mixtures	75413-	Kohlrabi, creamed
	5312102	Canned Sauerkraut Juice	75414-	Mushrooms, Okra, fried, stuffed, creamed
	5321-	Frozen Tomato Juice	754180-	Squash, baked, fried, creamed, etc.
	5371-	Fresh Tomato Juice	7541822	Christophine, creamed
	5381102	Aseptically Packed Tomato Juice	7550011	Beans, pickled
	5413101	Dry Algae	7550051	Celery, pickled
	5413102	Dry Celery	7550201	Cauliflower, pickled
	5413103	Dry Chives	755025-	Cabbage, pickled
	5413109	Dry Mushrooms	7550301	Cucumber pickles, dill
	5413111	Dry Parsley	7550302	Cucumber pickles, relish
	5413112	Dry Green Peppers	7550303	Cucumber pickles, sour
	5413113	Dry Red Peppers	7550304	Cucumber pickles, sweet
	5413114	Dry Seaweed	7550305	Cucumber pickles, fresh
	5413115	Dry Tomatoes	7550307	Cucumber, Kim Chee
	(does not include soups, sauces, gravies, mixtures, and ready-to-eat dinners; includes baby foods except mixtures)		7550308	Eggplant, pickled
			7550311	Cucumber pickles, dill, reduced salt
			7550314	Cucumber pickles, sweet, reduced salt
			7550500	Mushrooms, pickled
			7550700	Okra, pickled
			75510-	Olives
			7551101	Peppers, hot
			7551102	Peppers,pickled
			7551301	Seaweed, pickled
			7553500	Zucchini, pickled
			76102-	Dark Green Veg., baby
			76401-	Beans, baby (excl. most soups & mixtures)
Protected Vegetable	4922-	Fresh Pumpkin, Winter Squash	732-	Pumpkin
	4942-	Fresh Lima Beans	733-	Winter Squash
	4947-	Fresh Peas	7510200	Lima Beans, raw
	49482-	Fresh Soy Beans	7510550	Cactus, raw
	4956-	Fresh Corn	7510960	Corn, raw
	4958303	Succotash, home canned	7512000	Peas, raw
	4958304	Succotash, home frozen	7520070	Aloe vera juice
	4958401	Fresh Cactus (prickly pear)	752040-	Lima Beans, cooked
	4958503	Burdock	752041-	Lima Beans, canned
	4958505	Bitter Melon	7520829	Bitter Melon
	4958507	Horseradish Tree Pods	752083-	Bitter Melon, cooked
	51122-	Comm. Canned Pumpkin and Squash (baby)	7520950	Burdock
	51142-	Beans, comm. canned	752131-	Cactus
	51143-	Beans, lima and soy, comm. canned	752160-	Corn, cooked
	51146-	Corn, comm. canned	752161-	Corn, yellow, cooked
	5114701	Peas, green, comm. canned	752162-	Corn, white, cooked
	5114702	Peas, baby, comm. canned	752163-	Corn, canned
	5114703	Peas, blackeye, comm. canned	7521749	Hominy
	5114705	Pigeon Peas, comm. canned	752175-	Hominy
	5114919	Succotash, comm. canned	75223-	Peas, cowpeas, field or blackeye, cooked
	5115304	Lima Beans, canned, low sod.	75224-	Peas, green, cooked
	5115306	Corn, canned, low sod.	75225-	Peas, pigeon, cooked
	5115307	Creamed Corn, canned, low sod.	75301-	Succotash
	511531-	Peas and Beans, canned, low sod.	75402-	Lima Beans with sauce

APPENDIX 3D. FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1987-88 USDA NFCS DATA (cont'd)

Food Product	Household Code/Definition		Individual Code	
Protected Vegetable (cont.)	52122-	Winter Squash, comm. froz.	75411-	Corn, scalloped, fritter, with cream
	52132-	Lima Beans, comm. froz.	7541650	Pea salad
	5213401	Peas, gr., comm. froz.	7541660	Pea salad with cheese
	5213402	Peas, gr., with sauce, comm. froz.	75417-	Peas, with sauce or creamed
	5213403	Peas, gr., with other veg., comm. froz.	7550101	Corn relish
	5213404	Peas, gr., with other veg., comm. froz.	76205-	Squash, yellow, baby
	5213405	Peas, blackeye, comm froz.	76405-	Corn, baby
	5213406	Peas, blackeye, with sauce, comm froz.	76409-	Peas, baby
	52135-	Corn, comm. froz.	76411-	Peas, creamed, baby
	5213712	Artichoke Hearts, comm. froz.	(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)	
	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)			
Rooted Vegetable	48-	Potatoes, Sweetpotatoes	71-	White Potatoes and Puerto Rican St. Veg.
	4921-	Fresh Carrots	7310-	Carrots
	4953-	Fresh Onions, Garlic	7311140	Carrots in sauce
	4954-	Fresh Beets	7311200	Carrot chips
	4957-	Fresh Turnips	734-	Sweetpotatoes
	4958101	Fresh Celeriac	7510250	Beets, raw
	4958102	Fresh Horseradish	7511150	Garlic, raw
	4958104	Fresh Radishes, no greens	7511180	Jicama (yambean), raw
	4958105	Radishes, home canned	7511250	Leeks, raw
	4958106	Radishes, home frozen	75117-	Onions, raw
	4958107	Fresh Radishes, with greens	7512500	Radish, raw
	4958108	Fresh Salsify	7512700	Rutabaga, raw
	4958109	Fresh Rutabagas	7512900	Turnip, raw
	4958110	Rutabagas, home frozen	752080-	Beets, cooked
	4958115	Fresh Parsnips	752081-	Beets, canned
	4958116	Parsnips, home canned	7521362	Cassava
	4958117	Parsnips, home frozen	7521740	Garlic, cooked
	4958502	Fresh Lotus Root	7521771	Horseradish
	4958509	Ginger Root	7521850	Lotus root
	4958510	Jicama, including yambean	752210-	Onions, cooked
	51121-	Carrots, comm. canned	7522110	Onions, dehydrated
	51145-	Beets, comm. canned	752220-	Parsnips, cooked
	5114908	Garlic Pulp, comm. canned	75227-	Radishes, cooked
	5114910	Horseradish, comm. prep.	75228-	Rutabaga, cooked
	5114915	Onions, comm. canned	75229-	Salsify, cooked
	5114916	Rutabagas, comm. canned	75234-	Turnip, cooked
	5114917	Salsify, comm. canned	75235-	Water Chestnut
	5114921	Turnips, comm. canned	7540501	Beets, harvard
	5114922	Water Chestnuts, comm. canned	75415-	Onions, creamed, fried
	51151-	Carrots, canned, low sod.	7541601	Parsnips, creamed
	5115305	Beets, canned, low sod.	7541810	Turnips, creamed
	5115502	Turnips, low sod.	7550021	Beets, pickled
	52121-	Carrots, comm. froz.	7550309	Horseradish
	5213714	Beets, comm. froz.	7551201	Radishes, pickled
	5213722	Onions, comm. froz.	7553403	Turnip, pickled
	5213723	Onions, comm. froz., with sauce	76201-	Carrots, baby
	5213725	Turnips, comm. froz.	76209-	Sweetpotatoes, baby
	5312103	Canned Carrot Juice	76403-	Beets, baby
	5312104	Canned Beet Juice	(does not include vegetable soups; vegetable mixtures; or vegetable with meat mixtures)	
	5372102	Fresh Carrot Juice		

APPENDIX 3D. FOOD CODES AND DEFINITIONS USED IN ANALYSIS OF THE 1987-88 USDA NFCS DATA (cont'd)

Food Product	Household Code	Definition	Individual Code	Definition
Root Vegetables (cont.)	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)			
USDA SUBCATEGORIES				
Dark Green Vegetables	491-	Fresh Dark Green Vegetables	72-	Dark Green Vegetables
	5111-	Comm. Canned Dark Green Veg.		all forms
	51154-	Low Sodium Dark Green Veg.		leafy, nonleafy, dk. gr. veg. soups
	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)			
Deep Yellow Vegetables	492-	Fresh Deep Yellow Vegetables	73-	Deep Yellow Vegetables
	5112-	Comm. Canned Deep Yellow Veg.		all forms
	51151-	Low Sodium Carrots		carrots, pumpkin, squash, sweetpotatoes, dp. yell. veg. soups
	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)			
Other Vegetables	494-	Fresh Light Green Vegetables	75-	Other Vegetables
	495-	Fresh Other Vegetables		all forms
	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)			
Citrus Fruits	501-	Fresh Citrus Fruits	61-	Citrus Fruits and Juices
	5121	Comm. Canned Citrus Fruits	6720500	Orange Juice, baby food
	5331	Canned Citrus and Citrus Blend Juice	6720600	Orange-Apricot Juice, baby food
	5341	Frozen Citrus and Citrus Blend Juice	6720700	Orange-Pineapple Juice, baby food
	5351	Aseptically Packed Citrus and Citr. Blend Juice	672110	Orange-Apple-Banana Juice, baby food
	5361	Fresh Citrus and Citrus Blend Juice	(excludes dried fruits)	
	(includes baby foods; excludes dried fruits)			
Other Fruits	62-	Fresh Other Vitamin C-Rich Fruits	5353-	Dried Fruits
	503-	Fresh Other Fruits	63	Other Fruits
	5122-	Comm. Canned Fruits Other than Citrus	64	Fruit Juices and Nectars Excluding Citrus
	5222-	Frozen Strawberries	671	Fruits, baby
	5332-	Frozen Other than Citr. or Vitamin C-Rich Fr.	67202	Apple Juice, baby
	5333-	Canned Fruit Juice Other than Citrus	67203	Baby Juices
	5352-	Frozen Juices Other than Citrus	67204	Baby Juices

Food Product	Household Code/Definition		Individual Code	
Other Fruits (cont.)	5362-	Aseptically Packed Fruit Juice Other than Citr.	67212	Baby Juices
	542-	Fresh Fruit Juice Other than Citrus Dry Fruits	67213	Baby Juices
	(includes baby foods; excludes dried fruits)		673	Baby Fruits
			674	Baby Fruits

4. DRINKING WATER INTAKE 4-1
4.1 INTRODUCTION 4-1
4.2 DRINKING WATER INTAKE STUDIES 4-2
4.3. PREGNANT AND LACTATING WOMEN 4-7
4.4 RECOMMENDATIONS 4-8
4.5 REFERENCES FOR CHAPTER 4 4-9

Table 4-1. Estimated Direct and Indirect Community Total Water Ingestion By Source for U.S. Population 4-10
Table 4-2. Estimate of Total Direct and Indirect Water Ingestion, All Sources By Broad Age Category for U.S. Children 4-11
Table 4-3. Estimate of Direct and Indirect Community Water Ingestion By Fine Age Category for U.S. Children 4-12
Table 4-4. Estimate of Direct and Indirect Community Water Ingestion By Broad Age Category for U.S. Children 4-13
Table 4-5. Estimate of Direct and Indirect Bottled Water Ingestion By Fine Age Category for U.S. Children 4-14
Table 4-6. Estimate of Direct and Indirect Bottled Water Ingestion By Broad Age Category for U.S. Children 4-15
Table 4-7. Estimate of Direct and Indirect Other Water Ingestion By Fine Age Category for U.S. Children 4-16
Table 4-8. Estimate of Direct and Indirect Other Water Ingestion By Broad Age Category for U.S. Children 4-17
Table 4-9. Chi-square GOF statistics for 12 Models, Tapwater Data, Based on Maximum Likelihood Method of Parameter Estimation 4-18
Table 4-10. P-Values for Chi-Square GOF Tests of 12 Models, Tapwater Data 4-18
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 Modles 4-19
Table 4-12. Total Fluid Intake of Women 15-49 Years Old 4-20
Table 4-13. Total Tapwater Intake of Women 15-49 Years Old 4-20
Table 4-14. Total Fluid (mL/Day) Derived from Various Dietary Sources by Women Aged 15-49 Years[a] 4-21
Table 4-15. Summary of Recommended Community Drinking Water Intake Rates 4-22
Table 4-16. Confidence in Tapwater Intake Recommendations 4-23

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 toxics from drinking water requires information on the quantity of water consumed. The purpose of this section is to describe key published studies that provide information on drinking water consumption (Section 4.2) among children and to provide recommendations of consumption rate values that should be used in exposure assessments (Section 4.3).

Currently, the U.S. EPA uses the quantity 1 L per day for infants (individuals of 10 kg body mass or less) and children as a default drinking water intake rates (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 (NAS, 1977) estimated that daily consumption of water may vary with levels of physical activity and fluctuations in temperature and humidity. It is reasonable to assume that 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, while *indirect intake* includes water added during food preparation, but not water intrinsic to purchased foods. Data for consumption of various sources (i.e., the 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 drinking water surveys currently available are based on recall. This may be a source of uncertainty in the estimated intake rates because of the subjective nature of this type of survey technique.

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

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

4.2 DRINKING WATER INTAKE STUDIES

U.S. EPA Office of Water (2000) - Estimated Per Capita Water Ingestion in the United States - The U.S. EPA used data from a U.S. Department of Agriculture (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. Over 15,000 persons responded to the study conducted between 1994 and 1996 on what they ate and drank over two non-consecutive days (USDA, 1998). The U.S. EPA used the drinking water ingestion data to derive estimates of consumption rates by age groups, gender, water source, vulnerable subsets of the population (i.e., lactating and pregnant women) (U.S. EPA, 2000). The ingestion rates are expressed in both volume (milliliters [ml]) per day per person and volume per kilogram (kg) body weight (BW) 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 (U.S. EPA, 2000).

In the study, the U.S. EPA reported that community water (i.e., tapwater-public water supply) accounts for approximately 75 percent of the mean ingested water (U.S. EPA, 2000). 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 while 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 (i.e., <1 year, 1-10 years, 11-19 years) and percentiles.

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 quantity of water ingested decreases with age, the quantity consumed per unit mass of body weight (BW) increases (U.S. EPA, 2000). For instance, the mean community water consumption is 342 ml per child per 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 (kg) BW/day for under 1 year, 19 ml/kg BW/day for 1 to 10 years, and 12 ml/kg BW/day for 11 to 19 years. The significance of this finding is that although children may be encounter lower overall doses, the younger, vulnerable ages (i.e., infants) have significantly higher dose rates per unit of BW. Tables 4-3 and 4-4 show the daily community water consumption rate estimates by fine and broad age groups in units of mL/day and mL per mass of BW per day. Tables 4-5 and 4-6 present the data for bottled water ingestion.

Water consumption rates for other sources of water are compiled in Tables 4-7 and 4-8. 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 BW increases as the age decreases. Missing water sources have not been included in the summary of water sources because of its negligible quantity. Missing water sources comprise only about one percent 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., 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 6,000 children enhances the precision and accuracy of the estimates for the overall population and population subsets. The survey was conducted on non-consecutive 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 on water consumption and 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 (i.e., 2 non-consecutive 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. As such, 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.

Myers et al. (1999) - Options for Development of Parametric Probability Distributions for Exposure Factors - Myers et al. (1999) 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 (Ershow and Cantor, 1989) of the EFH. EFH Table 3-7 data summaries analyzed by Myers et al. (1999)

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 Myers et al. (1999) incorporates the following elements:

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 utilizes a twelve-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 Myers et al. (1999), 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 (MCS), 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. As stated in Myers et al. (1999), "In each case the null hypothesis tested is that the data arose from the given type of model. A low p-value casts doubt on the null hypothesis. Clearly, the only model that appears to fit most of the datasets is the five-parameter generalized F distribution with a point mass at zero, referred to as GenF5. 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 is shown in Myers et al. (1999) and is described there as follows:

"[This table] summarizes several additional aspects of interest for the tapwater populations. For each age group shown, the first row (SOURCE=data) is basically a data summary. Within the first row, the columns labeled N, MEAN, and SDEV contain the sample size, the sample mean, and the sample standard deviation. Within the first row, the columns labeled P01, P05, ..., P99 contain the nominal probabilities .01, .05, ..., .99. The values in the first row for MEAN, SDEV, and the nine nominal probabilities can be thought of as 11 targets that the models are trying to hit.

The other rows (2nd through 6th rows) within each age group contain results from fitting four models, including gamma, lognormal and Weibull, using selected estimation criteria. The model and estimation criterion are indicated by the variable SOURCE. For instance, SOURCE = gammle indicates the two-parameter gamma model fit using maximum likelihood estimation. The model gf5 is the five-parameter generalized F with a point mass at zero. 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.

The last three columns contain summary GOF measures. CHIDF is the value of the chi-square statistic divided by its degrees of freedom. The methods are ordered with respect to this CHIDF measure. CHIDF is more comparable across cases involving different degrees of freedom than is the chi-square statistic. PGOF is the p-value for model goodness-of-fit based on the chi-square test. Low-values of PGOF, such as PGOF <0.05, cast doubt on the null hypothesis that the given type of model is correct. Note that maximum likelihood estimation performed much worse for the lognormal model than the WLS method of estimation, as determined by CHIDF and PGOF measures.

If a two-parameter model must be used for tapwater consumption, then the gamma model with parameters estimated by maximum likelihood is recommended. The five-parameter generalized F distribution could be used for sensitivity analyses. The age effect seems sufficiently strong to justify the use of separate age groups in risk assessment."

4.3. PREGNANT AND LACTATING WOMEN

Ershow et al. (1991) - Intake of Tapwater and Total Water by Pregnant and Lactating Women - Ershow et al. (1991) used data from the 1977-78 USDA NFCS to estimate total fluid and total tapwater intake among pregnant and lactating women (ages 15-49 years). Data for 188 pregnant women, 77 lactating women, and 6,201 non-pregnant, non-lactating control women were evaluated. The participants were interviewed based on 24 hour recall, and then asked to record a food diary for the next 2 days. "Tapwater" included tapwater consumed directly as a beverage and tapwater used to prepare food and tapwater-based beverages. "Total water" was defined as all water from tapwater and non-tapwater sources, including water contained in food. Estimated total fluid and total tapwater intake rates for the three groups are presented in Tables 4-12 and 4-13, respectively. Lactating women had the highest mean total fluid intake rate (2.24 L/day) compared with both pregnant women (2.08 L/day) and control women (1.94 L/day). Lactating women also had a higher mean total tapwater intake rate (1.31 L/day) than pregnant women (1.19 L/day) and control women (1.16 L/day). The tapwater distributions are neither normal nor lognormal, but lactating women had a higher mean tapwater intake than controls and pregnant women. Ershow et al. (1991) also reported that rural women (n=1,885) consumed more total water (1.99 L/day) and tapwater (1.24 L/day) than urban/suburban women (n=4,581, 1.93 and 1.13 L/day, respectively). Total water and tapwater intake rates were lowest in the northeastern region of the United States (1.82 and 1.03 L/day) and highest in the western region of the United States (2.06 L/day and 1.21 L/day). Mean intake per unit body weight was highest among lactating women for both total fluid and total tapwater intake. Total tapwater intake accounted for over 50 percent of mean total fluid in all three groups of women (Table 4-13). Drinking water accounted for the largest single proportion of the total fluid intake for control (30 percent), pregnant (34 percent), and lactating women (30 percent) (Table 4-14). All other beverages combined accounted for approximately 46 percent, 43 percent, and 45 percent of the total water intake for control, pregnant, and lactating women, respectively. Food accounted for the remaining portion of total water intake.

This survey has an adequately large size (6,201 individuals) and it is representative of the United States population with respect to age distribution, racial composition, and residential location. The chief limitation of the study is that the data were collected in 1978 and do not reflect the expected increase in the consumption of soft drinks and bottled water or changes in the diet within the last two decades. Since the data were collected for only a three-day period, the extrapolation to chronic intake is uncertain.

4.4 RECOMMENDATIONS

The studies described in this section were used in selecting recommended drinking water (tapwater) consumption rates for children. The mean and upper-percentile estimates reported in these studies are reasonably similar. The surveys described here are based on short-term recall which may be biased toward excess intake rates. However, Cantor et al. (1987) noted that retrospective dietary assessments generally produce moderate correlations with "reference data from the past." A summary of the recommended values for drinking water intake rates is presented in Table 4-15.

The intake rates, as expressed as liters per day, 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 4-16. The 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 U.S. EPA (2000) study.

4.5 REFERENCES FOR CHAPTER 4

Cantor, K.P.; Hoover, R.; Hartge, P.; Mason, T.J.; Silverman, D.T.; et al. (1987) Bladder cancer, drinking water source, and tapwater consumption. A case-control study. J. Natl. Cancer Inst. 79(6):1269-1270.

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

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

Myers, L., J. Lashley, and R. Whitmore. (1999) Options for Development of Parametric Probability Distributions for Exposure Factors, submitted to U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C., September 30.

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

USDA. (1998) 1994-1996 Continuing survey of food intakes and 1994-1996 diet and health survey.

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

U.S. EPA. (1991) National primary drinking water regulations; final rule. Federal Register. 56(20):3526-3597. January 30, 1991.

U.S. EPA. (1996) Exposure Factors Handbook. Washington, DC: Office of Research and Development, National Center for Environmental Assessment. SAB Review Draft (EPA/600/P-95/002Ba).

U.S. EPA. (1997a) Exposure Factors Handbook. Washington, DC: Office of Research and Development, (EPA/600/P-95/002F).

U.S. EPA. (1997b) Risk Assessment Forum. Guiding Principles for Monte Carlo Analysis, (EPA/630/R-97/001).

U.S. EPA. (2000) Estimated per capita water ingestion in the United States. Washington, DC: Office of Science and Technology, Office of Water.

Table 4-1. Estimated Direct and Indirect Community Total Water Ingestion By Source for U.S. Population

Source	Sample Size	Mean (ml/person/day) Estimate	Mean 90% CI Lower Bound	Mean 90% CI Upper Bound	90th Percentile (ml/person/day) Estimate	90th 90% CI Lower Bound	90th 90% CI Upper Bound	95th Percentile (ml/person/day) Estimate	95th 90% CI Lower Bound	95th 90% CI Upper Bound
Community Water Supply	15,303	927	902	951	2,016	1,991	2,047	2,544	2,485	2,576
Bottled Water	15,303	161	147	176	591	591	632	1,036	1,006	1,065
Other Sources	15,303	128	101	155	343	305	360	1,007	947	1,074
Missing Sources	15,303	16	13	20	-	-	-	-	-	-
All Sources	15,303	1,232	1,199	1,265	2,341	2,308	2,366	2,908	2,840	2,960

- Denotes zero.

(1) Source of Data - USDA Continuing Survey of Food Intakes by Individuals (1994-1996)
(2) Estimates are based on 2-day averages for non-consecutive days.

Source: U.S. EPA (2000)

Table 4-2. Estimate of Total Direct and Indirect Water Ingestion, All Sources By Broad Age Category for U.S. Children

		Quantity, Percentiles (ml/person-day)									
Age (years)	Sample Size	Mean	1th	5th	10th	25th	50th	75th	90th	95th	99th
< 1	359	484	-	-	-	124	449	747	949	1,182	1,645[a]
1 - 10	3,980	528	4	75	133	254	444	710	1,001	1,242	1,891
11 - 19	1,641	907	-	118	219	395	715	1,188	1,780	2,185	3,805
		Quantity, Percentiles (ml/kg-day)									
< 1	359	67	-	-	-	16	57	101	156	170	218a
1 - 10	3,980	25	-	4	6	12	21	33	49	64	98
11 -19	1,641	16	-	2	4	7	13	20	30	39	64

Source of Data: 1994-96 USDA Survey of Food Intakes by Individuals (CSFII)
- Denotes zero.
a - Sample size was insufficient for minimum reporting requirements according to "Third Report on Nutritional Monitoring in the U.S. (1994-96)"

Source: U.S. EPA (2000)

Table 4-3. Estimate of Direct and Indirect Community Water Ingestion By Fine Age Category for U.S. Children

			Quantity, Percentile (ml/person-day)								
Age (years)	Sample Size	Mean	1^{th}	5^{th}	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}	95^{th}	99^{th}
< 0.5	199	280	-	-	-	-	35	552	861	945[a]	1,286[a]
0.5 - 0.9	160	412	-	-	-	36	322	712	884	1,101[a]	1,645[a]
1 - 3	1,834	313	-	-	-	74	236	469	691	942	1,358
4 - 6	1,203	420	-	-	22	133	330	591	917	1,165	1,902[a]
7 - 10	943	453	-	-	29	139	355	671	978	1,219	1,914[a]
11 - 14	816	594	-	-	27	181	435	801	1,365	1,722	2,541[a]
15 - 19	825	760	-	-	25	201	540	1,030	1,610	2,062	3,830[a]
			Quantity, Percentile (ml/kg-day)								
< 0.5	191	47	-	-	-	-	5	90	139	170[a]	217[a]
0.5 - 0.9	153	45	-	-	-	4	36	79	103	122[a]	169[a]
1 - 3	1,752	23	-	-	1	6	17	33	51	67	109[a]
4 - 6	1,113	21	-	-	1	6	16	29	44	64	91[a]
7 - 10	879	15	-	-	1	5	11	21	32	39	60[a]
11 - 14	790	12	-	-	1	4	9	17	26	34	54[a]
15 -19	816	12	-	-	-	3	9	16	25	32	61[a]

Source of Data: 1994-96 USDA Survey of Food Intakes by Individuals (CSFII)
 - Denotes zero.
a - Sample size was insufficient for minimum reporting requirements according to “Third Report on Nutritional Monitoring in the U.S. (1994-96)”
Source: U.S. EPA (2000)

Table 4-4. Estimate of Direct and Indirect Community Water Ingestion By Broad Age Category for U.S. Children

			Quantity, Percentile (ml/person-day)								
Age (years)	Sample Size	Mean	1th	5th	10th	25th	50th	75th	90th	95th	99th
< 1	344	342	-	-	-	-	173	652	878	1,040	1,438[a]
1 - 10	3,744	400	-	-	12	118	302	571	905	1,118	1,731
11 - 19	1,606	683	-	-	26	191	473	937	1,533	1,946	3,671
			Quantity, Percentile (ml/kg-day)								
< 1	344	46	-	-	-	-	19	82	127	156	205[a]
1 - 10	3,744	19	-	-	-	5	15	27	42	56	91
11 - 19	1,606	12	-	-	1	3	9	16	26	33	59

Source of Data: 1994-96 USDA Survey of Food Intakes by Individuals (CSFII)
- Denotes zero.
a - Sample size was insufficient for minimum reporting requirements according to "Third Report on Nutritional Monitoring in the U.S. (1994-96)."
Source: U.S. EPA (2000)

Table 4-5. Estimate of Direct and Indirect Bottled Water Ingestion By Fine Age Category for U.S. Children

			Quantity, Percentile (ml/person-day)									
Age (years)	Sample Size	Mean	1th	5th	10th	25th	50th	75th	90th	95th	99th
< 0.5	199	110	-	-	-	-	-	38	519	809	1,045[a]
0.5 - 0.9	160	113	-	-	-	-	-	5	496	727[a]	1,006[a]
1 - 3	1,834	62	-	-	-	-	-	-	235	411	820
4 - 6	1,203	73	-	-	-	-	-	-	279	521	915[a]
7 - 10	943	76	-	-	-	-	-	-	271	497	917[a]
11 - 14	816	100	-	-	-	-	-	-	344	679	1,415[a]
15 - 19	825	130	-	-	-	-	-	-	468	867	1,775[a]
			Quantity, Percentile (ml/kg-day)								
< 0.5	191	20	-	-	-	-	-	6	81	152[a]	170[a]
0.5 - 0.9	153	14	-	-	-	-	-	2	51	92[a]	125[a]
1 - 3	1,752	5	-	-	-	-	-	-	17	30	61
4 - 6	1,113	4	-	-	-	-	-	-	13	24	49[a]
7 - 10	879	2	-	-	-	-	-	-	8	14	26[a]
11 - 14	790	2	-	-	-	-	-	-	7	13	27[a]
15 -19	816	2	-	-	-	-	-	-	7	12	28[a]

Source of Data: 1994-96 USDA Survey of Food Intakes by Individuals (CSFII)
- Denotes zero.
a - Sample size was insufficient for minimum reporting requirements according to “Third Report on Nutritional Monitoring in the U.S. (1994-96)”
Source: U.S. EPA (2000)

Table 4-6. Estimate of Direct and Indirect Bottled Water Ingestion By Broad Age Category for U.S. Children

			Quantity, Percentile (ml/person-day)								
Age (years)	Sample Size	Mean	1th	5th	10th	25th	50th	75th	90th	95th	99th
< 1	359	111	-	-	-	-	-	23	522	793	1,083[a]
1 - 10	3,980	71	-	-	-	-	-	-	264	472	906
11 - 19	1,641	116	-	-	-	-	-	-	414	764	1,648
			Quantity, Percentile (ml/kg-day)								
< 1	344	17	-	-	-	-	-	5	76	123	169[a]
1 - 10	3,744	3	-	-	-	-	-	-	12	22	49
11 - 19	1,606	2	-	-	-	-	-	-	7	13	28

Source of Data: 1994-96 USDA Survey of Food Intakes by Individuals (CSFII)
- Denotes zero.
a - Sample size was insufficient for minimum reporting requirements according to "Third Report on Nutritional Monitoring in the U.S. (1994-96)."
Source: U.S. EPA (2000)

Table 4-7. Estimate of Direct and Indirect Other Water Ingestion By Fine Age Category for U.S. Children

			Quantity, Percentile (ml/person-day)								
Age (years)	Sample Size	Mean	1^{th}	5^{th}	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}	95^{th}	99^{th}
< 0.5	199	18	-	-	-	-	-	-	-	86[a]	468[a]
0.5 - 0.9	160	30	-	-	-	-	-	-	23	202[a]	554[a]
1 - 3	1,834	35	-	-	-	-	-	-	8	295	710
4 - 6	1,203	43	-	-	-	-	-	-	32	322	830[a]
7 - 10	943	67	-	-	-	-	-	-	206	554	1,049[a]
11 - 14	816	106	-	-	-	-	-	-	341	800	1,811[a]
15 - 19	825	77	-	-	-	-	-	-	234	552	1,411[a]
			Quantity, Percentile (ml/kg-day)								
< 0.5	191	3	-	-	-	-	-	-	-	15[a]	86[a]
0.5 - 0.9	153	3	-	-	-	-	-	-	5	24[a]	63[a]
1 - 3	1,752	3	-	-	-	-	-	-	2	21	48
4 - 6	1,113	2	-	-	-	-	-	-	2	15	42[a]
7 - 10	879	2	-	-	-	-	-	-	7	18	37[a]
11 - 14	790	2	-	-	-	-	-	-	7	16	36[a]
15 -19	816	1	-	-	-	-	-	-	4	9	21[a]

Source of Data: 1994-96 USDA Survey of Food Intakes by Individuals (CSFII)
 - Denotes zero.
a - Sample size was insufficient for minimum reporting requirements according to “Third Report on Nutritional Monitoring in the U.S. (1994-96)”
Source: U.S. EPA (2000)

Table 4-8. Estimate of Direct and Indirect Other Water Ingestion By Broad Age Category for U.S. Children

			Quantity, Percentile (ml/person-day)								
Age (years)	Sample Size	Mean	1th	5th	10th	25th	50th	75th	90th	95th	99th
< 1	359	23	-	-	-	-	-	-	-	148	556[a]
1 - 10	3,980	50	-	-	-	-	-	-	103	405	920
11 - 19	1,641	90	-	-	-	-	-	-	286	666	1,710
			Quantity, Percentile (ml/kg-day)								
< 1	344	3	-	-	-	-	-	-	-	21	66[a]
1 - 10	3,744	2	-	-	-	-	-	-	5	18	43
11 - 19	1,606	2	-	-	-	-	-	-	5	11	29

Source of Data: 1994-96 USDA Survey of Food Intakes by Individuals (CSFII)
 - Denotes zero.
a - Sample size was insufficient for minimum reporting requirements according to “Third Report on Nutritional Monitoring in the U.S. (1994-96).”
Source: U.S. EPA (2000)

Table 4-9. Chi-square GOF statistics for 12 Models, 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

Legend: 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.

Table 4-10. P-Values for Chi-Square GOF Tests of 12 Models, 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

Legend: 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.

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 Modles

Source	N	P01	P05	P10	P25	P50	P75	P90	P95	P99	MEAN	SDEV	CHIDF	PGOF
INFANTS (Age <1)														
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 (Ages 1-10)														
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 (Ages 11-19)														
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

Table 4-12. Total Fluid Intake of Women 15-49 Years Old

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

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

Source: Ershow et al., 1991.

Table 4-13. Total Tapwater Intake of Women 15-49 Years Old

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

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

Source: Ershow et al., 1991.

Table 4-14. Total Fluid (mL/Day) Derived from Various Dietary Sources by Women Aged 15-49 Years[a]

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

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

Table 4-15. Summary of Recommended Community Drinking Water Intake Rates

Age Group/ Population	Mean	Percentiles			Multiple	Fitted Distributions
		50^{th}	90^{th}	95^{th}		
<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[c]
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[c]
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[c]
Pregnant[b] Women	1.2 L/day 18.3 mL/kg-day	1.1 L/day 16 mL/kg-day	2.2 L/day 35 mL/kg-day	2.4 L/day 40 mL/kg-day	Table 3-25	
Lactating[b] Women	1.3 L/day 21.4 mL/kg-day	1.3 L/day 21 mL/kg-day	1.9 L/day 35 mL/kg-day	2.2 L/day 37 mL/kg-day	Table 3-25	

[a]Source: U.S. EPA (2000).
[b]Source: Ershow et al. (1991).
[c]Source: Myers et al. (1999).

Table 4-16. Confidence in Tapwater Intake Recommendations

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	The U.S. EPA (2000) and Ershow and Cantor (1989) studies had thorough expert panel review. Review procedures were not reported in the Canadian study; it was a government report. Other reports presented are published in scientific journals.	High
• Accessibility	The two monographs are available from the sponsoring agencies; the others are library-accessible.	High
• Reproducibility	Methods are well-described.	High
• Focus on factor of interest	The studies are directly relevant to tapwater. In addition, for U.S. EPA (2000) study 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 one week) on recall of intake.	High
• Currency	Data collected for USDA (1998) used by U.S. EPA (2000) are current. The Ershow and Cantor (1989) and Canadian surveys used data from 1978 era.	High
• Adequacy of data collection period	These are one- to three-day intake data. However, long term variability may be small. Their use as a chronic intake measure can be assumed.	Medium
• Validity of approach	The approach was competently executed.	High
• Study size	The two U.S. monographs (U.S. EPA, 2000; Ershow and Cantor, 1989) each sufficiently sample populations (i.e., 6,000 and 11,000, respectively) for their studies	High
• Representativeness of the population	The U.S. EPA (2000), Ershow and Cantor (1989), and Canadian surveys were validated as demographically representative.	High
• Characterization of variability	The full distributions were given in the main studies.	High
• Lack of bias in study design (high rating is desirable)	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 three key studies for the child recommendations.	High for adult and children. Medium for the other recommended subpopulation values.
• Agreement between researchers	This agreement was good.	High
Overall Rating	The data are excellent and current.	**High**

TABLE OF CONTENTS

5. SOIL INGESTION AND PICA 5-1
5.1 INTRODUCTION 5-1
5.2 SOIL INTAKE STUDIES 5-1
5.3 PREVALENCE OF PICA 5-18
5.4 DELIBERATE SOIL INGESTION AMONG CHILDREN 5-19
5.5 RECOMMENDATIONS 5-25
5.6 REFERENCES FOR CHAPTER 5 5-27

LIST OF TABLES

Table 5-1. Estimated Daily Soil Ingestion Based on Aluminum, Silicon, and Titanium Concentrations 5-29
Table 5-2. Calculated Soil Ingestion by Nursery School Children 5-30
Table 5-3. Calculated Soil Ingestion by Hospitalized, Bedridden Children 5-31
Table 5-4. Mean and Standard Deviation Percentage Recovery of Eight Tracer Elements . . 5-31
Table 5-5. Soil and Dust Ingestion Estimates for Children Ages 1-4 Years 5-32
Table 5-6. Average Daily Soil Ingestion Values Based on Aluminum, Silicon, and Titanium as Tracer Elements 5-32
Table 5-7. Geometric Mean (Gm) and Standard Deviation (Gsd) Ltm Values for Children at Daycare Centers and Campgrounds 5-33
Table 5-8. Estimated Geometric Mean Ltm Values of Children Attending Daycare Centers According to Age, Weather Category, and Sampling Period 5-34
Table 5-9. Distribution of Average (Mean) Daily Soil Ingestion Estimates per Child for 64 Children (Mg/day) 5-35
Table 5-10. Estimated Distribution of Individual Mean Daily Soil Ingestion Based on Data for 64 Subjects Projected over 365 Days 5-35
Table 5-11. Estimated Soil Ingestion Rate Summary Statistics And Parameters for Distributions Using Binder et Al. (1986) Data with Actual Fecal Weights 5-36
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) 5-37
Table 5-13. Soil Ingestion Estimates for Median and Best Four Trace Elements Based on Food/Soil Ratios for 64 Anaconda Children (mg/day) Using Al, Si, Ti, Y, and Zr . . . 5-38
Table 5-14. Dust Ingestion Estimates for Median and Best Four Trace Elements Based on Food/Soil Ratios for 64 Anaconda Children (mg/day) Using Al, Si, Ti, Y, and Zr 5-39
Table 5-15. Daily Soil Ingestion Estimation in a Soil-pica Child by Tracer and by Week (mg/day) 5-40
Table 5-16. Ratios of Soil, Dust, and Residual Fecal Samples in the Soil Pica Child 5-41
Table 5-17. Daily variation of Soil Ingestion by Children Displaying Soil Pica in Wong (1988) 5-42
Table 5-18. Prevalence of Non-Food Ingestion Mouthing Behaviors by Child's Age: Percent of Children Whose Parents Reports the Behavior in the Past Month . 5-43
Table 5-19. Average Outdoor Object Mouthing Scores for Children by Age, Frequency of Sand/Dirt Play, and General Mouthing Quartiles 5-46
Table 5-20. Summary of Estimates of Soil Ingestion by Children 5-47
Table 5-21. Summary of Recommended Values for Soil Ingestion 5-47
Table 5-22. Confidence in Soil Intake Recommendation 5-48

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 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 the *Exposure Factors Handbook* 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

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

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

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

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

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

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

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

The average quantity of soil ingested by the school children in this study was as follows: 230 mg/day (range 23 to 979 mg/day) for aluminum; 129 mg/day (range 48 to 362 mg/day) for AIR; and 1,430 mg/day (range 64 to 11,620 mg/day) for titanium (Table 5-2). As in the Binder et al. (1986) study, a fraction of the children (6/19) showed titanium values well above 1,000 mg/day, with most of the remaining children showing substantially lower values. Based on the Limiting Tracer Method (LTM), mean soil intake was estimated to be 105 mg/day with a population standard deviation of 67 mg/day (range 23 to 362 mg/day). Use of the LTM assumed that "the maximum amount of soil ingested corresponded with the lowest estimate from the three tracers" (Clausing et al., 1987). Geometric mean soil intake was estimated to be 90 mg/day. This assumes that the maximum amount of soil ingested cannot be higher than the lowest estimate for the individual tracers.

Mean soil intake for the hospitalized children was estimated to be 56 mg/day based on aluminum (Table 5-3). For titanium, three of the children had estimates well in excess of 1,000 mg/day, with the remaining three children in the range of 28 to 58 mg/day. Using the LTM method, the mean soil ingestion rate was estimated to be 49 mg/day with a population standard deviation of 22 mg/day (range 26 to 84 mg/day). The geometric mean soil intake rate was 45 mg/day. The data on hospitalized children suggest a major nonsoil source of titanium for some children, and may suggest a background nonsoil source of aluminum. However, conditions specific to hospitalization (e.g., medications) were not considered. AIR measurements were not reported for the hospitalized children. Assuming that the tracer-based soil ingestion rates observed in hospitalized children actually represent background tracer intake from dietary and other nonsoil sources, mean soil ingestion by nursery school children was estimated to be 56 mg/day, based on the LTM (i.e., 105 mg/day for nursery school children minus 49 mg/day for hospitalized children) (Clausing et al. 1987).

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

Calabrese et al. (1989) - How Much Soil do Young Children Ingest: An Epidemiologic Study - Calabrese et al. (1989) studied soil ingestion among children using the basic tracer design developed by Binder et al. (1986). However, in contrast to the Binder et al. (1986) study, eight tracer elements (i.e., aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium) were analyzed instead of only three (i.e., aluminum, silicon, and titanium). A total of

64 children between the ages of 1 and 4 years old were included in the study. These children were all selected from the greater Amherst, Massachusetts area and were predominantly from two-parent households where the parents were highly educated. The Calabrese et al. (1989) study was conducted over eight days during a two week period and included the use of a mass-balance methodology in which duplicate samples of food, medicines, vitamins, and others were collected and analyzed on a daily basis, in addition to soil and dust samples collected from the child's home and play area. Fecal and urine samples were also collected and analyzed for tracer elements. Toothpaste, low in tracer content, was provided to all participants.

In order to validate the mass-balance methodology used to estimate soil ingestion rates among children and to determine which tracer elements provided the most reliable data on soil ingestion, known amounts of soil (i.e., 300 mg over three days and 1,500 mg over three days) containing eight tracers were administered to six adult volunteers (i.e., three males and three females). Soil samples and feces samples from these adults and duplicate food samples were analyzed for tracer elements to calculate recovery rates of tracer elements in soil. Based on the adult validation study, Calabrese et al. (1989) confirmed that the tracer methodology could adequately detect tracer elements in feces at levels expected to correspond with soil intake rates in children. Calabrese et al. (1989) also found that aluminum, silicon, and yttrium were the most reliable of the eight tracer elements analyzed. The standard deviation of recovery of these three tracers was the lowest and the percentage of recovery was closest to 100 percent (Calabrese, et al., 1989). The recovery of these three tracers ranged from 120 to 153 percent when 300 mg of soil had been ingested over a three-day period and from 88 to 94 percent when 1,500 mg soil had been ingested over a three-day period (Table 5-4).

Using the three most reliable tracer elements, the mean soil intake rate for children, adjusted to account for the amount of tracer found in food and medicines, was estimated to be 153 mg/day based on aluminum, 154 mg/day based on silicon, and 85 mg/day based on yttrium (Table 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 (i.e., 95th) values were 223 mg/day for aluminum, 276 mg/day for silicon, and 106 mg/day for yttrium. Similar results were observed when soil and dust ingestion was combined (Table 5-5). Intake of soil and dust was estimated using a weighted ingestion for one child in the study ranged from approximately 10 to

14 grams/day during the second week of observation. Average soil ingestion for this child was 5 to 7 mg/day, based on the entire study period.

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

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

$$S_{i.e} \quad \frac{(DW_f + DW_P) \; x \; E_f \quad 2E_u) \quad (DW_{fd} \; x \; E_{fd})}{E_{soil}} \qquad (5\text{-}2)$$

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

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

Van Wïjnen et al. (1990) - Estimated Soil Ingestion by Children - In a study by Van Wïjnen et al. (1990), soil ingestion among Dutch children ranging in age from 1 to 5 years was evaluated using a tracer element methodology similar to that used by Clausing et al. (1987). Van Wïjnen et al. (1990) measured three tracers (i.e., titanium, aluminum, and AIR) in soil and feces and estimated soil ingestion based on the LTM. An average daily feces weight of 15 g dry weight was assumed. A total of 292 children attending daycare centers were sampled during the first of two sampling periods and 187 children were sampled in the second sampling period; 162 of these children were sampled during both periods (i.e., at the beginning and near the end of the summer of 1986). A total of 78 children were sampled at campgrounds, and 15 hospitalized children were sampled. The mean values for these groups were: 162 mg/day for children in daycare centers, 213 mg/day for campers and 93 mg/day for hospitalized children. Van Wïjnen et al. (1990) also reported geometric mean LTM values because soil intake rates were found to be skewed and the log transformed data were approximately normally distributed. Geometric mean LTM values were estimated to be 111 mg/day for children in daycare centers, 174 mg/day for children vacationing at campgrounds (Table 5-7) and 74 mg/day for hospitalized children (70-120 mg/day based on the 95 percent confidence limits of the mean). AIR was the limiting tracer in about 80 percent of the samples. Among children attending daycare centers, soil intake was also found to be higher when the weather was good (i.e., <2 days/week precipitation) than when the weather was bad (i.e., >4 days/week precipitation (Table 5-8). Van Wïjnen et al. (1990) suggest that the mean LTM value for hospitalized infants represents background intake of tracers and should be used to correct the soil intake rates based on LTM values for other sampling groups. Using mean values, corrected soil intake rates were 69 mg/day (162 mg/day minus 93 mg/day) for daycare children and 120 mg/day (213 mg/day minus 93 mg/day) for campers. Corrected geometric mean soil intake was estimated to range from 0 to 90 mg/day with a 90th percentile value of 190 mg/day for the various age categories within the daycare group and 30 to 200 mg/day with a 90th percentile value of 300 mg/day for the various age categories within the camping group.

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

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

Table 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 estimation of ingestion, the mean estimates decreased for Al (153 mg/d to 122 mg/d) and Si (154 mg/d to 139 mg/d), but increased for Ti (218 mg/d to 271 mg/d) and Y (85 mg/d to 165 mg/d). The "overall" mean estimate from this reanalysis was 179 mg/d. Table 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 percent of the children and 208 mg/day or less for 95 percent of the children. The upper percentile values for most of the individual trace elements are somewhat higher. Next, estimates of the respondents soil intake averaged over a period of 365 days were presented based upon the lognormal models fit to the daily ingestion estimates (Table 5-10). The estimated median value of the 64 respondents' daily soil ingestion averaged over a year is 75 mg/day, while the 95th percentile is 1,751 mg/day.

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

In developing the 365 day soil ingestion estimates, data that were obtained over a short period of time (as is the case with all available soil ingestion studies) were extrapolated over a year. The 2-week study period may not reflect variability in tracer element ingestion over a year. While Stanek and Calabrese (1995a) attempt to address this through lognormal modeling of the long term intake, new uncertainties are introduced through the parametric modeling of the limited subject day data. Also, the sample population size of the original study was small and site limited, and, therefore, is not representative of the U.S. population. Study mean estimates of soil ingestion, such as the study mean estimates presented in Table 5-9, are substantially more reliable than any available distributional estimates.

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

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

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

Thompson and Burmaster (1991) - Parametric Distributions for Soil Ingestion by Children - Thompson and Burmaster (1991) developed parameterized distributions of soil ingestion rates for children based on a reanalysis of the key study data collected by Binder et al. (1986). In the original Binder et al. (1986) study, an assumed fecal weight of 15 g/day was used. Thompson and Burmaster reestimated the soil ingestion rates from the Binder et al. (1986) study using the actual stool weights of the study participants instead of the assumed stool weights. Because the actual stool weights averaged only 7.5 g/day, the soil ingestion estimates presented by Thompson and Burmaster (1991) are approximately one-half of those reported by Binder et al. (1986). Table 5-11 presents the distribution of estimated soil ingestion rates calculated by Thompson and Burmaster (1991) based on the three tracers elements (i.e., aluminum, silicon, and titanium), and on the arithmetic average of soil ingestion based on aluminum and silicon. The mean soil intake rates were 97 mg/day for aluminum, 85 mg/day for silicon, and 1,004 mg/day for titanium. The 90th percentile estimates were 197 mg/day for aluminum, 166 mg/day for silicon, and 2,105 mg/day for titanium. Based on the arithmetic average of aluminum and silicon for each child, mean soil intake was estimated to be 91 mg/day and 90th percentile intake was estimated to be 143 mg/day.

Thompson and Burmaster (1991) tested the hypothesis that soil ingestion rates based on the adjusted Binder et al. (1986) data for aluminum, silicon and the average of these two tracers were lognormally distributed. The distribution of soil intake based on titanium was not tested for lognormality because titanium may be present in food in high concentrations and the Binder et al. (1986) study did not correct for food sources of titanium (Thompson and Burmaster, 1991). Although visual inspection of the distributions for aluminum, silicon, and the average of these tracers all indicated that they may be lognormally distributed, statistical tests indicated that only silicon and the average of the silicon and aluminum tracers were lognormally distributed. Soil intake rates based on aluminum were not lognormally distributed. Table 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.

Sedman and Mahmood (1994) - Soil Ingestion by Children and Adults Reconsidered Using the Results of Recent Tracer Studies - Sedman and Mahmood (1994) used the results of two of the key children’s tracer studies (Calabrese et al. 1989; Davis et al. 1990) to determine estimates of average daily soil ingestion in young children and for over a lifetime. In the two studies, the intake and excretion of a variety of tracers were monitored, and concentrations of tracers in soil adjacent to the 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 (i.e., quantity of tracer recovered in the feces in excess of the measured intake) by the average concentration of tracer in soil samples from each child's dwelling. Sedman and Mahmood (1994) adjusted the mean estimates of soil ingestion in children for each 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 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 two year old child was 220 mg/kg for the Calabrese et al. (1989) study and 170 mg/kg for the Davis et al. (1990) study (Sedman and Mahmood, 1994). From the adjusted soil ingestion estimates, based on a normal distribution of means, the mean estimate for a 2-year old child was 195 mg/day and the overall mean of soil ingestion and the standard error of the mean was 53 mg/day (Sedman and Mahmood, 1994). Based on uncertainties associated with the method employed, Sedman and Mahmood (1994) recommended a conservative estimate of soil ingestion in young children of 250 mg/day. Based on the 250 mg/day ingestion rate in a 2-year old child, an average daily soil ingestion over a lifetime was estimated to be 70 mg/day. The lifetime estimates were derived using the equation presented above that describes changes in soil ingestion with age (Sedman and Mahmood, 1994).

Calabrese and Stanek (1995) - Resolving Intertracer Inconsistencies in Soil Ingestion Estimation - Calabrese and Stanek (1995) explored sources and magnitude of positive and negative errors in soil ingestion estimates for children on a subject-week and trace element basis. Calabrese and Stanek (1995) identified possible sources of positive errors to be the following:

- Ingestion of high levels of tracers before the study starts and low ingestion during study period may result in over estimation of soil ingestion; and
- Ingestion of element tracers from a non-food or non-soil source during the study period.

Possible sources of negative bias identified by Calabrese and Stanek (1995) are the following:

- Ingestion of tracers in food, but the tracers are not captured in the fecal sample either due to slow lag time or not having a fecal sample available on the final study day; and
- Sample measurement errors which result in diminished detection of fecal tracers, but not in soil tracer levels.

The authors developed an approach which attempted to reduce the magnitude of error in the individual trace element ingestion estimates. Results from a previous study conducted by Calabrese et al. (1989) were used to quantify these errors based on the following criteria: (1) a lag period of 28 hours was assumed for the passage of tracers ingested in food to the feces (this value was applied to all subject-day estimates); (2) daily soil ingestion rate was estimated for each tracer for each 24-hr day a fecal sample was obtained; (3) the median tracer-based soil ingestion rate for each subject-day was determined. Also, upper and lower bound estimates were determined based on criteria formed using an assumption of the magnitude of the relative standard deviation (RSD) presented in another study conducted by Stanek and Calabrese (1995a). Daily soil ingestion rates for tracers that fell beyond the upper and lower ranges were excluded from subsequent calculations, and the median soil ingestion rates of the remaining tracer elements were considered the best estimate for that particular day. The magnitude of positive or negative error for a specific tracer per day was derived by determining the difference between the value for the tracer and the median value; (4) negative errors due to missing fecal samples at the end of the study period were also determined (Calabrese and Stanek, 1995).

Table 5-12 presents the estimated magnitude of positive and negative error for six tracer elements in the children's study (i.e., conducted by Calabrese et al., 1989). The original mean soil ingestion rates ranged from a low of 21 mg/day based on zirconium to a high of 459 mg/day based on titanium (Table 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 report is valuable in providing additional understanding of the nature of potential errors in trace element specific estimates of soil ingestion. However, the operational definition used for estimating the error in a trace element estimate was the observed difference of that tracer from a median tracer value. Specific identification of sources of error, or direct evidence that individual tracers were indeed in error was not developed. Corrections to individual tracer means were then made according to how different values for that tracer were from the median values. This approach is based on the hypothesis that the median tracer value is the most accurate estimate of soil ingestion, and the validity of this assumption depends on the specific set of tracers used in the study and need not be correct. The approach used for the estimation of daily tracer intake is the same as in Stanek and Calabrese (1995a), and some limitations of that approach are mentioned in the review of that study.

Calabrese et al. (1997) – Soil Ingestion for Children Residing on a Superfund Site - 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 (i.e., aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium) were analyzed. The methodology used in this study is very similar to the one conducted in Calabrese et al. (1989). As in Calabrese et al. (1989), 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, Montana area. Thirty-six of the 64 children were male, and the children ranged in age from 1 to 3 years with approximately an equal number of children in each age group. The Calabrese et al. (1997) study was conducted for seven consecutive days during a two week period in the month of September. Duplicate samples of meals, beverages, and over-the-counter medicines and vitamins were collected over the seven day period, along with fecal samples. In addition, soil and dust samples were collected from the children's home 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 ten 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 the eight tracer elements (Al, Si, Ti, Ce, La, Nd, Y, and Zr). It was found that ingestion of soil from 20 to 500 mg/day could be detected in a reliable manner.

Calabrese et al. (1997) estimated soil ingestion by each tracer element using the Best Tracer Method (BTM) which allows for the selection of the most recoverable tracer for a particular group of subjects (Stanek and Calabrese, 1995b). In this case BA, Mn, and V were dropped as they were found to be poor performing tracers. The median soil ingestion estimates for the four best trace elements based on Food/Soil ratios for the 64 children using Al, Si, Ti, Y, and Zr were presented (Table 5-13). 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 280 mg/day. Using the median of the 4 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 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 this knowledge might have resulted in reduced exposure. 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 Al, Si, Ti, Y, and Zr were also presented (Table 5-14). The mean dust ingestion rate based on the best tracer was 130 mg/day and the 95th percentile rate was 614 mg/day.

The advantages of this study were the use of a longer 7 consecutive day study period rather than two periods of 3 and 4 days (Stanek and Calabrese, 1995a), the use of the BTM, the use of an expanded adult validation study which used 10 volunteers rather than 6 (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. Calabrese et al. (1997) believe that this error is not likely to affect the median by more than 40 mg/day.

5.3 PREVALENCE OF PICA

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

It should be noted that the pica statistics cited above apply to the incidence of general pica and not soil pica. Information on the incidence of soil pica is limited, but it appears that soil pica is less common. A study by Vermeer and Frate (1979) showed that the incidence of geophagia (i.e., earth-eating) was about 16 percent among children from a rural black community in Mississippi. However, geophagia was described as a cultural practice among the community surveyed and may not be representative of the general population. Average daily consumption of soil was estimated to be 50 g/day. Bruhn and Pangborn (1971) reported the incidence of pica for "dirt" to be 19 percent in children, 14 percent in pregnant women, and 3 percent in nonpregnant women. However, "dirt" was not clearly defined. The Bruhn and Pangborn (1971) study was conducted among 91 non-black, low income families of migrant agricultural workers in California. Based on the data from the five key tracer studies (Binder et al., 1986; Clausing et al., 1987; Van 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 the user to use the appropriate value for their specific study population.

5.4 DELIBERATE SOIL INGESTION AMONG CHILDREN

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

Calabrese et al. (1991) - Evidence of Soil Pica Behavior and Quantification of Soil Ingestion - Calabrese et al. (1991) estimated that upper range soil ingestion values may range from approximately 5-7 grams/day. This estimate was based on observations of one pica child among the 64 children who participated in the study. In the study, a 3.5-year old female exhibited extremely high soil ingestion behavior during one of the two weeks of observation. Intake ranged from 74 mg/day to 2.2 g/day during the first week of observation and 10.1 to 13.6 g/day during the second week of observation (Table 5-15). These results are based on mass-balance analyses for seven (i.e., aluminum, barium, manganese, silicon, titanium, vanadium, and yttrium) of the eight tracer elements used. Intake rates based on zirconium was significantly lower but Calabrese et al. (1991) indicated that this may have "resulted from a limitation in the analytical protocol."

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

Table 5-16 presents tracer ratios of soil, dust, and residual fecal samples in the soil pica child. Calabrese and Stanek (1992) reported that there was a maximum total of 28 pairs of tracer ratios based on eight tracers. However, only 19 pairs of tracer ratios were available for quantitative evaluation as shown in Table 5-16. Of these 19 pairs, 9 fecal tracer ratios fell within the boundaries for soil and dust (Table 5-16). For these 9 tracer soils, an interpolation was performed to estimate the relative contribution of soil and dust to the residual fecal tracer ratio. The other 10 fecal tracer ratios that fell outside the soil and dust boundaries were concluded to be 100 percent of the fecal tracer ratios from soil origin (Calabrese and Stanek, 1992). Also, the

9 residual fecal samples within the boundaries revealed that a high percentage (71-99 percent) of the residual fecal tracers were estimated to be of soil origin. Therefore, Calabrese and Stanek (1992) concluded that the predominant proportion of the fecal tracers was from outdoor soil and not from indoor dust origin.

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

Calabrese, E. J. and E. J. Stanek (1993) - Soil Pica: Not a Rare Event - Calabrese and Stanek critiqued a study by Wong (1988) that attempted to estimate the amount of soil ingested by two groups of children. Wong (1988) studied a total of 52 children who were in two separate government institutions in Jamaica. The children had an average age of 3.1 years (ranging from 0.3 to 7.6 years) and 7.2 years (ranging from 1.8 to 14 years). The younger group (from the Glenhope Place of Safety) contained 24 children and the older group (from the Reddies Place of Safety) had 28 children. Fecal samples were obtained from the subject children and the amount of silicon, a soil tracer, in dry feces was measured in order to quantify soil ingestion.

Using a hospital control group of 30 children with an average age of 4.8 years (ranging from 0.3 to 12 years), the authors of the study collected an unspecified number of daily fecal samples. Based on these samples, dry feces were observed as containing 1.45 percent silicon or 14.5 mg of silicon per 1 g of dry feces. The authors assumed that this amount of silicon in dry feces was representative of the typical background amount of silicon from dietary sources only. Observed quantities of silicon greater than 1.45 percent were then assumed to be from soil ingestion.

Wong (1988) calculated the amount of soil ingested by using the standard soil ingestion estimation formula (Binder et al. 1986). One fecal sample was collected from each subject per month over the four month study period.

For the 28 children in the older group (average age 7.2 years), soil ingestion was estimated to be 58 mg/day based on the mean minus one outlier and 1,520 mg/day based on the mean of all the children. The group contained one outlier, a child with an estimated average soil ingestion rate of 41 g/day over the four months. Some of the observed soil ingestion results for this group of children included:

- 7 of 28 had average soil ingestion of >100 mg/day,
- 4 of 28 had average soil ingestion of >200 mg/day,
- 1 of 28 had average soil ingestion of >300 mg/day, and
- 8 of 28 showed no indication of soil ingestion for any month.

Estimated average soil ingestion in the younger group of children (average age 3.1 years) 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 four months. Observed soil ingestion estimates for this group included:

- 14 of 24 had average soil ingestion of <100 mg/day,
- 10 of 24 had average soil ingestion of >100 mg/day,
- 5 of 24 had average soil ingestion of >600 mg/day,
- 4 of 24 had average soil ingestion of >1,000 mg/day, and
- 5 of 24 showed no indication of soil ingestion for any month.

Over the entire 4 month study duration, 9 of 84 total samples (or 10.5%) showed soil ingestion estimates of >1 g/day (pica behavior). Of the 52 children studied by Wong (1988), six children 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 (Glenhope Place of Safety), 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 6 children exhibiting pica behavior. As shown in Table 5-17, 3 of 6 children (#11, 12, and 22) showed soil pica on only 1 of 4 days. The other 3 children (#14, 18, and 27) ingested ≥1.0 g/d on 2 of 4, on 3 of 4, and 4 of 4 days, respectively. Subject #27 displayed a high degree of soil pica, ranging from 3.7 to 60.6 g/d of soil ingestion; however, it was indicated that this child was mentally retarded while the other pica children were considered to have normal mental capabilities.

Sources of uncertainty or error in this study include differences between the hospital (i.e., control) study group (the background control) and the 2 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 since 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, given these uncertainties, the results are important in that they indicate that soil pica is not a rare occurrence in younger children.

Stanek et al. (1998) - Prevalence of Soil Mouthing/Ingestion among Healthy Children Aged 1 to 6 - Stanek et al. (1998) presented a methodology that links mouthing behavior among children to the prevalence of ingestion of non-food 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 old attending 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. Stanek et al. (1998) questioned the participants 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. Stanek et al. (1998) 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 step-wise manner identified factors related to high outdoor mouthing rates. Stanek et al. (1998) first considered variables that indicated opportunity for exposure, then subjects' characteristics (e.g., teething) and environmental factors, and finally, concurrent reported behaviors.

Table 5-18 presents the prevalence of non-ingestion/mouthing behaviors by child's age as the percent of children whose parents reported the behavior in the past month. Stanek et al. (1998) found that outdoor soil mouthing behavior prevalence was 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. Stanek et al. (1998) conducted principal component analyses on response to four questions relating to ingestion of outdoor objects (Table 5-18) 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. Stanek et al. (1998) found outdoor ingestion/mouthing rates for children 1 years of age to be 4.73 per week and 0.44 per week for children 2-6 years of age. Stanek et al. (1998) estimated the frequency of children playing in sand/dirt as a measure of potential exposure, and found that 71 percent of the children were reported to play in sand or dirt at least weekly, and 45 percent were reported as playing in the sand or dirt daily. The authors found that children who played in the sand or dirt had 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. Stanek et al. (1998) found similar results when comparing the time spent outdoors to reported outdoor ingestion and mouthing rates. Sixty-five percent of one-year old children were reported to spend less than 3 hour per day outdoors, while 42 percent of children 2-6 years old spend less than 3 hours per day outdoors.

Table 5-19 presents average outdoor mouthing rates by age and sand/dirt play frequency. Stanek et al. (1998) presented the data for children by quartiles according to their general mouthing rates and applied linear regression models fit to general mouthing rates. The authors 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 of this study might have important health implications as it showed that one-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 data were only available for the healthy children who were present for well-visits.

5.5 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 5-20 and the recommended values are presented in Table 5-21. The mean values ranged 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, since 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 1,432 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, since 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.

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, while 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 5-22. It is important, however, to understand the various uncertainties associated with these values. First, individuals were not studied for sufficient periods of time to get a good estimate of the usual intake. Therefore, the values presented in this section may not be representative of long term exposures. Second, the experimental error in measuring soil ingestion values for individual children is also a source of uncertainty. For example, incomplete sample collection of both input (i.e., food and nonfood sources) and output (i.e., urine and feces) is a limitation for some of the studies conducted. In addition, an individual's soil ingestion value may be artificially high or low depending on the extent to which a mismatch between input and output occurs due to individual variation in the gastrointestinal transit time. Third, the degree to which the tracer elements used in these studies are absorbed in the human body is uncertain. Accuracy of the soil ingestion estimates depends on how good this assumption is. Fourth, there is uncertainty with regard to the homogeneity of soil samples and the accuracy of parent's knowledge about their child's playing areas. Fifth, all the soil ingestion studies presented in this section with the exception of Calabrese et al. (1989) were conducted during the summer when soil contact is more likely.

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

5.6 REFERENCES FOR CHAPTER 5

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

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

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

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

Calabrese, E.J.; Stanek, E.J. (1993) Soil pica: not a rare event. J. Environ. Sci. Health. A28(2):373-384.

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

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

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

Calabrese, E.J.; Stanek, E.J.; Pekow, P.; Barnes, R.M. (1997) Soil ingestion estimates for children residing on a Superfund site. Ecotoxicology and Environmental Safety. 36:258-268.

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

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

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

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

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

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

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

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

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

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

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

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

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

Stanek, E.J.; Calabrese, E.J.; Mundt, K.; Pekow, P.; Yeatts, K.B. (1998) Prevalence of soil mouthing/ingestion among healthy children aged 1 to 6. Journal of Soil Contamination. 7(2):227-242.

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

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

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

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

Wong, M.S. (1988) The Role of Environmental and Host Behavioural Factors in Determining Exposure to Infection with Ascaris lumbricoldes and Trichuris trichlura. Ph.D. Thesis, Faculty of Natural Sciences, University of the West Indies. 1988.

Table 5-1. Estimated Daily Soil Ingestion Based on Aluminum, Silicon, and Titanium Concentrations

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

Source: Binder et al. (1986).

Table 5-2. Calculated Soil Ingestion by Nursery School Children

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

Source: Adapted from Clausing et al. (1987).

Table 5-3. Calculated Soil Ingestion by Hospitalized, Bedridden Children

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

Source: Adapted from Clausing et al. (1987).

Table 5-4. Mean and Standard Deviation Percentage Recovery of Eight Tracer Elements

	300 mg Soil Ingested		1,500 mg Soil Ingested	
Tracer Element	Mean	SD	Mean	SD
Al	152.8	107.5	93.5	15.5
Ba	2304.3	4533.0	149.8	69.5
Mn	1177.2	1341.0	248.3	183.6
Si	139.3	149.6	91.8	16.6
Ti	251.5	316.0	286.3	380.0
V	345.0	247.0	147.6	66.8
Y	120.5	42.4	87.5	12.6
Zr	80.6	43.7	54.6	33.4

Source: Adapted from Calabrese et al. (1989).

Table 5-5. Soil and Dust Ingestion Estimates for Children Ages 1-4 Years

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

[a]Corrected for Tracer Concentrations in Foods

Source: Adapted from Calabrese et al. (1989).

Table 5-6. Average Daily Soil Ingestion Values Based on Aluminum, Silicon, and Titanium as Tracer Elements[a]

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

[a]Excludes three children who did not provide any samples (N=101).
[b]Negative values occurred as a result of correction for nonsoil sources of the tracer elements.

Source: Adapted from Davis et al. (1990).

Table 5-7. Geometric Mean (Gm) and Standard Deviation (Gsd) Ltm Values for Children at Daycare Centers and Campgrounds

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

[a]Age and/or sex not registered for eight children.
[b]Age not registered for seven children.

Source: Adapted from Van Wijnen et al. (1990).

Table 5-8. Estimated Geometric Mean Ltm Values of Children Attending Daycare Centers According to Age, Weather Category, and Sampling Period

Weather Category	Age (years)	First Sampling Period n	First Sampling Period Estimated Geometric Mean LTM Value (mg/day)	Second Sampling Period n	Second Sampling Period Estimated Geometric Mean LTM Value (mg/day)
Bad (>4 days/week 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/week precipitation)	<1			1	61
	1-<2			10	96
	2-<3			13	99
	3-<4			19	94
	4-<5			1	61
Good (<2 days/week 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. Distribution of Average (Mean) Daily Soil Ingestion Estimates per Child for 64 Children[a] (Mg/day)

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

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

Source: Stanek and Calabrese (1995a).

Table 5-10. Estimated Distribution of Individual Mean Daily Soil Ingestion Based on Data for 64 Subjects Projected over 365 Days[a]

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

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

Source: Stanek and Calabrese (1995a).

Table 5-11. Estimated Soil Ingestion Rate Summary Statistics
And Parameters for Distributions Using Binder et Al. (1986)
Data with Actual Fecal Weights

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

[a] MEAN = arithmetic average of soil ingestion based on aluminum and silicon.

Source: Thompson and Burmaster (1991).

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]

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

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

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

Source: Calabrese and Stanek (1995).

Table 5-13. Soil Ingestion Estimates for Median and Best Four Trace Elements Based on Food/Soil Ratios for 64 Anaconda Children (mg/day) Using Al, Si, Ti, Y, and Zr

	Min	P5	P10	SP25	P50	SP75	P90	P95	Max	Mean	SD
Median of best 4	-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
2nd best	-115.9	-62.1	-48.6	-26.6	1.5	38.4	119.5	262.3	928.5	33.2	144.8
3rd best	-170.5	-88.9	-67.0	-52.0	-18.8	25.6	154.7	376.1	1293.5	31.2	199.6
4th 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 Median and Best Four Trace Elements Based on Food/Soil Ratios for 64 Anaconda Children (mg/day) Using Al, Si, Ti, Y, and Zr

	Min	P5	P10	SP25	P50	SP75	P90	P95	Max	Mean	SD
Median of best 4	-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
2nd best	-239.8	-147.2	-137.1	-59.1	7.6	153.1	356.4	409.5	1685.1	82.7	283.6
3rd best	-375.7	-247.5	-203.1	-81.7	-14.4	49.4	406.5	500.5	913.2	25.5	235.9
4th 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 (mg/day)

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

Source: Calabrese et al. (1991).

Table 5-16. Ratios of Soil, Dust, and Residual Fecal Samples in the Soil Pica Child

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

Source: Calabrese and Stanek (1992).

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		
Number 11	1	55
	2	1,447
	3	22
	4	40
Number 12	1	0
	2	0
	3	7,924
	4	192
Number 14	1	1,016
	2	464
	3	2,690
	4	898
Number 18	1	30
	2	10,343
	3	4,222
	4	1,404
Number 22	1	0
	2	--
	3	5,341
	4	0
Reddles Place of Study		
Number 27	1	48,314
	2	60,692
	3	51,422
	4	3,782

Source: Calabrese and Stanek (1993).

Table 5-18. Prevalence of Non-Food Ingestion/Mouthing Behaviors by Child's Age: Percent of Children Whose Parents Reports the Behavior in the Past Month

		Child's Age (years)						
Non-Food Ingestion/mouthing prevalence		1	2	3	4	5	6	All
	N	171	70	93	82	90	22	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
	% Daily	44	6	6	0	0	9	17

Table 5-18. Prevalence of Non-Food Ingestion/Mouthing Behaviors by Child's Age: Percent of Children Whose Parents Reports the Behavior in the Past Month (continued)

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
	% Daily	1	1	1	0	2	0	1

Table 5-18. Prevalence of Non-Food Ingestion/Mouthing Behaviors by Child's Age: Percent of Children Whose Parents Reports the Behavior in the Past Month (continued)

"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
Suck hair	% > Monthly	62	76	85	96	88	73	78
	% > Weekly	57	64	77	88	81	68	71
	% Daily	42	39	43	55	52	45	45

Source: Stanek et al. (1998).

Table 5-19. Average Outdoor Object Mouthing Scores for Children by Age, Frequency of Sand/Dirt Play, and General Mouthing Quartiles

	1 Year old Sand/dirt play?				Age 2 to 6 years Sand/dirt play?			
	>Daily		Daily		>Daily		Daily	
Outdoor object mouthing scores	Mean	N	Mean	N	Mean	N	Mean	N
General mouthing Score quartiles (Mean)								
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	23	0.5	2	1.5	4
Slope based on general mouthing quartile score	0.11		0.34		0.007		0.054	
SE	0.052		0.060		0.021		0.019	

Source: Stanek et al. (1998).

Table 5-20. Summary of Estimates of Soil Ingestion by Children

Mean (mg/day)					Upper Percentile (mg/day)				References
Al	Si	AIR[a]	Ti	Y	Al	Si	Ti	Y	
181	184				584	578			Binder et al. 1986
230		129							Clausing et al. 1987
39	82		245.5						Davis et al. 1990
64.5[b]	160[b]		268.4[b]						
153	154		218	85	223	276	1,432	106	Calabrese et al. 1989
154[b]	483[b]		170[b]	65[b]	478[b]	653[b]	1,059[b]	159[b]	
122	139	–	271	165	254	224	279	144	Stanek and Calabrese, 1995a
133[c]					217[c]				Stanek and Calabrese, 1995b
69-120[d]									Van Wïjnen et al. 1990
66[c]					280[c]				Calabrese et al. 1997
196[b]					994[b]				
Average = 138 mg/day soil					358 mg/day soil				
193 mg/day soil and dust combined					790 mg/day soil and dust combined				

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

Table 5-21. Summary of Recommended Values for Soil Ingestion

Population	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 5-22. Confidence in Soil Intake Recommendation

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	All key studies are from peer review literature.	High
• Accessibility	Papers are widely available from peer review journals.	High
• Reproducibility	Methodology used was presented, but results are difficult to reproduce.	Medium
• Focus on factor of interest	The focus of the studies was on estimating soil intake rate by children; studies did not focus on intake rate by adults.	High (for children) Low (for adults)
• Data pertinent to U.S.	Two of the key studies focused on Dutch children; other studies used children from specific areas of the U.S.	Medium
• Primary data	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 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, socio-economics, and geographical location; Studies focused on specific areas; two of the studies used Dutch children.	Low
• Characterization of variability	Day-to-day variability was not very well characterized.	Low
• Lack of bias in study design (high rating is desirable)	The selection of the population studied may introduce some bias in the results (i.e., children near a smelter site, volunteers in nursery school, Dutch children).	Medium
• Measurement error	Errors may result due to problems with absorption of the tracers in the body and mismatching inputs and outputs.	Medium
Other Elements		
• Number of studies	There are 7 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)

TABLE OF CONTENTS

6. OTHER NON-DIETARY INGESTION FACTORS 6-1
6.1 INTRODUCTION 6-1
6.2 STUDIES RELATED TO NON-DIETARY INGESTION 6-2
6.3 RECOMMENDATIONS 6-9
6.4 REFERENCES FOR CHAPTER 6 6-11

LIST OF TABLES

Table 6-1. Extrapolated Total Mouthing Times Minutes per Day (time awake) 6-12
Table 6-2. Frequency of Contact, by Contact Variable Contacts per Hour 6-13
Table 6-3. Summary of Studies on Mouthing Behavior 6-14
Table 6-4. Summary of Mouthing Frequency Data 6-15
Table 6-5. Confidence in Mouthing Behavior Recommendations 6-16

6. OTHER NON-DIETARY INGESTION FACTORS

6.1 INTRODUCTION

Young children (i.e., ages 6 months through approximately 4 years) also have the potential for exposure to toxic substances through non-dietary 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). This route of exposure may exceed other routes ingestion (i.e., food, pica, drinking water, breast milk) and dermal exposure because non-dietary ingestion may result in higher ingestion rates of contaminated material (Weaver et al., 1998). This exposure route is also a difficult route to model because there is little literature or research that has been performed on mouthing behavior (Reed et al., 1998) 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). This exposure route becomes difficult to model because contact with surfaces is intermittent and nonuniform over different parts of the body. The intermittent and nonuniform nature of the mouthing itself also makes 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, children 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 comforting a child when they are tired or upset. In addition, teething normally causes substantial mouthing behavior, sucking or chewing, to alleviate discomfort in their gums. Each child is different, and large differences occur between children, even within the same family.

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

Gurunathan et al. (1998) estimate that young children spend as much as 90 percent of their days inside, so exposure to contaminants that may infiltrate the home (i.e., volatile and semi-volatile organic constituents [VOCs and SVOCs]) through the vapor phase 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 in stuffed animals where they can serve as reservoirs for toxic constituents (Gurunathan et al., 1998).

There have been few studies investigating 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 (U.S. EPA, 1999). 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; or, videotaping in which trained videographers tape a child's activities and subsequently extract the pertinent data manually or with computer software (U.S. EPA, 1999).

Some researchers express mouthing behavior in terms of frequency of occurrence (e.g., contacts/hour, contacts/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 (Hubal, 2000). Time spent in various macroactivities in several microenvironments (e.g., indoors at home) are presented in Chapter 9).

6.2 STUDIES RELATED TO NON-DIETARY INGESTION

Groot et al. (1998) - Mouthing Behavior of Young Children - 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 if PVC toys softened with phthalates could pose health risks to children from mouthing. As part of the effort, Groot et al. (1998) asked parents to observe their children and gather information which 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 ten times per day for 15-minute intervals (i.e., 150 minutes total per day) for two 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 Groot et al. (1998) effort. 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 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 children were estimated to mouth 37 minutes per day and the 6- to 12-month children 44 minutes per day. After 12 months, the estimated mouthing time drops quickly to 16 minutes per day for 12- to 18-month children and 9 minutes per day for 18- to 36-month 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. Groot et al. (1998) acknowledge this shortcoming and recommend further study using a larger sample population. In addition, the study also incorporated mostly higher-educated persons. The area where the study was performed consisted primarily of parents with higher education. The study had recruited persons of lower education and socioeconomic levels, but these persons chose not to participate in the study after recruitment (Groot et al., 1998). 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 did not differentiate the types of objects mouthed. In addition, children were observed for a period of two consecutive days and may not reflect long-term behavior. The study may not be representative of the U.S. population.

Reed et al. (1999) - Quantification of Children's Hand and Mouthing Activities through a Videotaping Methodology - 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) (Reed et al., 1999). 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 their children. In addition, the study also differentiated between the usage of right and left hands.

Over the course of the research, Reed et al. (1999) found that the behavior of children was similar between the day and residential settings except for the contact rate of hand to smooth surfaces. Children in residential settings had higher contact rates with smooth surfaces than children in day care centers. The results of the study are compiled in Table 6-2. The highest contacts were with object (123 contacts/hr), smooth surfaces (84 contacts/hr), and other (83 contacts/hr). The two lowest contact rates were the hand-to-mouth (9.5 contacts/hr) and object-to-mouth (16.3 contacts/hr) (Reed et al., 1999). 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). Reed et al. (1999) 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 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 (Reed et al., 1999). The preference ratio for the right hand over the left hand for this category was 6.8 to 1 (Reed et al., 1999).

The advantages of the Reed et al. (1999) 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, plastic toys, and into the polyurethane foam (PUF) 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 of the study and the lack of comment as to the representativeness of the sample population to the U.S. population. Reed et al. (1999) acknowledge the weakness in regard to the sample size and recommend further work with a larger population. The study makes no mention of the representativeness of the sample population or addresses the need for a representative population for any additional study.

Zartarian et al. (1997) - Quantified Dermal Activity Data from a Four-Child Pilot Field Study - 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 (Zartarian et al., 1997). As such, the research was not specifically intended to gather data for non-dietary ingestion; however, the activities used to evaluate the use of videotaping provide data were for dermal and non-dietary exposure.

Four Mexican-American farm worker children 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 (Zartarian et al., 1997). Two girls and two boys were the subject of the videotaping. The videotaping gathered information on detailed micro-activity patterns of children to be used to evaluate software for videotaped activities and translation training methods (Zartarian et al., 1997). The data were also reported by type of object/surface and by hand (i.e., left or right).

Zartarian et al. (1997) present 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 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 Zartarian et al. (1997) estimated the average as 9 contacts/hr. As was reported by Reed et al. (1999), the most frequently contacted objects were toys and hard (i.e., smooth) surfaces (Zartarian et al., 1997). Zartarian et al. (1997) report that the average contact time with objects is only 2 to 3 seconds and that questionnaires and diaries, therefore, would be insufficient in gathering that level of activity.

The Zartarian et al. (1997) 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 the methodology of collecting observations, not the contact data itself. So 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 because the sample population consists of only four Mexican-American farm worker children.

Davis (1995), Soil Ingestion in Children with Pica (Final Report), EPA Cooperative Agreement CR 816334-01 - In 1992, the Fred Hutchinson Cancer Research Center under Cooperative Agreement with EPA conducted a study to estimate 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 five 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 four months of 1992 and included 92 children from the Tri-Cities area in Washington State. These 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 period of 7 days.

Since 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. These included: 1) tongue contacts object; 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 repulsed by object in mouth - tries to get it out; 3) other person stops child's contact with object; and 4) child out of sight or view. In addition to further characterize potential exposures to soil associated with the three types of mouthing behaviors, six object categories were included to be used along with the three mouthing behaviors. These were: 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, Davis (1995) collected information about how long the child spent indoors and outdoors each day, and the general types of outdoor settings in which the child played.

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, while 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 this is based on one 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 one hour on each of the four days. If this were true, each child would have a total of 960 intervals of observations (i.e., 3,600 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 one 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 are awake during the day. According to Davis (1995) small children are awake approximately 8.9 hours per day for ages 0 to 48 months. Based upon this estimate, the Davis (1995) findings translate into about 55 minutes per day of mouthing activity and 6 minutes per 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 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/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 if 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: male/female <24 months and male/female > 24 months. Children <24 months exhibited the highest frequency of mouthing behavior with 76 ± 5 contacts/hr (n= 30 subjects; 106 observations). On the other hand, children > 24 months exhibited a lower frequency of mouthing behavior with 38 ± 3 contacts/hr (n= 56 subjects; 192 observations). These results suggest that as children grow older, they are less likely to place objects into their mouths.

The Davis (1995) work has both strengths and weaknesses. The strengths of this work are that it incorporates more children (e.g., 92) in the sample population than any of the other literature reviewed. In addition, the research is very detailed in defining the parameters and variables associated with mouthing behavior. The research also gathered information over four days whereas most of the literature involved only one or two 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.

6.3 RECOMMENDATIONS

Due to the paucity of the available research data, it is difficult to recommend with any degree of certainty estimates for non-dietary ingestion. Table 6-3 summarizes the studies on mouthing behavior that were described in this chapter. Table 6-4 summarizes the results of these studies. As mentioned earlier, the studies presented use different units of 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 study thus far that presents data for infants. These data, as well as 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. Reed et al. (1999) and Zartarian (1997) both studied hand-to-mouth behavior. Although there are uncertainties with the results of these two studies due to sample size, they are fairly consistent in their results. Based on these two studies, a value of 9 contacts/hour seems to be a reasonable estimate of hand-to-mouth behavior. Reed et al. (1999)

also studied object-to-mouth frequency. Based on the Reed et al. (1999) and the analysis of the Davis (1995) data, total mouthing behavior, including hand-to-mouth as well as objects, ranged from 26 contacts/hour (i.e., 9.5 (hand-to-mouth)+ 16.3 (object-to-mouth)) to 76 contacts/hour with a weighted average of 45 contacts/hour.

The frequency of contact of finger-to-mouth (9.5 contacts/hr) greatly exceeds the 1.56 contacts/hr for fingers to mouth suggested by the U.S. EPA (1997) in their guidance for calculating exposure to pesticides. The estimate of 9.5 contacts/hr is close to the 9 contacts/hr estimated by Zartarian et al. (1997) for a study conducted using video taping as reported by Reed et al. (1999). The agreement of the two studies suggests that the U.S. EPA (1997) value of 1.56 contacts/hr may significantly underestimate the non-dietary exposure route. Table 6-5 presents the confidence ratings for the recommended values.

6.4 REFERENCES FOR CHAPTER 6

Davis (1995). Soil Ingestion in Children with Pica (Final Report), EPA Cooperative Agreement CR 816334-01

Groot M., Lekkerkerk M., Steenbekkers L. (1998) Mouthing behavior of young children - an observational study. H&C onderzoeksraport 3.

Gurunathan S., Robson M., Freeman N., Buckley B., Roy A., Meyer R., Bukowski J., and Lioy P. (1998) Accumulation of chloropyrifos on residential surfaces and toys accessible to children. Environ. Health Pers. 106(1):9-16.

Hubal, E.A.; Sheldon, L.S.; Burke, J.M.; McCurdy, T.R.; Berry, M.R.; Rigas, M.L.; Zartarian, V.G. (2000) Children's exposure assessment: A review of factors influencing children's exposure, and the data available to characterize and assess that exposure. Prepared by U.S. Environmental Protection Agency, National Exposure Research Laboratory, RTP, NC.

Reed K., Jimenez M., Freeman N., and Lioy P. (1999) Quantification of children's hand and mouthing activities through a videotaping methodology. JEAEE. 9:513-520.

U.S. EPA (1997) Standard operating procedures (SOPs) for residential exposure assessment. Washington, DC: Office of Pesticide Programs.

U.S. EPA, National Exposure Research Laboratory. (1999) Children's exposure assessment: A review of factors influencing children's exposure, and the data available to characterize and assess that exposure.

Weaver V., Buckley T., and Groopman J. (1998) Approaches to environmental exposure assessment in children. Environ. Health Pers. 106(3):827-831

Zartarian V., Ferguson A., and Leckie J. (1997) Quantified dermal activity data from a four-child pilot field study. JEAEE 7(4):543-553.

Table 6-1. Extrapolated Total Mouthing Times Minutes per Day (time awake)

Age (months)	No. Children	Mean	Standard Dev.	Minimum	Maximum
3 - 6	5	36.9	19.1	14.5	67
6 - 12	14	44	44.7	2.4	171.5
12 - 18	12	16.4	18.2	0	53.2
18 - 36	11	9.3	9.8	0	30.9

Note: The object most mouthed in all age groups in the fingers except for the 6 - 12 month group which mostly mouthed on toys.

Source: Groot et al. (1998)

Table 6-2. Frequency of Contact, by Contact Variable Contacts per Hour

Variable	Mean	Median	Minimum	Maximum	90th Percentile
Clothing	66.6	65	22.8	129.2	103.3
Dirt	11.4	0.3	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	175.8
Object to mouth	16.3	3.6	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. Summary of Studies on Mouthing Behavior

Study	Population Size	Population Studies
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 1997	4	2.5-4.2 years children of farm workers
Davis 1995	92	10-60 months Washington State

Table 6-4. Summary of Mouthing Frequency Data

Age (months)	Mouthing Frequency/Time	Population Size	Reference
3-6	1 min/day	5	Groot et al. 1998
6-12	44 min/day	14	
12-18	16 min/day	12	
18-36	9 min/day	11	
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	55 min/day	92	EPA analysis of Davis 1995
<24	76 ±5 contacts/hr	30	
>24	38 ±3 contacts/hr	56	

Table 6-5. Confidence in Mouthing Behavior Recommendations

Considerations	Rationale	Rating
Study Elements		
Peer Review	Three of the studies are from peer review journals, one from a contractor's report to EPA	Medium
Accessibility	Studies in journals have wide circulation. Contractor's report only available 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 David et al. 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 is 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 size, variability in the population cannot be assessed. Variation in behavior due to seasons cannot be evaluated. Measuring children's behavior is difficult.	**Low/Medium**

TABLE OF CONTENTS

7. INHALATION ROUTE 7-1
7.1 INTRODUCTION 7-1
7.2 INHALATION RATE STUDIES 7-1

7.3 RECOMMENDATIONS 7-7
7.4 REFERENCES FOR CHAPTER 7 7-9
APPENDIX 7A VENTILATION DATA 7A-1

LIST OF TABLES

Table 7-1. Calibration And Field Protocols For Self-monitoring of Activities Grouped by Subject Panels 7-10
Table 7-2. Subject Panel Inhalation Rates by Mean VR, Upper Percentiles, And Self-estimated Breathing Rates 7-10
Table 7-3. Distribution of Predicted Intake Rates by Location And Activity Levels For Elementary And High School Students 7-11
Table 7-4. Average Hours Spent Per Day in a Given Location and Activity Level For Elementary (EL) and High School (HS) Students 7-11
Table 7-5. Distribution Patterns of Daily Inhalation Rates For Elementary (EL) And High School (HS) Students Grouped by Activity Level 7-12
Table 7-6. Summary of Average Inhalation Rates (M^3/hr) by Age Group And Activity Levels For Laboratory Protocols 7-13
Table 7-7. Summary of Average Inhalation Rates (M^3/hr) by Age Group And Activity Levels in Field Protocols 7-14
Table 7-8. Comparisons of Estimated Basal Metabolic Rates (BMR) With Average Food-energy Intakes For Individuals Sampled in The 1977-78 NFCS 7-15
Table 7-9. Daily Inhalation Rates Calculated From Food-energy Intakes 7-16
Table 7-10. Daily Inhalation Rates Obtained From The Ratios Of Total Energy Expenditure to Basal Metabolic Rate (BMR) 7-17
Table 7-11. Inhalation Rates For Short-term Exposures 7-18
Table 7-12. Confidence in Inhalation Rate Recommendations 7-19
Table 7-13. Summary of Recommended Values For Inhalation 7-20
Table 7-14. Summary of Children's Inhalation Rates For Short-Term Exposure Studies 7-21

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 adults. Infants and young children have a higher resting metabolic rate and rate of oxygen consumption per unit body weight than 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 one week and one 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 1996). Thus, 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

Linn et al. (1992) - Documentation of Activity Patterns in "High-Risk" Groups Exposed to Ozone in the Los Angeles Area - Linn et al. (1992) conducted a study that estimated the inhalation rates for "high-risk" subpopulation groups exposed to ozone (O_3) in their daily activities in the Los Angeles area. The population surveyed consisted of several panels of both adults and children. The panels consisting of children included: *Panel 2*: 17 healthy elementary school students (5 males, 12 females, ages 10-12 years); *Panel 3*: 19 healthy high school students (7 males, 12 females, ages 13-17 years); *Panel 6*: 13 young asthmatics (7 males, 6 females, ages 11-16 years).

Initially, a calibration test was conducted, followed by a training session. Finally, a field study was conducted which involved subjects' collecting their own heart rate and diary data. 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 HR (Linn et al., 1992).

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 99th percentile VR were derived from all HR recordings (that appeared to be valid) without considering the diary data. Each of the three activity levels was determined from both the concurrent diary data and HR recordings by direct calculation or regression (Linn et al., 1992). Linn et al. (1992) 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 healthy subjects, (Table 7-2). Also, Linn et al. (1992) reported that in every panel, the predicted VR correlated significantly with the subjective estimates of activity levels.

A limitation of this study is that calibration data may overestimate the predictive power of HR during actual field monitoring. The wide variety of exercises in everyday activities may result in greater variation of the VR-HR relationship than calibrated. Another limitation of this study is the small sample size of each subpopulation surveyed. An advantage of this study is that diary data can provide rough estimates of ventilation patterns which are useful in exposure assessments. Another advantage is that inhalation rates were presented for both healthy and asthmatic children.

Spier et al. (1992) - Activity Patterns in Elementary and High School Students Exposed To Oxidant Pollution - Spier et al. (1992) investigated activity patterns of 17 elementary school students (10-12 years old) and 19 high school students (13-17 years old) in suburban Los Angeles from late September to October (oxidant pollution season). Calibration tests were conducted in supervised outdoor exercise sessions. The exercise sessions consisted of 5 minutes for each: rest, slow walking, jogging, and fast walking. 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 their 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 during the 3 days once per minute by wearing a Heart Watch. VR values for each self-estimated breathing rate and activity type were estimated from the HR recordings by employing the VR and HR equation obtained from the calibration tests.

The data presented in Table 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 hours spent indoors by high school students (21.2 hours) were higher than for elementary school students (19.6 hours). The converse was true for outdoor activities; 2.7 hours for high school students, and 4.4 hours for elementary school students (Table 7-4). Based on the data presented in Tables 7-3 and 7-4, the average activity-specific inhalation rates for elementary (10-12 years) and high school (13-17 years) students were calculated 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. This may affect the validity of the data set generated. An advantage of this study is that inhalation rates were determined for children and adolescents. These data are useful in estimating exposure for the younger population.

Adams (1993) - Measurement of Breathing Rate and Volume in Routinely Performed Daily Activities - 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 used to predict inhalation rates through other measured variables: breathing frequency (f_B) and oxygen consumption (V_{O2}). A total of 160 subjects participated in the primary study. For children, there were two age dependent groups: (1) children 6 to 12.9 years old, (2) adolescents between 13 and 18.9 years old, (Adams, 1993). 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 (Adams, 1993).

Resting protocols conducted in the laboratory for all age groups consisted of three phases (25 minutes each) of lying, sitting, and standing. They were categorized as resting and sedentary activities. Two active protocols, moderate (walking) and heavy (jogging/ running) phases, were performed on a treadmill over a progressive continuum of intensities made up of 6 minute intervals, at 3 speeds, ranging from slow to moderately fast. All protocols involved measuring VR, HR, f_B (breathing frequency), and V_{O2} (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, while 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 field protocols, IR for the children's group revealed no significant gender differences. Therefore, IR data presented in Appendix Tables 7A-1 and 7A-2 were categorized as young children, children (no gender) by activity levels (resting, sedentary, light, moderate, and heavy). These categorized data from the Appendix tables are summarized as IR in m^3/hr 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 activity levels (light, sedentary, and moderate) in field protocols. Accurate predictions of IR across all population groups and activity types were obtained by including body surface area (BSA), HR, and f_B in multiple regression analysis (Adams, 1993). Adams (1993) calculated BSA from measured height and weight using the equation:

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

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.

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

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

where:

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

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

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) are 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 (Layton, 1993). This factor compensated for a consistent bias in USDA-NFCS attributed to under reporting of the foods consumed or the methods used to ascertain dietary intakes. Layton (1993) used a weighted average oxygen uptake of 0.05 L O_2/KJ which was determined from data reported in the 1977-78 USDA-NFCS and the second National Health and Nutrition Examination Survey (NHANES II). The survey sample for NHANES II was approximately 20,000 participants. The ventilatory equivalent (VQ) of 27 used was calculated as the geometric mean of VQ data that were obtained from several studies by Layton (1993).

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 reported for children between the ages of 6-8 years (10 m^3/day), for males between 15-18 years (17 m^3/day), and females between 9-11 years (13 m^3/day). Inhalation rates were also calculated for active and inactive periods for the various age/gender cohorts.

The inhalation rate for inactive periods was estimated by multiplying the basal metabolic rate (BMR) times the oxygen uptake (H) times the 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. These 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 to 13.09 m^3/day, respectively.

Second Approach

Inhalation rates were calculated by multiplying the BMR of the population cohorts times A (ratio of total daily energy expenditure to daily BMR) times H 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 (Layton, 1993). 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 - 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, and for older children (10-18 years), inhalation 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 MET, H, and VQ. The data obtained for short term exposures are presented in Table 7-11.

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

7.3 RECOMMENDATIONS

The recommended inhalation rates for children are based on the studies described in this chapter. Different survey designs and populations were utilized in the studies described in this Chapter. Excluding the study by Layton (1993), 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, based on other aspects of the study design, these studies were selected as the basis for recommended inhalation rates.

The selection of inhalation rates to be used for exposure assessments depends on the age of the exposed population and the specific activity levels of this population during various exposure scenarios. The confidence ratings and recommended inhalation rates are presented in Tables 7-12 and 7-13, respectively. Based on the study results from Layton (1993), the recommended daily inhalation rate for infants (children less than 1 yr), during long-term dose assessments is 4.5 m^3/day. 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 aged 9-11 years are 14 m^3/day for males and 13 m^3/day for females. For children aged 12-14 years and 15-18 years, the recommended values are shown in Table 7-13.

Recommended short-term inhalation rates for children aged 18 years and under are also summarized in Table 7-13. The short-term inhalation rates were calculated by averaging the inhalation rates for each activity level from the various key studies (Table 7-14). The recommended average hourly inhalation rates are as follows: 0.3 m^3/hr during rest; 0.4 m^3/hr for sedentary activities; 1.0 m^3/hr for light activities; 1.2 m^3/hr for moderate activities; and 1.9 m^3/hr for heavy activities. The recommended short-term exposure data also include infants (less than 1 yr).

7.4 REFERENCES FOR CHAPTER 7

Adams, W.C. (1993) Measurement of breathing rate and volume in routinely performed daily activities, Final Report. California Air Resources Board (CARB) Contract No. A033-205. June 1993. 185 pgs.

Basiotis, P.P.; Thomas, R.G.; Kelsay, J.L.; Mertz, W. (1989) Sources of variation in energy intake by men and women as determined from one year's daily dietary records. Am. J. Clin. Nutr. 50:448-453.

Layton, D.W. (1993) Metabolically consistent breathing rates for use in dose assessments. Health Physics 64(1):23-36.

Linn, W.S.; Shamoo, D.A.; Hackney, J.D. (1992) Documentation of activity patterns in "high-risk" groups exposed to ozone in the Los Angeles area. In: Proceedings of the Second EPA/AWMA Conference on Tropospheric Ozone, Atlanta, Nov. 1991. pp. 701-712. Air and Waste Management Assoc., Pittsburgh, PA.

Spier, C.E.; Little, D.E.; Trim, S.C.; Johnson, T.R.; Linn, W.S.; Hackney, J.D. (1992) Activity patterns in elementary and high school students exposed to oxidant pollution. J. Exp. Anal. Environ. Epid. 2(3):277-293.

WHO (1986) Principles for evaluating health risks from chemicals during infancy and early childhood: the need for a special approach. Environmental Health Criteria 59, World Health Organization, International Programme on Chemical Safety.

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 male, 12 female, age 10-12	Outdoor exercises each consisted of 20 minute rest, slow walking, jogging and fast walking	Saturday, Sunday and Monday (school day) in early autumn; HR recordings and activity diary during waking hours and during sleep.
Panel 3 - Healthy High School Students - 7 male, 12 female, age 13-17	Outdoor exercises each consisted of 20 minute rest, slow walking, jogging and fast walking	Same as Panel 2, however, no HR recordings during sleep for most subjects.
Panel 6 - Young Asthmatics - 7 male, 6 female, age 11-16	Laboratory exercise tests on bicycles and treadmills	Similar to Panel 4, summer monitoring for 2 successive weeks, including 2 controlled exposure studies with few or no observable respiratory effects.

Source: Linn et al., 1992

Table 7-2. Subject Panel Inhalation Rates by Mean VR, Upper Percentiles, And Self-estimated Breathing Rates

	Inhalation Rates (m^3/hr)					
	N[a]	Mean VR (m^3/hr)	99th Percentile VR	Mean VR at Activity Levels (m^3/hr)[b]		
Panel				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 Intake Rates by Location And Activity Levels For Elementary And High School Students

					Inhalation Rates (m³/hr)			
						Percentile Rankings[b]		
Age (yrs)	Student	Location	Activity Level	% Recorded Time[a]	Mean ± SD	1[st]	50[th]	99.9th
10-12	Elc (n[d]=17)	Indoors	slow	49.6	0.84 ± 0.36	0.18	0.78	2.34
			medium	23.6	0.96 ± 0.42	0.24	0.84	2.58
			fast	2.4	1.02 ± 0.60	0.24	0.84	3.42
		Outdoors	slow	8.9	0.96 ± 0.54	0.36	0.78	4.32
			medium	11.2	1.08 ± 0.48	0.24	0.96	3.36
			fast	4.3	1.14 ± 0.60	0.48	0.96	3.60
13-17	HS[c] (n[d]=19)	Indoors	slow	70.7	0.78 ± 0.36	0.30	0.72	3.24
			medium	10.9	0.96 ± 0.42	0.42	0.84	4.02
			fast	1.4	1.26 ± 0.66	0.54	1.08	6.84[c]
		Outdoors	slow	8.2	0.96 ± 0.48	0.42	0.90	5.28
			medium	7.4	1.26 ± 0.78	0.48	1.08	5.70
			fast	1.4	1.44 ± 1.08	0.48	1.02	5.94

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

Source: Spier et al. (1992).

Table 7-4. Average Hours Spent Per Day in a Given Location and Activity Level For Elementary (EL) and High School (HS) Students

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

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

Source: Spier et al. (1992).

Table 7-5. Distribution Patterns of Daily Inhalation Rates For Elementary (EL) And High School (HS) Students Grouped by Activity Level

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

[a]For this report, activity type presented in Table 7-2 was redefined as light activity for slow, moderate activity for medium, and heavy activity for fast.
[b]Daily inhalation rate was calculated by multiplying the hours spent at each activity level (Table 7-4) by the corresponding inhalation rate (Table 7-3).
[c]Number of elementary (EL) and high school students (HS).

Source: Adapted from Spier et al. (1992) (Generated using data from Tables 7-3 and 7-4).

Table 7-6. Summary of Average Inhalation Rates (M^3/hr) by Age Group And Activity Levels For Laboratory Protocols

Age Group	Resting[a]	Sedentary[b]	Light[c]	Moderate[d]	Heavy[e]
Young Children[f]	0.37	0.40	0.65	DNP[g]	DNP
Children[h]	0.45	0.47	0.95	1.74	2.23

[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]Young children (both genders) 3 - 5.9 yrs old.
[g]DNP. Group did not perform this protocol or N was too small for appropriate mean comparisons. All young children did not run.
[h]Children (both genders) 6 - 12.9 yrs old.

Source: Adapted from Adams (1993).

Table 7-7. Summary of Average Inhalation Rates (M^3/hr) by Age Group And Activity Levels in Field Protocols

Age Group	Light[a]	Sedentary[b]	Moderate[c]
Young Children[d]	DNP[e]	DNP	0.68
Children[f]	DNP	DNP	1.07

[a]Light activity was defined as car maintenance (males), housework (females), and yard work (females) (see Appendix Table 7A-2 for original data).
[b]Sedentary activity was defined as car driving and riding (both genders) (see Appendix Table 7A-2 for original data).
[c]Moderate activity was defined as mowing (males); wood working (males); yard work (males); and play (children) (see Appendix Table 7A-2 for original data).
[d]Young children (both genders) = 3 - 5.9 yrs old.
[e]DNP. Group did not perform this protocol or N was too small for appropriate mean comparisons.
[f]Children (both genders) = 6 - 12.9 yrs old.

Source: Adams (1993).

Table 7-8. Comparisons of Estimated Basal Metabolic Rates (BMR) With Average Food-energy Intakes For Individuals Sampled in The 1977-78 NFCS

Cohort/Age (years)	Body Weight kg	BMR[a] MJ d^{-1b}	BMR[a] kcal d^{-1c}	Energy Intake (EFD) MJ d^{-1}	Energy Intake (EFD) kcal d^{-1}	Ratio EFD/BMR
Children						
Under 1	7.6	1.74	416	3.32	793	1.90
1 to 2	13	3.08	734	5.07	1209	1.65
3 to 5	18	3.69	881	6.14	1466	1.66
6 to 8	26	4.41	1053	7.43	1774	1.68
Males						
9 to 11	36	5.42	1293	8.55	2040	1.58
12 to 14	50	6.45	1540	9.54	2276	1.48
15 to 18	66	7.64	1823	10.8	2568	1.41
Females						
9 to 11	36	4.91	1173	7.75	1849	1.58
12 to 14	49	5.64	1347	7.72	1842	1.37
15 to 18	56	6.03	1440	7.32	1748	1.21

[a]Calculated from the appropriate age and gender-based BMR equations given in Appendix Table 7A-3.
[b]MJ d^{-1} - mega joules/day
[c]kcal d^{-1} - kilo calories/day

Source: Layton (1993).

Table 7-9. Daily Inhalation Rates Calculated From Food-energy Intakes

Cohort/Age (years)	L[d]	Daily Inhalation Rate[a] (m^3/day)	(h)Sleep (h)	MET[b] Value A[e]	F[f]	Inhalation Rates Inactive[c] (m^3/day)	Active[c] (m^3/day)
Children							
<1	1	4.5	11	1.9	2.7	2.35	6.35
1 - 2	2	6.8	11	1.6	2.2	4.16	9.15
3 - 5	3	8.3	10	1.7	2.2	4.98	10.96
6 - 8	3	10	10	1.7	2.2	5.95	13.09
Males							
9 - 11	3	14	9	1.9	2.5	7.32	18.3
12 - 14	3	15	9	1.8	2.2	8.71	19.16
15 - 18	4	17	8	1.7	2.1	10.31	21.65
Females							
9 - 11	3	13	9	1.9	2.5	6.63	16.58
12 - 14	3	12	9	1.6	2.0	7.61	15.20
15 - 18	4	12	8	1.5	1.7	8.14	13.84

[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

VQ = Ventilation equivalent = 27 = geometric mean of VQs (unitless)

[b]MET = Metabolic equivalent

[c]Inhalation rate for inactive periods was calculated as BMR x H x VQ 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)

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

[e]For individuals 9 years of age and older, A was calculated by multiplying the ratio for EFD/BMR (unitless) (Table 7-10) by the factor 1.2 (see text for explanation).

[f]F = (24A - S)/(24 - S) (unitless), ratio of the rate of energy expenditure during active hours to the estimated BMR (unitless)

Where:

S = Number of hours spent sleeping each day (hrs)

Source: Layton (1993).

Table 7-10. Daily Inhalation Rates Obtained From The Ratios Of Total Energy Expenditure to Basal Metabolic Rate (BMR)

Gender/Age (yrs)	Body Weight[a] (kg)	BMR[b] (MJ/day)	VQ	A[c]	H (m^3O_2/MJ)	Inhalation Rate, V_E (m^3/day)[d]
Male						
0.5 - <3	14	3.4	27	1.6	0.05	7.3
3 - <10	23	4.3	27	1.6	0.05	9.3
10 - <18	53	6.7	27	1.7	0.05	15
Female						
0.5 - <3	11	2.6	27	1.6	0.05	5.6
3 - <10	23	4.0	27	1.6	0.05	8.6
10 - <18	50	5.7	27	1.5	0.05	12

[a]Body weight was based on the average weights for age/gender cohorts in the U.S. population.

[b]The BMRs (basal metabolic rate) are calculated using the respective body weights and BMR equations (see Appendix Table 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; VQ = ventilation equivalent and H = oxygen uptake.

Source: Layton (1993).

Table 7-11. Inhalation Rates For Short-term Exposures

			Activity Type				
			Rest	Sedentary	Light	Moderate	Heavy
			MET (BMR Multiplier)				
			1	1.2	2[c]	4[d]	10[e]
Gender/Age (yrs)	Weight (kg)[a]	BMR[b] (MJ/day)	Inhalation Rate (m^3/hr)[f,g]				
Male							
0.5 - <3	14	3.40	0.19	0.23	0.38	0.78	1.92
3 - <10	23	4.30	0.24	0.29	0.49	0.96	2.40
10 - <18	53	6.70	0.38	0.45	0.78	1.50	3.78
Female							
0.5 - <3	11	2.60	0.14	0.17	0.29	0.60	1.44
3 - <10	23	4.00	0.23	0.27	0.45	0.90	2.28
10 - <18	50	5.70	0.32	0.38	0.66	1.26	3.18

[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 of 1.5 - 2.5.

[d]Range of 3 - 5.

[e]Range of >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: $\frac{60\ min}{hr} \times \frac{m^3}{1000L} \times \frac{L}{min}$

Source: Layton (1993).

Table 7-12. 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.	High
• Primary data	Both data collection and re-analysis of existing data occurred.	Medium
• Currency	Recent studies were evaluated.	High
• Adequacy of data collection period	Effort was made to collect data over time.	High
• Validity of approach	Measurements 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 six 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 7-13. Summary of Recommended Values For Inhalation

Population	Mean	Upper Percentile
Long-term Exposures		
Infants		
<1 year	4.5 m^3/day	---
Children		
1-2 years	6.8 m^3/day	---
3-5 years	8.3 m^3/day	---
6-8 years	10 m^3/day	---
9-11 years		
males	14 m^3/day	---
females	13 m^3/day	---
12-14 years		
males	15 m^3/day	---
females	12 m^3/day	---
15-18 years		
males	17 m^3/day	---
females	12 m^3/day	---
Short-term Exposures		
Children (18 years 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	---

Table 7-14. Summary of Children's Inhalation Rates
For Short-Term Exposure Studies

Arithmetic Mean (m^3/hr)					
Activity Level					
Rest	Sedentary	Light	Moderate	High	Reference
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	Linn et al., 1992 (10-12 yrs)

APPENDIX 7A

VENTILATION DATA

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	1.5 mph	10.25	DNP
	1.875 mph	10.53	DNP
	2.0 mph	DNP	14.13
	2.25 mph	11.68	DNP
	2.5 mph	DNP	15.58
	3.0 mph	DNP	17.79
	3.3 mph	DNP	DNP
	4.0 mph	DNP	DNP
Running	3.5 mph	DNP	26.77
	4.0 mph	DNP	31.35
	4.5 mph	DNP	37.22
	5.0 mph	DNP	DNP
	6.0 mph	DNP	DNP

[a]Young Children, male and female 3-5.9 yr olds; Children, male and female 6-12.9 yr olds; Adult Females, adolescent, young to middle-aged, and older adult females; Adult Males, adolescent, young to middle-aged, and older adult males; DNP, group did not perform this protocol or N was too small for appropriate mean comparisons

Source: Adams (1993).

TABLE 7A-2. Mean Minute Ventilation (V_e, L/min) by Group and Activity for Field Protocols

Activity	Young Children[a]	Children
Play	11.31	17.89
Car Driving	DNP	DNP
Car Riding	DNP	DNP
Yardwork	DNP	DNP
Housework	DNP	DNP
Car Maintenance	DNP	DNP
Mowing	DNP	DNP
Woodworking	DNP	DNP

[a]Young Children, male and female 3-5.9 yr olds; Children, male and female 6-12.9 yr olds; Adult Females, adolescent, young to middle-aged, and older adult females; Adult Males, adolescent, young to middle-aged, and older adult males; DNP, group did not perform this protocol or N was too small for appropriate mean comparisons;

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 (y)	BMR MJ d^{-1}	±SD	CV[a]	Body Weight (kg)	N[b]	BMR Equation[c]	r[d]
Males							
Under 3	1.51	0.918	0.61	6.6	162	0.249 bw - 0.127	0.95
3 to < 10	4.14	0.498	0.12	21	338	0.095 bw + 2.110	0.83
10 to < 18	5.86	1.171	0.20	42	734	0.074 bw + 2.754	0.93
Females							
Under 3	1.54	0.915	0.59	6.9	137	0.244 bw - 0.130	0.96
3 to < 10	3.85	0.493	0.13	21	413	0.085 bw + 2.033	0.81
10 to < 18	5.04	0.780	0.15	38	575	0.056 bw + 2.898	0.8

[a]Coefficient of variation (SD/mean)
[b]N = number of subjects
[c]Body weight (bw) in kg
[d]coefficient of correlation

Source: Layton (1993).

TABLE OF CONTENTS

8. DERMAL ROUTE 8-1
8.1 INTRODUCTION 8-1
8.2 SURFACE AREA 8-2
8.2.1 Background 8-2
8.2.2 Measurement Techniques 8-2
8.2.3 Body Surface Area Studies 8-3
8.2.4 Application of Body Surface Area Data 8-7
8.3 SOIL ADHERENCE TO SKIN 8-8
8.3.1 Background 8-8
8.3.2 Soil Adherence to Skin Studies 8-9
8.4 RECOMMENDATIONS 8-12
8.4.1 Body Surface Area 8-12
8.4.2 Soil Adherence to Skin 8-13
8.5 REFERENCES FOR CHAPTER 8 8-15

APPENDIX 8A - Formulae for Total Body Surface Area 8A-1

LIST OF TABLES

Table 8-1. Total Body Surface Area of Male Children in Square Meters[a] 8-17
Table 8-2. Total Body Surface Area of Female Children in Square Meters[a] 8-18
Table 8-3. Percentage of Total Body Surface Area by Body Part For Children 8-19
Table 8-4. Descriptive Statistics For Surface Area/body Weight (Sa/bw) Ratios (M^2/kg) . . . 8-20
Table 8-5. Clothing choices and assumed body surface areas exposed 8-21
Table 8-6. Estimated skin surface exposed during warm weather outdoor play for children under age 5 (based on SCS-I data). 8-21
Table 8-7. Number and percentage of respondents with children and those reporting outdoor play[a] activities in both warm and cold weather 8-22
Table 8-8. Play frequency and duration for all child players (from SCS-II data) 8-22
Table 8-9. Hand washing and bathing frequency for all child players (from SCS-II data) . . . 8-23
Table 8-10. NHAPS and SCS-II play duration[a] comparison 8-23
Table 8-11. NHAPS and SCS-II hand wash frequency comparison 8-24
Table 8-12. Summary of Field Studies 8-25
Table 8-13. Geometric Mean And Geometric Standard Deviations of Soil Adherence by Activity And Body Region 8-26
Table 8-14. Summary of Groups Assayed in Round 2 of Field Measurements 8-27
Table 8-15. Attire for Individuals within Children's Groups Studied 8-28
Table 8-16. Geometric Means (Geometric Standard Deviations) of Round 2 Post-activity Loadings 8-29
Table 8-17. Summary of Controlled Green House Trials - Children Playing 8-30
Table 8-18. Preactivity Loadings Recovered from Greenhouse Trial Children Volunteers . . 8-31
Table 8-19. Summary of Recommended Values For Skin Surface Area 8-33
Table 8-20. Confidence in Body Surface Area Measurement Recommendations 8-34
Table 8-21. Confidence in Soil Adherence to Skin Recommendations 8-35

LIST OF FIGURES

Figure 8-1. Schematic of Dose and Exposure: Dermal Route 8-2
Figure 8-2. Skin Coverage as Determined by Fluorescence vs. Body Part for Adults Transplanting Plants and for Children Playing in Wet Soils 8-32
Figure 8-3. Gravimetric Loading vs. Body Part for Adult Transplanting Plants in Wet Soil and for Children Playing in Wet and Dry Soils 8-32

8. DERMAL ROUTE

8.1 INTRODUCTION

Children may be more highly exposed to environmental toxicants through dermal routes than adults. For instance, children often play and crawl on contaminated surfaces and are more likely to wear less clothing than adults. These factors result in higher dermal contact with contaminated media. In addition, children have a higher surface area relative to body weight. In fact, the surface-area-to-body weight ratio for newborn infants is more then two times greater then 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; 1992b). These include:

- Water (e.g., bathing, washing, swimming);
- Soil (e.g., outdoor recreation, gardening, construction);
- Sediment (e.g., wading, fishing);
- Liquids (e.g., use of commercial products);
- Vapors/fumes (e.g., use of commercial products); and
- Indoors (e.g., carpets, floors, countertops).

The major factors that must be considered when estimating dermal exposure 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.

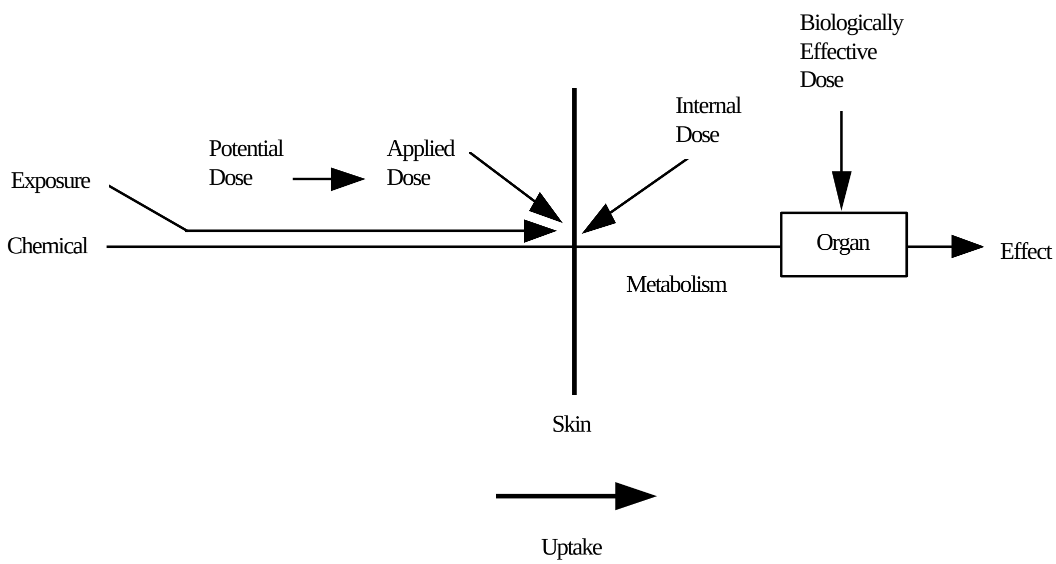


Figure 8-1. Schematic of Dose and Exposure: Dermal Route

Source: U.S. Environmental Protection Agency (1992a).

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, estimation of the surface area for the total body or a specific body part can be used to calculate the contact rate for the pollutant. This section presents estimates for total body surface area and for body parts and presents information on the application of body surface area data.

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 have been summarized in *Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments* (U.S. EPA, 1985). The coating method consists of coating either the whole body or specific body regions with a substance of known or measured area. Triangulation consists of marking the area of the body into geometric figures, then calculating the figure areas from their linear dimensions. Surface integration is performed by using a planimeter and adding the areas.

The triangulation measurement technique developed by Boyd (1935) has been found to be highly reliable. It estimates the surface area of the body using geometric approximations that assume parts of the body resemble geometric solids (Boyd, 1935). More recently, Popendorf and Leffingwell (1976), and Haycock et al. (1978) have developed similar geometric methods that assume body parts correspond to geometric solids, such as the sphere and cylinder. A linear method proposed by DuBois and DuBois (1916) is based on the principle that the surface areas of the parts of the body are proportional, rather than equal to the surface area of the solids they resemble.

In addition to direct measurement techniques, several formulae have been proposed to estimate body surface area from measurements of other major body dimensions (i.e., height and weight) (U.S. EPA, 1985). Generally, the formulae are based on the principles that body density and shape are roughly the same and that the relationship of surface area to any dimension may be represented by the curve of central tendency of their plotted values or by the algebraic expression for the curve. A discussion and comparison of formulae to determine total body surface area are presented in Appendix 8A.

8.2.3 Body Surface Area Studies

U.S. EPA (1985) - Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments - U.S. EPA (1985) analyzed the direct surface area measurement data of Gehan and George (1970) using the Statistical Processing System (SPS) software package of Buhyoff et al. (1982). Gehan and George (1970) selected 401 measurements made by Boyd (1935) that were complete for surface area, height, weight, and age for their analysis. Boyd (1935) had reported surface area estimates for 1,114 individuals using coating, triangulation, or surface integration methods (U.S. EPA, 1985).

U.S. EPA (1985) used SPS to generate equations to calculate surface area as a function of height and weight. These equations were then used to calculate body surface area distributions of the U.S. population using the height and weight data obtained from the National Health and

Nutrition Examination Survey (NHANES) II and the computer program QNTLS of Rochon and Kalsbeek (1983).

The equation proposed by Gehan and George (1970) was determined by U.S. EPA (1985) to be the best choice for estimating total body surface area. However, the paper by Gehan and George (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 (U.S. EPA, 1985).

Regression equations were developed 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.

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, NHANES II height and weight data, and using QNTLS. Estimates are not included for children younger than 2 years old because NHANES height data are not available for this age group. For children, the error associated with height and weight cannot be assumed to be zero because of their relatively small sizes. Therefore, the standard errors of the percentile estimates cannot be estimated, since it cannot be assumed that the errors associated with the exogenous variables (height and weight) are independent of that associated with the model; there are insufficient data to determine the relationship between these errors.

Measurements of the surface area of children's body parts are summarized as a percentage of total surface area in Table 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 percent of total body surface area contributed by the head decreases from childhood to adult, while the percent contributed by the leg increases.

Phillips et al. (1993) - Distributions of Total Skin Surface Area to Body Weight Ratios - Phillips et al. (1993) observed a strong correlation (0.986) between body surface area and body weight and studied the effect of using these factors as independent variables in the LADD equation. Phillips et al. (1993) concluded that, because of the correlation between these two variables, the use of body surface area to body weight (SA/BW) ratios in human exposure assessments is more appropriate than treating these factors as independent variables. Direct measurement (coating, triangulation, and surface integration) data from the scientific literature were used to calculate body surface area to body weight (SA/BW) ratios for two age groups of children (infants aged 0 to 2 years and children aged 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. 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.

Wong et al. (2000) - Adult Proxy Responses to a Survey of Children's Dermal Soil Contact Activities - 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, that 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). Questions were posed for SCS-II 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.

For SCS-I, the population size of children sampled was 211. Older children (those between the ages of 5 and 17) 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. The clothing worn during these play activities during warm weather months (April though October) also was questioned. 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).

Results of SCS-I indicate 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 percent and the hands 6 percent.

In the 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 ("non-players") 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 8-7. The frequency (days/week), duration (hours/day), and total hours per week spent playing outdoors was determined for those children identified as "players" (Table 8-8). The responses indicated that during the warmer months children spend a relatively high percentage of time outdoor and a lesser amount of time in cold weather. The median play frequency reported was 7 days/week in warm weather and 3 days/week in cold weather. Median play duration was 3 hours/day in warm weather and 1 hour/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 8-9. Based on these results, hand washing occurred a median of 4 times per day during both warm and cold weather months. The median frequency for baths and showers was estimated to be 7 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 that of the general population. This may be explained by the fact that phone surveys cannot sample those households without telephones. Additional uncertainty or error in the study results may be presented by the use of surrogate respondents. Adult respondents were questioned regarding child 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. In Tables 8-10 and 8-11 iformation extracted from the National Human Activity Pattern Survey (NHAPS) (U.S. EPA, 1996). Table 8-10 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 are shown in Table 8-11. Corresponding information for bathing frequency data collected from SCS-II was not collected in NHAPS. As indicated in Tables 8-10 and 8-11, where comparison is possible, NHAPS and SCS-II results showed similarities in observed behaviors.

8.2.4 Application of Body Surface Area Data

For swimming and bathing scenarios, past exposure assessments have assumed that 75 percent to 100 percent of the skin surface is exposed (U.S. EPA, 1992b). Central and upper-percentile values for children should be derived from Table 8-1 or 8-2.

Unlike 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 sleeve 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 a short sleeve 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 percent to 25 percent of the skin area may be exposed to soil. Since some studies have suggested that exposure can occur under clothing, the upper end of this range was selected in *Dermal Exposure Assessment: Principles and Applications* (U.S. EPA, 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 percent of the skin is exposed during the winter, 10 percent during the spring and fall, and 25 percent during the summer.

The previous discussion, has presented information about the area of skin exposed to soil. These estimates of exposed skin area should be useful to assessors using the traditional approach of multiplying the soil adherence factor by exposed skin area to estimate the total amount of soil on skin. The next section 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 SOIL ADHERENCE TO SKIN

8.3.1 Background

Soil adherence to the surface of the skin is a required parameter to calculate dermal dose when the exposure scenario involves dermal contact with a chemical in soil. A number of studies have attempted to determine the magnitude of dermal soil adherence. These studies are described in detail in U.S. EPA (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

Kissel et al. (1996a) - Factors Affecting Soil Adherence to Skin in Hand-Press Trials: Investigation of Soil Contact and Skin Coverage - Kissel et al. (1996a) conducted soil adherence experiments using five soil types (descriptor) obtained locally in the Seattle, Washington, area: sand (211), loamy sand (CP), loamy sand (85), sandy loam (228), and silt loam (72). All soils were analyzed by hydrometer (settling velocity) to determine composition. Clay contents ranged from 0.5 to 7.0 percent. Organic carbon content, determined by combustion, ranged from 0.7 to 4.6 percent. Soils were dry sieved to obtain particle size ranges of <150, 150-250, and >250 μm. For each soil type, the amount of soil adhering to an adult female hand, using both sieved and unsieved soils, was determined by measuring the difference in soil sample weight before and after the hand was pressed into a pan containing the test soil. Loadings were estimated by dividing the recovered soil mass by total hand area, although loading occurred primarily on only one side of the hand. Results showed that generally, soil adherence to hands could be directly correlated with moisture content, inversely correlated with particle size, and independent of clay content or organic carbon content.

Kissel et al. (1996b) - Field Measurement of Dermal Soil Loading Attributable to Various Activities: Implications for Exposure Assessment - Further experiments were conducted by Kissel et al. (1996b) 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. Several of the activities studied by Kissel (1996b) involved children, as shown in Table 8-12. A summary of field studies by activity, gender, age, field conditions, and clothing worn is presented in Table 8-12. Subjects' body surfaces (forearms, hands, lower legs in all cases, faces, and/or feet; pairs in some cases) were washed before and after monitored activities. Paired samples were pooled into single ones. Mass recovered was converted to loading using allometric models of surface area. These data are presented in Table 8-13. 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.

Holmes, Jr., K.K., J.H. Shirai, K.Y. Richter, and J.C. Kissel (1999) - Field Measurement of Dermal Soil Loadings in Occupational and Recreational Activities - 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 and playing indoors in a residential setting. This study was conducted as a follow up to previous field sampling of soil adherence on individuals participating in various activities (Kissel et al., 1996). For this round of sampling, soil loading data were collected utilizing the same methods used and described in Kissel et al. (1996). Information regarding the groups of children studied and their observed activities are presented in Table 8-14.

The daycare children studied were all at one location and measurements were taken on three 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 each other, wrestling, sleeping, and eating. The number of children within each day's group and the clothing worn is described in Table 8-15.

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 while the second group (Indoor kids No. 2) had six children. The play area was described by Holmes et al. (1999) as being primarily carpeted. The clothing worn by the children within each day's group is described in Table 8-15.

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 8-16. According to Holmes et al. (1999), 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 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 (*n*) is a disadvantage of this study. Also, the children studied and the activity setting may not be representative of the U.S. population.

Kissel et al. (1998) - Investigation of Dermal Contact with Soil in Controlled Trials - 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. As described in Kissel et al.(1998), 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 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 representing wet and dry soils. For wet soils, both combinations of 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 8-17.

Before each trial, each child was washed in order to obtain a preactivity or background gravimetric measurement. Preactivity data are shown in Table 8-18. 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 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 fluorescence data. According to Kissel et al. (1998), the relatively low loadings observed on non-hand body parts may be 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 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 are widely accepted. The representativeness of these data to the general population is somewhat limited since variability due to race or gender have not been systematically addressed.

The recommendations for body surface area for children are summarized in Table 8-19. These recommendations are based on U.S. EPA (1985) and Phillips et al. (1993). Table 8-20 presents the confidence ratings for various aspects of the recommendations for body surface area. The U.S. EPA (1985) study is based on generally accepted measurements that enjoy widespread usage, summarizes and compares previous reports in the literature, provides statistical distributions for adults, and provides data for total body surface area and body parts by gender for children. The results are based on selected measurements from the original data collected by Boyd (1935). 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; 1996b) for specific activities. The experimental design and measurement methods used by Kissel et al. (1996a; 1996b) 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 remain to be studied in more detail. Therefore, caution is required in interpretation and application of these results for exposure assessments.

In consideration, of these general observations and the recent data from Kissel et al. (1996a, 1996b), changes are needed from 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 8-12 which best represents the exposure scenario of concern and use the corresponding adherence value from Table 8-13. Although this approach represents an improvement, it still has shortcomings. For example, it is difficult to decide which activity in Table 8-13 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 8-13 provides the best estimates available on activity-specific adherence values, but are based on limited data. Therefore, they have a high degree of uncertainty such that considerable judgment must be used when selecting them for an assessment. The confidence ratings for various aspects of this recommendation are summarized in Table 8-21. Insufficient data are available to develop a distribution or a probability function for soil loadings.

Past EPA guidance has recommended assuming that soil exposure occurs primarily to exposed body surfaces and used typical clothing scenarios to derive estimates of exposed skin area. The approach recommended above for estimating soil adherence addresses this issue in a different manner. This change was motivated by two developments. First, increased acceptance that soil and dust particles can get under clothing and be deposited on skin. Second, recent studies of soil adherence have measured soil on entire body parts (whether or not they were covered by clothing) and averaged the amount of soil adhering to skin over the area of entire body part. The soil adherence levels resulting from these new studies must be combined with the surface area of the entire body part (not merely unclothed surface area) to estimate the amount of contaminant on skin. An important caveat, however, is that this approach assumes that clothing in the exposure scenario of interest matches the clothing in the studies used to derive these adherence levels such that the same degree of protection provided by clothing can be assumed in both cases. If clothing differs significantly between the studies reported here and the exposure scenarios under investigation, considerable judgment is needed to adjust either the adherence level or surface area assumption.

The dermal adherence value represents the amount of soil on the skin at the time of measurement. Assuming that the amount measured on the skin represents its accumulation between washings and that people wash at least once per day, these adherence values can be interpreted as daily contact rates (U.S. EPA, 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).

8.5 REFERENCES FOR CHAPTER 8

Anderson E., Browne N., Duletsky S., Ramig J. and Wam T. (1985) Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments. U. S. EPA Office of Health and Environmental Assessment, Washington, D.C. NTIS PB85-242667.

Boyd, E. (1935) The growth of the surface area of the human body. Minneapolis, Minnesota: University of Minnesota Press.

Buhyoff, G.J.; Rauscher, H.M.; Hull, R.B.; Killeen, K.; Kirk, R.C. (1982) User's Manual for Statistical Processing System (version 3C.1). Southeast Technical Associates, Inc.

Cohen-Hubal, E.A.; Sheldon, L.S.; Burke, J.M.; McLundy, T.R.; Berry, M.R.; Rigas, M.L.; Zartarian, V.G.; Freeman, N.C.G. (1999) Children's exposure assessment: A review of factors influencing children's exposure, and the data available to characterize and assess that exposure. Research Triangle Park, NC: U.S. Environmental Protection Agency, National Exposure Research Laboratory.

Dubois, D.; Dubois, E.F. (1916) A formula to estimate the approximate surface area if height and weight be known. Arch. of Intern. Med. 17:863-871.

Gehan, E.; George, G.L. (1970) Estimation of human body surface area from height and weight. Cancer Chemother. Rep. 54(4):225-235.

Garlock T.J., Shirai, J.H. and Kissel, J.C. (1999) Adult responses to a survey of soil contact related behaviors. J. Exposure Anal. Environ. Epid. 1999: 9: 134-142.

Geigy Scientific Tables (1981) Nomograms for determination of body surface area from height and mass. Lentner, C. (ed.). CIBA-Geigy Corporation, West Caldwell, NJ. pp. 226-227.

George, S.L.; Gehan, E.A.; Haycock, G.B.; Schwartz, G.J. (1979) Letters to the editor. J. Ped. 94(2):342.

Haycock, G.B.; Schwartz, G.J.; Wisotsky, D.H. (1978) Geometric method for measuring body surface area: A height-weight formula validated in infants, children, and adults. J. Ped. 93(1):62-66.

Holmes, K.K.; Kissel, J.C.; Richter, K.Y. (1996) Investigation of the influence of oil on soil adherence to skin. J. Soil. Contam. 5(4):301-308.

Holmes, Jr., K.K., J.H. Shirai, K.Y. Richter, and J. C. Kissel (1999) Field Measurement of Dermal Loadings in Occupational and Recreational Activities, Environmental Research, Section A, 80, 148-157.

Kissel, J.; Richter, K.; Duff, R.; Fenske, R. (1996a) Factors Affecting Soil Adherence to Skin in Hand-Press Trials. Bull. Environ. Contamin. Toxicol. 56:722-728.

Kissel, J.; Richter, K.; Fenske, R. (1996b) Field measurements of dermal soil loading attributable to various activities: Implications for exposure assessment. Risk Anal. 16(1):116-125.

Kissel, J.C., Shirai, J. H., Richter, K.Y., and R.A. Fenske (1998) Investigation of Dermal Contact with Soil in Controlled Trials, Journal of Soil Contamination, 7(6): 737-752.

Murray, D.M.; Burmaster, D.E. (1992) Estimated distributions for total surface area of men and women in the United States. J. Expos. Anal. Environ. Epidemiol. 3(4):451-462.

Phillips, L.J.; Fares, R.J.; Schweer, L.G. (1993) Distributions of total skin surface area to body weight ratios for use in dermal exposure assessments. J. Expos. Anal. Environ. Epidemiol. 3(3):331-338.

Popendorf, W.J.; Leffingwell, J.T. (1976) Regulating OP pesticide residues for farmworker protection. In: Residue Review 82. New York, NY: Springer-Verlag New York, Inc., 1982. pp. 125-201.

Rochon, J.; Kalsbeek, W.D. (1983) Variance estimation from multi-stage sample survey data: the jackknife repeated replicate approach. Presented at 1983 SAS Users Group Conference, New Orleans, Louisiania, January 1983.

Sendroy, J.; Cecchini, L.P. (1954) Determination of human body surface area from height and weight. J. Appl. Physiol. 7(1):3-12.

U.S. EPA. (1985) Development of statistical distributions or ranges of standard factors used in exposure assessments. Washington, DC: Office of Research and Development, Office of Health and Environmental Assessment. EPA 600/8-85-010. Available from: NTIS, Springfield, VA. PB85-242667.

U.S. EPA. (1992a) Guidelines for exposure assessment. Federal Register. FR 57:104:22888-22938. May 29, 1992.

U.S. EPA. (1992b) Dermal exposure assessment: principles and applications. Washington, DC: Office of Research and Development, Office of Health and Environmental Assessment/OHEA. U.S. EPA/600/8-9-91.

U. S. Environmental Protection Agency (U.S. EPA) (1996) Analysis of the National Human Activity Pattern Survey (NHAPS) Respondents from a Standpoint of Exposure assessment. Office of Research and Development, Washington, D.C., EPA/600/R-96/074.

Van Graan, C.H. (1969) The determination of body surface area. Supplement to the South African J. of Lab. and Clin. Med. 8-2-69.

Wong E. Y., Shirai, J.H, Garlock, T. J., and Kissel, J.C. (2000) Adult Proxy Responses to a Survey of Children’s Dermal Soil Contact Activities, Submitted for publication.

Table 8-1. Total Body Surface Area of Male Children in Square Meters[a]

Age (yr)[b]	Percentile								
	5	10	15	25	50	75	85	90	95
2 < 3	0.527	0.544	0.552	0.569	0.603	0.629	0.643	0.661	0.682
3 < 4	0.585	0.606	0.620	0.636	0.664	0.700	0.719	0.729	0.764
4 < 5	0.633	0.658	0.673	0.689	0.731	0.771	0,796	0.809	0.845
5 < 6	0.692	0.721	0.732	0.746	0.793	0.840	0.864	0.895	0.918
6 < 7	0.757	0.788	0.809	0.821	0.866	0.915	0.957	1.01	1.06
7 < 8	0.794	0.832	0.848	0.877	0.936	0.993	1.01	1.06	1.11
8 < 9	0.836	0.897	0.914	0.932	1.00	1.06	1.12	1.17	1.24
9 < 10	0.932	0.966	0.988	1.00	1.07	1.13	1.16	1.25	1.29
10 < 11	1.01	1.04	1.06	1.10	1.18	1.28	1.35	1.40	1.48
11 < 12	1.00	1.06	1.12	1.16	1.23	1.40	1.47	1.53	1.60
12 < 13	1.11	1.13	1.20	1.25	1.34	1.47	1.52	1.62	1.76
13 < 14	1.20	1.24	1.27	1.30	1.47	1.62	1.67	1.75	1.81
14 < 15	1.33	1.39	1.45	1.51	1.61	1.73	1.78	1.84	1.91
15 < 16	1.45	1.49	1.52	1.60	1.70	1.79	1.84	1.90	2.02
16 < 17	1.55	1.59	1.61	1.66	1.76	1.87	1.98	2.03	2.16
17 < 18	1.54	1.56	1.62	1.69	1.80	1.91	1.96	2.03	2.09
3 < 6	0.616	0.636	0.649	0.673	0.728	0.785	0.817	0.842	0.876
6 < 9	0.787	0.814	0.834	0.866	0.931	1.01	1.05	1.09	1.14
9 < 12	0.972	1.00	1.02	1.07	1.16	1.28	1.36	1.42	1.52
12 < 15	1.19	1.24	1.27	1.32	1.49	1.64	1.73	1.77	1.85
15 < 18	1.50	1.55	1.59	1.65	1.75	1.86	1.94	2.01	2.11

[a]Lack of height measurements for children <2 years in NHANES II precluded calculation of surface areas for this age group.
[b]Estimated values calculated using NHANES II data.

Source: U.S. Environmental Protection Agency (1985).

Table 8-2. Total Body Surface Area of Female Children in Square Meters[a]

	Percentile								
Age (yr)[b]	5	10	15	25	50	75	85	90	95
2 < 3	0.516	0.532	0.544	0.557	0.579	0.610	0.623	0.637	0.653
3 < 4	0.555	0.570	0.589	0.607	0.649	0.688	0.707	0.721	0.737
4 < 5	0.627	0.639	0.649	0.666	0.706	0.758	0.777	0.794	0.820
5 < 6	0.675	0.700	0.714	0.735	0.779	0.830	0.870	0.902	0.952
6 < 7	0.723	0.748	0.770	0.791	0.843	0.914	0.961	0.989	1.03
7 < 8	0.792	0.808	0.819	0.854	0.917	0.977	1.02	1.06	1.13
8 < 9	0.863	0.888	0.913	0.932	1.00	1.05	1.08	1.11	1.18
9 < 10	0.897	0.948	0.969	1.01	1.06	1.14	1.22	1.31	1.41
10 < 11	0.981	1.01	1.05	1.10	1.17	1.29	1.34	1.37	1.43
11 < 12	1.06	1.09	1.12	1.16	1.30	1.40	1.50	1.56	1.62
12 < 13	1.13	1.19	1.24	1.27	1.40	1.51	1.62	1.64	1.70
13 < 14	1.21	1.28	1.32	1.38	1.48	1.59	1.67	1.75	1.86
14 < 15	1.31	1.34	1.39	1.45	1.55	1.66	1.74	1.76	1.88
15 < 16	1.38	1.49	1.43	1.47	1.57	1.67	1.72	1.76	1.83
16 < 17	1.40	1.46	1.48	1.53	1.60	1.69	1.79	1.84	1.91
17 < 18	1.42	1.49	1.51	1.56	1.63	1.73	1.80	1.84	1.94
3 < 6	0.585	0.610	0.630	0.654	0.711	0.770	0.808	0.831	0.879
6 < 9	0.754	0.790	0.804	0.845	0.919	1.00	1.04	1.07	1.13
9 < 12	0.957	0.990	1.03	1.06	1.16	1.31	1.38	1.43	1.56
12 < 15	1.21	1.27	1.30	1.37	1.48	1.61	1.68	1.74	1.82
15 < 18	1.40	1.44	1.47	1.51	1.60	1.70	1.76	1.82	1.92

[a]Lack of height measurements for children <2 years in NHANES II precluded calculation of surface areas for this age group.
[b]Estimated values calculated using NHANES II data.

Source: U.S. EPA (1985).

Table 8-3. Percentage of Total Body Surface Area by Body Part For Children

		Percent of Total											
		Head		Trunk		Arms		Hands		Legs		Feet	
Age (yr)	N M:F	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max	Mean	Min-Max
< 1	2:0	18.2	18.2-18.3	35.7	34.8-36.6	13.7	12.4-15.1	5.3	5.21-5.39	20.6	18.2-22.9	6.54	6.49-6.59
1 < 2	1:1	16.5	16.5-16.5	35.5	34.5-36.6	13.0	12.8-13.1	5.68	5.57-5.78	23.1	22.1-24.0	6.27	5.84-6.70
2 < 3	1:0	14.2		38.5		11.8		5.30		23.2		7.07	
3 < 4	0:5	13.6	13.3-14.0	31.9	29.9-32.8	14.4	14.2-14.7	6.07	5.83-6.32	26.8	26.0-28.6	7.21	6.80-7.88
4 < 5	1:3	13.8	12.1-15.3	31.5	30.5-32.4	14.0	13.0-15.5	5.70	5.15-6.62	27.8	26.0-29.3	7.29	6.91-8.10
5 < 6													
6 < 7	1:0	13.1		35.1		13.1		4.71		27.1		6.90	
7 < 8													
8 < 9													
9 < 10	0:2	12.0	11.6-12.5	34.2	33.4-34.9	12.3	11.7-12.8	5.30	5.15-5.44	28.7	28.5-28.8	7.58	7.38-7.77
10 < 11													
11 < 12													
12 < 13	1:0	8.74		34.7		13.7		5.39		30.5		7.03	
13 <14	1:0	9.97		32.7		12.1		5.11		32.0		8.02	
14 < 15													
15 < 16													
16 < 17	1:0	7.96		32.7		13.1		5.68		33.6		6.93	
17 < 18	1:0	7.58		31.7		17.5		5.13		30.8		7.28	

N: Number of subjects, male to female ratios.

Source: U.S. EPA (1985).

Table 8-4. Descriptive Statistics For Surface Area/body Weight (SA/BW) Ratios (m^2/kg)

					Percentiles						
Age (yrs.)	Mean	Range Min-Max	SD[a]	SE[b]	5	10	25	50	75	90	95
0-2	0.0641	0.0421-0.1142	0.0114	7.84e-4	0.0470	0.0507	0.0563	0.0617	0.0719	0.0784	0.0846
2.1 - 17.9	0.0423	0.0268-0.0670	0.0076	1.05e-3	0.0291	0.0328	0.0376	0.0422	0.0454	0.0501	0.0594

[a]Standard deviation.

[b]Standard error of the mean.

Source: Phillips et al. (1993).

Table 8-5. Clothing choices and assumed body surface areas exposed

Clothing response	Area assumed exposed	% of total body surface area[a]	
		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)	½ 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

a After Anderson et. al (1985).

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					
	pants	shirt sleeves	socks	shoes	hat[a]	all clothing
n	41	43	42	43	43	41
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.

Table 8-7. Number and percentage of respondents with children and those reporting outdoor play[a] activities in both warm and cold weather

	Respondents with children	Child players[a]		Child non players		Warm weather palyer[b]	Cold weather player	Player in both seasons
	n	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 8-8. Play frequency and duration for all child players (from SCS-II data)

	Cold weather			Warm weather		
	Frequency (d/wk)	Duration (hrs/d)	Total (hrs/wk)	Frequency (d/wk)	Duration (hrs/d)	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 8-9. Hand washing and bathing frequency for all child players (from SCS-II data)

	Cold weather		Warm weather	
	Hand washing (times/d)	Bathing (times/wk)	Hand washing (times/d)	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 8-10. NHAPS and SCS-II play duration[a] comparison

	Mean play duration (min/d)			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 8-11. NHAPS and SCS-II hand wash frequency comparison

		Percent reporting frequency (times/d) of:								
	Season	0	1-2	3-5	6-9	10-19	20-29	30+	"Don't know"	X^2 test[c]
NHAPS	cold	3	18	51	17	7	1	1	3	
SCS-II	cold	1	16	50	11	7	1	0	15	p = 0.06
NHAPS	warm	3	18	51	15	7	2	1	4	
SCS-II	warm	0	12	46	16	10	1	0	13	p = 0.001

Table 8-12. Summary of Field Studies

Activity	Month	Event[a] (hrs)	N[b]	M	F	Age (yrs)	Conditions	Clothing
Indoor								
Tae Kwon Do	Feb.	1.5	7	6	1	8-42	Carpeted floor	All in longsleeve-long pants martial arts uniform, sleeves rolled back, barefoot
Indoor Kids No. 1	Jan.	2	4	3	1	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	6	4	2	3-13	Playing on carpeted floor	5of 6 long pants, 5 of 6 long sleeves, socks, no shoes
Daycare Kids No. 1a	Aug.	3.5	6	5	1	1-6.5	Indoors: linoleum surface; outdoors: grass, bare earth, barked area	4 of 6 in long pants, 4 of 6 short sleeves, shoes
Daycare Kids No. 1b	Aug.	4	6	5	1	1-6.5	Indoors: linoleum surface; outdoors: grass, bare earth, barked area	4 of 6 in long pants, 4 of 6 short sleeves, no shoes
Daycare Kids No.2c	Sept.	8	5	4	1	1-4	Indoors, low napped carpeting, linoleum surfaces	4 of 5 long pants, 3of 5 long sleeves, all barefoot for part of the day
Daycare Kids No. 3	Nov.	8	4	3	1	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	8	0	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	8	1	7	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	11.5	7	3	4	16-35	Digging withtrowel, 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	6	5	1	9-14	Lake shoreline	All in short sleeve T-shirts, shorts, barefoot
Kids-in-mud No. 2	Sept.	0.33	6	5	1	9-14	Lake shoreline	All in short sleeve T-shirts, shorts, barefoot

[a]Event duration
[b]Number of subject
[c]Activities were confined to the house

Sources: Kissel et al. (1996b); Holmes et al. (1996).

Table 8-13. Geometric Mean And Geometric Standard Deviations of Soil Adherence by Activity And Body Region

Activity	N[a]	Post-activity 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		0.012 1.4
Indoor Kids No. 2	6	0.014 1.5	0.0041 2.0	0.0031 1.5		0.0091 1.7
Daycare Kids No. 1a	6	0.11 1.9	0.026 1.9	0.030 1.7		0.079 2.4
Daycare Kids No. 1b	6	0.15 2.1	0.031 1.8	0.023 1.2		0.13 1.4
Daycare Kids No. 2	5	0.073 1.6	0.023 1.4	0.011 1.4		0.044 1.3
Daycare Kids No. 3	4	0.036 1.3	0.012 1.2	0.014 3.0		0.0053 5.1
Outdoor						
Soccer No. 1	8	0.11 1.8	0.011 2.0	0.031 3.8	0.012 1.5	
Gardeners No. 1	8	0.20 1.9	0.050 2.1	0.072 --	0.058 1.6	0.17 --
Archeologists	7	0.14 1.3	0.041 1.9	0.028 4.1	0.050 1.8	0.24 1.4
Kids-in-mud No. 1	6	35 2.3	11 6.1	36 2.0		24 3.6
Kids-in-mud No. 2	6	58 2.3	11 3.8	9.5 2.3		6.7 12.4

[a]Number of subjects.

Sources: Kissel et al. (1996b); Holmes et al. (1996).

Table 8-14. Summary of Groups Assayed in Round 2 of Field Measurements

Activity	Month	Event[a] (hrs)	n^b	Males	Females	Ages
Daycare kids No. 1a	Aug.	3.5	6	5	1	1 - 6.5
Daycare kids No. 1b	Aug.	4	6	5	1	1 - 6.5
Daycare kids No. 2	Sept.	8	5	4	1	1 - 4
Daycare kids No. 3	Nov.	8	4	3	1	1 - 4.5
Indoor kids No. 1	Jan.	2	4	3	1	6 - 13
Indoor kids No. 2	Feb.	2	6	4	2	3 - 13

a Event duration.
b Number of subjects.

Table 8-15. Attire for Individuals within Children's Groups Studied

		Pants		Sleeves		Socks		Shoes
Activity	*n*[a]	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[b]	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 Number of subjects.
b 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.

Table 8-16. Geometric Means (Geometric Standard Deviations) of Round 2 Post-activity Loadings

		Postactivity Dermal Soil Loadings (mg/cm2)				
Activity	*n*[a]	Hands	Forearms	Lower legs	Faces[b]	Feet
Daycare kids No. 1a	4	0.11 (1.9)	0.026 (1.9)	0.030 (1.7)		0.079 (2.4)
Daycare kids No. 1b	6	0.15 (2.1)	0.031 (1.8)	0.023 (1.2)		0.13 (1.4)
Daycare kids No. 2	6	0.073 (1.6)	0.023 (1.4)	0.011 (1.4)		0.044 (1.3)
Daycare kids No. 3	6	0.036 (1.3)	0.012 (1.2)	0.014 (3.0)		0.0053 (5.1)
Indoor kids No. 1	5	0.0073 (1.9)	0.0042 (1.9)	0.0041 (2.3)		0.012 (1.4)
Indoor kids No. 2	4	0.014 (1.5)	0.0041 (2.0)	0.0031 (1.5)		0.0091 (1.7)

a Number of subjects (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.

Table 8-17. Summary of Controlled Green House Trials - Children Playing

Activity	Ages	Duration (min)	Soil moisture (%)	Clothing[a]	n	Male	Female
Playing	8-12	20	17-18	L	4	3	1
			16-18	S	9	5	4
			3-4	S	5	3	2

a L, long sleeves and long pants; S, short sleeves and short pants.

Table 8-18. Preactivity Loadings Recovered from Greenhouse Trial Children Volunteers

Area	n	Body part surface area (cm^2)	Geometric mean (95% C.I.) ($\mu g/cm^2$)
Hands	12	420-798	9.4 (5.4 - 15.8)
Forearms	12	584-932	3.4 (2.3 - 5.2)
Lower legs	12	1,206-2,166	1.0 (0.7 - 1.5)
Face	12	388-602	0.8 (0.5 - 1.5)

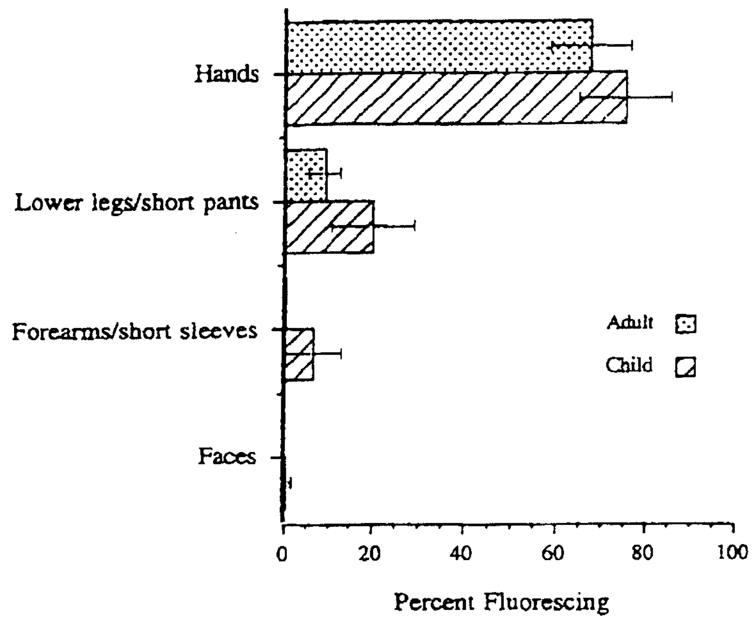


Figure 8-2. Skin Coverage as Determined by Fluorescence vs. Body Part for Adults Transplanting Plants and for Children Playing in Wet Soils

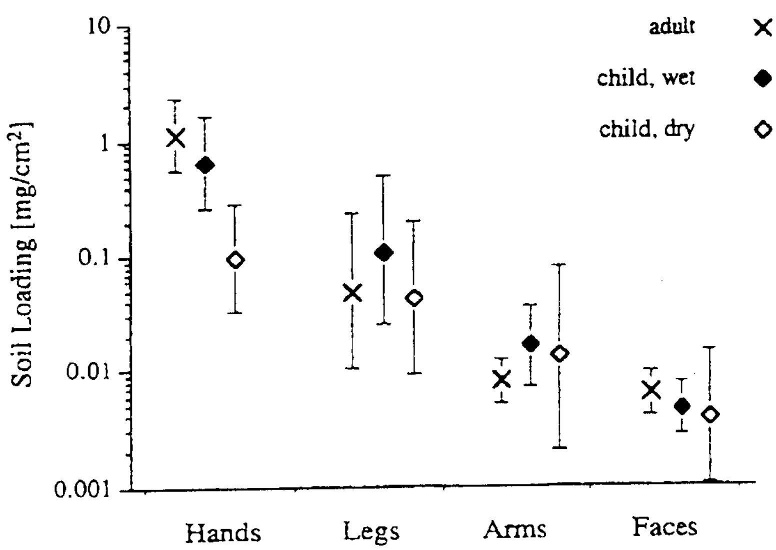


Figure 8-3. Gravimetric Loading vs. Body Part for Adult Transplanting Plants in Wet Soil and for Children Playing in Wet and Dry Soils

Table 8-19. Summary of Recommended Values For Skin Surface Area

Surface Area	Central Tendency	Upper Percentile	Multiple Percentiles
Whole body	---	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

Table 8-20. 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 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	1 experiment; two independent re-analyses of this data set.	Medium
• Agreement among researchers	Consistent results obtained with different analyses; but from a single set of measurements.	Medium
Overall Rating	This factor can be directly measured. It is not subject to dispute. Influence of age, race, or gender have not been detailed adequately in these studies.	**Medium**

Table 8-21. 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 were directly measure 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 the State of Washington 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, but application of results to other similar activities may be subject to variation.	Low/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 .	**Low**

APPENDIX 8A

FORMULAE FOR TOTAL BODY SURFACE AREA

APPENDIX 8A
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):

$$SA = KW^{2/3} \tag{8A-1}$$

where:

SA = surface area in square meters;
W = weight in kg; and
K = constant.

While the above equation has been criticized because human bodies have different specific gravities and because the surface area per unit volume differs for individuals with different body builds, it gives a reasonably good estimate of surface area.

A formula published in 1916 that still finds wide acceptance and use is that of DuBois and DuBois. Their model can be written:

$$SA = a_0 H^{a1} W^{a2} \tag{8A-2}$$

where:

SA = surface area in square meters;
H = height in centimeters; and
W = weight in kg.

The values of a_0 (0.007182), a_1 (0.725), and a_2 (0.425) were estimated from a sample of only nine individuals for whom surface area was directly measured. Boyd (1935) stated that the Dubois formula was considered a reasonably adequate substitute for measuring surface area. Nomograms for determining surface area from height and mass presented in Volume I of the Geigy Scientific Tables (1981) are based on the DuBois and DuBois formula. In addition, a computerized literature search conducted for this report identified several articles written in the last 10 years in which the DuBois and DuBois formula was used to estimate body surface area.

Boyd (1935) developed new constants for the DuBois and DuBois model based on 231 direct measurements of body surface area found in the literature. These data were limited to measurements of surface area by coating methods (122 cases), surface integration (93 cases), and triangulation (16 cases). The subjects were Caucasians of normal body build for whom data on weight, height, and age (except for exact age of adults) were complete. Resulting values for the constants in the DuBois and DuBois model were a_0 = 0.01787, a_1 = 0.500, and a_2 = 0.4838. Boyd also developed a formula based exclusively on weight, which was inferior to the DuBois and DuBois formula based on height and weight.

Gehan and George (1970) proposed another set of constants for the DuBois and DuBois model. The constants were based on a total of 401 direct measurements of surface area, height, and weight of all postnatal subjects listed in Boyd (1935). The methods used to measure these subjects were coating (163 cases), surface integration (222 cases), and triangulation (16 cases).

Gehan and George (1970) used a least-squares method to identify the values of the constants. The values of the constants chosen are those that minimize the sum of the squared percentage errors of the predicted values of surface area. This approach was used because the importance of an error of 0.1 square meter depends on the surface area of the individual. Gehan and George (1970) used the 401 observations summarized in Boyd (1935) in the least-squares method. The following estimates of the constants were obtained: a_0 = 0.02350, a_1 = 0.42246, and a_2 = 0.51456. Hence, their equation for predicting SA is:

$$SA = 0.02350\ H^{0.42246} W^{0.51456} \qquad (8A\text{-}3)$$

or in logarithmic form:

$$1nSA = -3.75080 = 0.42246 1nH = 0.51456 1nW \qquad (8A\text{-}4)$$

where:

SA = surface area in square meters;
H = height in centimeters; and
W = weight in kg.

This prediction explains more than 99 percent of the variations in surface area among the 401 individuals measured (Gehan and George, 1970).

The equation proposed by Gehan and George (1970) was determined by the U.S. EPA (1985) as the best choice for estimating total body surface area. However, the paper by Gehan and George gave insufficient information to estimate the standard error about the regression. Therefore, the 401 direct measurements of children and adults (i.e., Boyd, 1935) were reanalyzed in U.S. EPA (1985) using the formula of Dubois and Dubois (1916) and the Statistical Processing System (SPS) software package to obtain the standard error.

The Dubois and Dubois (1916) formula uses weight and height as independent variables to predict total body surface area (SA), and can be written as:

$$SA_i = a_0 H_i^{a1} W_i^{a2} e_i \qquad (8A\text{-}5)$$

or in logarithmic form:

$$1n(SA)_i = 1na_0 + a_1 1nH_i + a_2 1nW_i + 1ne_i \qquad (8A\text{-}6)$$

where:

Sai	=	surface area of the i-th individual (m^2);
Hi	=	height of the i-th individual (cm);
Wi	=	weight of the i-th individual (kg);
a_0, a_1, and a_2	=	parameters to be estimated; and
e_i	=	a random error term with mean zero and constant variance.

Using the least squares procedure for the 401 observations, the following parameter estimates and their standard errors were obtained:

$$a_0 = -3.73(0.18), a_1 = 0.417(0.054), a_2 = 0.517(0.022)$$

The model is then:

$$SA = 0.0239 H^{0.417} W^{0.517} \quad (8A\text{-}7)$$

or in logarithmic form:

$$1n\ SA = -3.73 + 0.417\ 1n\ H + 0.517\ 1n\ W \quad (8A\text{-}8)$$

with a standard error about the regression of 0.00374. This model explains more than 99 percent of the total variation in surface area among the observations, and is identical to two significant figures with the model developed by Gehan and George (1970).

When natural logarithms of the measured surface areas are plotted against natural logarithms of the surface predicted by the equation, the observed surface areas are symmetrically distributed around a line of perfect fit, with only a few large percentage deviations. Only five subjects differed from the measured value by 25 percent or more. Because each of the five subjects weighed less than 13 pounds, the amount of difference was small. Eighteen estimates differed from measurements by 15 to 24 percent. Of these, 12 weighed less than 15 pounds each, 1 was overweight (5 feet 7 inches, 172 pounds), 1 was very thin (4 feet 11 inches, 78 pounds), and 4 were of average build. Since the same observer measured surface area for these 4 subjects, the possibility of some bias in measured values cannot be discounted (Gehan and George 1970).

Gehan and George (1970) also considered separate constants for different age groups: less than 5 years old, 5 years old to less than 20 years old, and greater than 20 years old. The different values for the constants are presented below:

Table 8A-1. Estimated Parameter Values for Different Age Intervals

Age group	Number of persons	a_0	a_1	a_2
All ages	401	0.02350	0.42246	0.51456
<5 years old	229	0.02667	0.38217	0.53937
≥ 5 - <20 years old	42	0.03050	0.35129	0.54375
≥ 20 years old	30	0.01545	0.54468	0.46336

The surface areas estimated using the parameter values for all ages were compared to surface areas estimated by the values for each age group for subjects at the 3rd, 50th, and 97th percentiles of weight and height. Nearly all differences in surface area estimates were less than 0.01 square meter, and the largest difference was 0.03 m^2 for an 18-year-old at the 97th percentile. The authors concluded that there is no advantage in using separate values of a_0, a_1, and a_2 by age interval.

Haycock et al. (1978) without knowledge of the work by Gehan and George (1970), developed values for the parameters a_0, a_1, and a_2 for the DuBois and DuBois model. Their interest in making the DuBois and DuBois model more accurate resulted from their work in pediatrics and the fact that DuBois and DuBois (1916) included only one child in their study group, a severely undernourished girl who weighed only 13.8 pounds at age 21 months. Haycock et al. (1978) used their own geometric method for estimating surface area from 34 body measurements for 81 subjects. Their study included newborn infants (10 cases), infants (12 cases), children (40 cases), and adult members of the medical and secretarial staffs of 2 hospitals (19 cases). The subjects all had grossly normal body structure, but the sample included subjects of widely varying physique ranging from thin to obese. Black, Hispanic, and white children were included in their sample. The values of the model parameters were solved for the relationship between surface area and height and weight by multiple regression analysis. The least squares best fit for this equation yielded the following values for the three coefficients: a_0 = 0.024265, a_1 = 0.3964, and a_2 = 0.5378. The result was the following equation for estimating surface area:

$$SA = 0.024265 H^{0.3964} W^{0.5378} \qquad (8A\text{-}9)$$

expressed logarithmically as:

$$1n\ SA = 1n\ 0.024265 + 0.3964\ 1n\ H + 0.5378\ 1n\ W \qquad (8A\text{-}10)$$

The coefficients for this equation agree remarkably with those obtained by Gehan and George (1970) for 401 measurements.

George et al. (1979) agree that a model more complex than the model of DuBois and DuBois for estimating surface area is unnecessary. Based on samples of direct measurements by Boyd (1935) and Gehan and George (1970), and samples of geometric estimates by Haycock et al. (1978), these authors have obtained parameters for the DuBois and DuBois model that are different than those originally postulated in 1916. The DuBois and DuBois model can be written logarithmically as:

$$1n\ SA = 1n\ a_0 = a_1\ 1n\ H + a_2\ 1n\ W \qquad (8A\text{-}11)$$

The values for a_0, a_1, and a_2 obtained by the various authors discussed in this section are presented to follow:

Table 8A-2. Summary of Surface Area Parameter Values for the Dubois and Dubois Model

Author (year)	Number of persons	a_0	a_1	a_2
DuBois and DuBois (1916)	9	0.007184	0.725	0.425
Boyd (1935)	231	0.01787	0.500	0.4838
Gehan and George (1970)	401	0.02350	0.42246	0.51456
Haycock et al. (1978)	81	0.024265	0.3964	0.5378

The agreement between the model parameters estimated by Gehan and George (1970) and Haycock et al. (1978) is remarkable in view of the fact that Haycock et al. (1978) were unaware of the previous work. Haycock et al. (1978) used an entirely different set of subjects, and used geometric estimates of surface area rather than direct measurements. It has been determined that the Gehan and George model is the formula of choice for estimating total surface area of the body since it is based on the largest number of direct measurements.

Nomograms

Sendroy and Cecchini (1954) proposed a graphical method whereby surface area could be read from a diagram relating height and weight to surface area. However, they do not give an explicit model for calculating surface area. The graph was developed empirically based on 252 cases, 127 of which were from the 401 direct measurements reported by Boyd (1935). In the other 125 cases the surface area was estimated using the linear method of DuBois and DuBois (1916). Because the Sendroy and Cecchini method is graphical, it is inherently less precise and less accurate than the formulae of other authors discussed above.

TABLE OF CONTENTS

9. ACTIVITY FACTORS 9-1
9.1 INTRODUCTION 9-1
9.2 ACTIVITY PATTERNS 9-1
9.3 RECOMMENDATIONS 9-11
9.3.1 Recommendations for Activity Patterns 9-11
9.3.2 Summary of Recommended Activity Factors 9-13
9.4 REFERENCES FOR CHAPTER 9 9-14

LIST OF TABLES

Table 9-1. Mean Time Spent (minutes) Performing Major Activities Grouped by Age, Sex and Type of Day 9-15
Table 9-2. Mean Time Spent (minutes) in Major Activities Grouped by Type of Day for Five Different Age Groups 9-16
Table 9-3. Mean Time Spent Indoors and Outdoors Grouped by Age and Day of the Week 9-17
Table 9-4. Mean Time Spent at Three Locations for both CARB and National Studies (ages 12 years and older) 9-18
Table 9-5. Mean Time Spent (minutes/day) in Various Microenvironments Grouped by Total Population and Gender (12 years and over) in the National and CARB Data 9-19
Table 9-6. Mean Time Spent (minutes/day) in Various Microenvironments by Type of Day for the California and National Surveys 9-20
Table 9-7. Mean Time Spent (minutes/day) in Various Microenvironments by Age Groups for the National and California Surveys 9-21
Table 9-8. Mean Time (minutes/day) Children Ages 12 Years and Under Spent in Ten Major Activity Categories for All Respondents 9-22
Table 9-9. Mean Time Children Spent in Ten Major Activity Categories Grouped by Age and Gender 9-23
Table 9-10. Mean Time Children Ages 12 Years and Under Spent in Ten Major Activity Categories Grouped by Seasons and Regions 9-24
Table 9-11. Mean Time Children Ages 12 Years and Under Spent in Six Major Location Categories for All Respondents (minutes/day) 9-25
Table 9-12. Mean Time Children Spent in Six Location Categories Grouped by Age and Gender 9-25
Table 9-13. Mean Time Children Spent in Six Location Categories Grouped by Season and Region 9-26
Table 9-14. Mean Time Children Spent in Proximity to Three Potential Exposures Grouped by All Respondents, Age, and Gender 9-26
Table 9-15. Mean Time Spent Indoors and Outdoors Grouped by Age 9-31
Table 9-16. Range of Recommended Defaults for Dermal Exposure Factors 9-32
Table 9-17. Number of Times Taking a Shower at Specified Daily Frequencies by the Number of Respondents 9-32
Table 9-18. Time (minutes) Spent Taking a Shower and Spent in the Shower Room After Taking a Shower by the Number of Respondents 9-32
Table 9-19. Time (minutes) Spent Taking a Shower and Spent in the Shower Immediately After Showering 9-33
Table 9-20. Total Time Spent Altogether in the Shower or Bathtub and Time Spent in the Bathroom Immediately After by Number of Respondents 9-33
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 9-34
Table 9-22. Range of Number of Times Washing the Hands at Specified Daily Frequencies by the Number of Respondents 9-34
Table 9-23. Number of Minutes Spent Working or Being Near Excessive Dust in the Air

(minutes/day) 9-34
Table 9-24. Range of Number of Times per Day a Motor Vehicle was Started in a Garage or Carport and Started with the Garage Door Closed 9-35
Table 9-25. Number of Minutes Spent Playing on Sand, Gravel, Dirt, or Grass 9-35
Table 9-26. Number of Minutes Spent Playing in Sand, Gravel, Dirt or Grass (minutes/day) 9-36
Table 9-27. Range of Number of Minutes Spent Playing on Grass in a Day by the Number of Respondents 9-36
Table 9-28. Number of Minutes Spent Playing on Grass (minutes/day) 9-36
Table 9-29. Number of Times Swimming in a Month in Freshwater Swimming Pool by the Number of Respondents 9-37
Table 9-30. Number of Minutes Spent Swimming in a Month in Freshwater Swimming Pool (minutes/month) 9-37
Table 9-31. Range of the Average Amount of Time Actually Spent in the Water by Swimmers by the Number of Respondents 9-37
Table 9-32. Statistics for 24-Hour Cumulative Number of Minutes Spent Playing Indoors and Outdoors 9-38
Table 9-33. Statistics for 24-Hour Cumulative Number of Minutes Spent Sleeping/Napping 9-38
Table 9-34. Statistics for 24-Hour Cumulative Number of Minutes Spent Attending Full Time School 9-38
Table 9-35. Statistics for 24-Hour Cumulative Number of Minutes Spent in Active Sports and for Time Spent in Sports/Exercise 9-39
Table 9-36. Statistics for 24-Hour Cumulative Number of Minutes Spent in Outdoor Recreation and Spent Walking 9-39
Table 9-37. Statistics for 24-Hour Cumulative Number of Minutes Spent in Bathing 9-40
Table 9-38. Statistics for 24-Hour Cumulative Number of Minutes Eating or Drinking 9-40
Table 9-39. Statistics for 24-Hour Cumulative Number of Minutes Spent Indoors at School and Indoors at a Restaurant 9-40
Table 9-40. Statistics for 24-Hour Cumulative Number of Minutes Spent Outdoors on School Grounds/Playg at a Park/Golf Course, and at a Pool/River/Lake 9-41
Table 9-41. Statistics for 24-Hour Cumulative Number of Minutes Spent at Home in the Kitchen Bathroom, Bedroom, and in a Residence (All Rooms) 9-42
Table 9-42. Statistics for 24-Hour Cumulative Number of Minutes Spent Traveling Inside a Vehicle 9-43
Table 9-43. Statistics for 24-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 9-43
Table 9-44. Statistics for 24-Hour Cumulative Number of Minutes Spent in Malls, Grocery Stores, or Other Stores 9-43
Table 9-45. Statistics for 24-hour Cumulative Number of Minutes Spent with Smokers Present 9-44
Table 9-46. Range of Time (minutes) Spent Smoking Based on the Number of Respondents 9-45
Table 9-47. Number of Minutes Spent Smoking (minutes/day) 9-45

Table 9-48. Gender and Age Groups 9-46
Table 9-49. Assignment of At-Home Activities to Ventilation Levels for Children 9-47
Table 9-50. Aggregate Time Spent (minutes/day) At-Home in Activity Groups by Adolescents and Children 9-48
Table 9-51. Comparison of Mean Time (minutes/day) Spent At-Home by Gender (Adolescents) 9-48
Table 9-52. Comparison of Mean Time (minutes/day) Spent At-Home by Gender and Age for Children 9-48
Table 9-53. Number of Person-Days/Individuals[a] for Children in CHAD Database 9-49
Table 9-54. Number of Hours Per Day Children Spend in Various Microenvironments by Age Average ± Std. Dev. (Percent of Children Reporting >0 Hours in Microenvironment) 9-50
Table 9-55. Average Number of Hours Per Day Children Spend Doing Various Macroactivities *While Indoors at Home* by Age 9-51
Table 9-56. Confidence in Activity Patterns Recommendations 9-52
Table 9-57. Summary of Activity Pattern Studies 9-59
Table 9-58. Summary of Mean Time Spent Indoors and Outdoors from Several Studies . . . 9-60
Table 9-59. Summary of Recommended Values for Activity Factors 9-61

LIST OF FIGURES

Figure 9-1. Distribution of the Number of Hours per Day Study Children Spent Indoors at Home 9-27
Figure 9-2. Distribution of the Number of Hours per Day Study Children Spent Indoors Away from Home 9-28
Figure 9-3. Distribution of the Number of Hours per Day Study Children Spent Outdoors at Home 9-29
Figure 9-4. Distribution of the Number of Hours per Day Study Children Spent Outdoors Away from Home 9-30

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 a child until an activity is performed subjecting the child to contact with those contaminants. An activity or time spent will vary based on, 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., 1999). Children engage in more contact activities than adults, therefore, a much wider distribution of activities need to be considered when assessing exposure (Hubal et al., 2000). Behavioral patterns and preferred activities results in different exposures than for adults, but also for children of different developmental stages (Chance and Harmsen, 1998).

The purpose of this section is to provide information on various activities, length of time spent performing these activities, and locations and length of time spent by individuals within those various microenvironments. 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 arranged by age group, when available.

9.2 ACTIVITY PATTERNS

The purpose of this section is to describe published time use studies that provide information on time-activity patterns of children in the U.S. These studies are briefly described below. For a detailed description of the studies, the reader is referred to the Exposure Factors Handbook, Volume III (U.S. EPA, 1997).

Timmer et al. (1985) - How Children Use Time - Timmer et al. (1985) conducted a study using the data obtained on children's time use from a 1981-1982 Panel study. A total of 922 children participated in the survey. The children surveyed were between the ages of 3 and 17 years using a time diary and a standardized interview. The time diary involved children reporting their activities beginning at 12.00 a.m. the previous night; the duration and location of each activity; the presence of another individual; and whether they were performing other activities at the same time. The standardized interview administered to the children was to gather information about their psychological, intellectual (using reading comprehension tests), and emotional well-being; their hopes and goals; their family environment; and their attitudes and beliefs.

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, children spend about 40 percent of their time sleeping, 20 percent in school, and 10 percent eating, washing, dressing, and performing other personal activities (Timmer et al., 1985). The data in Table 9-1 indicate that girls spend more time than boys performing household work and personal care activities, and less time playing sports. Also, children spend most of their free time watching television. Table 9-2 presents the mean time children spend during weekdays and weekends performing major activities by five different age groups. Also, the significant effects of each variable (i.e., age, sex) are shown in Table 9-2. Older children spend more time performing household and market work, studying and watching television, and less time eating, sleeping, and playing. Timmer et al. (1985) estimated that on the average, boys spend 19.4 hours a week watching television and girls spend 17.8 hours per week performing the same activity.

A limitation associated with this study is that it was conducted in 1981 and there is a 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 exposure assessment results. Another limitation is that the data do not provide overall annual estimates of children's time use since data were collected only during the time of the year when children attend school and not during school vacation.

EPA estimated the total time indoors and outdoors using the Timmer data. Activities performed indoors were assumed to include household work, personal care, eating, sleeping, 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 which could have occurred indoors or outdoors (i.e., market work, sports, hobbies, art activities, playing, reading, and other passive leisure) were summed. Table 9-3 summarizes the results of this analysis by age groups and day of the week.

Robinson and Thomas (1991) - Time Spent in Activities, Locations, and Microenvironments: A California-National Comparison - Robinson and Thomas (1991) reviewed and compared data from the 1987-88 California Air Resources Board (CARB) time activity study 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 approximately 1,762 respondents. Data categorized for children 0-18 years old were not provided in the study. In addition, Robinson and Thomas (1991) defined a set of 16 microenvironments based on the activity and location codes employed in both studies. The mean duration of time spent for the total sample population, 12 years and older in three location categories is presented in Table 9-4 for both studies. Based on the data shown in Table 9-4, respondents spent most of their time indoors, 1255 and 1279 minutes/day for the CARB and national study, respectively.

Table 9-5 presents the mean duration of time and standard mean error for the 16 microenvironments grouped by total sample population and gender. Also included is the mean time spent for respondents (“Doers”) who reported participating in each activity. Table 9-5 shows that in both studies males spend more time in work locations, automobiles and other vehicles, autoplaces (garages), and physical outdoor activities, outdoor sites. In contrast, females spend more time cooking, engaging in other kitchen activities, performing other chores, and shopping. The same trends also occur on a per participant basis.

Table 9-6 shows the mean time spent in various microenvironments grouped by type of day (weekday or weekend) in both studies. Generally, respondents spent most of their time during the weekends in restaurants/bars (CARB study), motor vehicles, outdoor activities, social-cultural settings, leisure/communication activities, and sleeping. Microenvironmental differences by age are presented in Table 9-7.

Limitations associated with the Robinson and Thomas (1991) study are 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.

Wiley et al. (1991) - Study of Children's Activity Patterns - The California children's activity pattern survey design provided time estimates of children (under 12 years old) in various activities and locations (microenvironments) on a typical day (Wiley et al., 1991). A total of 1,200 children were included in the study. The average time respondents spent during the 10 activity categories for all children 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 dominant activity category, personal care (night sleep being the highest contributor), had the highest time expenditure of 794 mins/day (13.2 hours/day). All respondents reported sleeping at night, resulting in a mean daily time per participant of 794 mins/day spent sleeping. The activity category “don't know” had a duration of about 2 mins/day and only 4 percent of the respondents reported missing activity time.

Table 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." The detailed location with the highest average time expenditure are also shown. The largest amount of time spent was at home (1,078 minutes/day); 99 percent of respondents spent time at home (1,086 minutes/ participant/day). Tables 9-12 and 9-13 show the average time spent in the six locations grouped by age and gender, and season and region, respectively. There are age differences in time expenditure in educational settings for boys and girls (Table 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 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 grouped by age and gender. The sampled children spent more time closer to tobacco smoke (77 mins/day) than gasoline fumes (2 mins/day) and gas oven fumes (11 mins/day).

EPA estimated the total time indoors and outdoors using the data from the Wiley study. Activities performed indoors, were assumed to include household, childcare, 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 which could have occurred 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.

U.S. EPA (1992) - Dermal Exposure Assessment: Principles and Applications - U.S. EPA (1992) addressed the variables of exposure time, frequency, and duration needed to calculate dermal exposure as related to activity. The reader is referred to the document for a detailed discussion of these variables in relation to soil and water related activities. The suggested values that can be used for dermal exposure are presented in Table 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.

Davis (1995), Soil Ingestion in Children with Pica (Final Report), EPA Cooperative Agreement CR 816334-01 - In 1992, the Fred Hutchinson Cancer Research Center under Cooperative Agreement with EPA conducted a study to estimate 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 five 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 four months of 1992 and included 92 children from the Tri-Cities area in Washington State. Children ranged in age from 10 to 60 months. These children were volunteers among a group selected through random digit dialing. The study was conducted during a period of 7 days.

In addition to mouthing behavior data, information was collected about how long the child spent indoors and outdoors each day, and the general types of outdoor settings the child played in. Figure 9-1 presents the distribution of the number of hours per day study children spent indoors at home. Values were: the mean was 8.9 hours, the median was 9 hours, and the range was 30 minutes to 1.5 hours. Figure 9-2 presents the distribution of the number of hours per day study children spent indoors away from home. The mean number of hours spent indoors away from home was 1.8, the median was 1, and the range was 0-15 hours. Figure 9-3 presents the distribution of number of hours per day study children spent outdoors at home. The mean number of hours spent outdoors at home was 1.4, the median was 45 minutes, and the range was 0-9 hours. Figure 9-4 presents the number of hours per day study children spent outdoors away from home. The mean number of hours spent was approximately 30 minutes, the median was less than 15 minutes, and the range was 0-8 hours.

Tsang and Klepeis (1996) - National Human Activity Pattern Survey (NHAPS) - The National Human Activity Pattern Survey was conducted by the U.S. EPA (Tsang and Klepeis, 1996). It is the largest and most current human activity pattern survey available (Tsang and Klepeis, 1996). Data 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 (i.e., by gender, age, race, employment status, census region, season, etc.). The participants' responses were weighted according to geographic, socioeconomic, time/season, and other demographic factors to ensure that results were representative of the U.S. population.

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.

- **Table 9-17** presents number of times taking a shower at specified daily frequencies by number of respondents. The data shows that the majority of respondents take a shower one or two times a day.

- **Table 9-18** provides 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** provides 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 from 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 15-20 minutes and 2-5 minutes for taking a shower or bath and time spent in the bathroom after the bath, respectively.

- **Table 9-22** provides a range of number of times washing the hands in a day. Most respondents 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 indicates that approximately 75 minutes/day is 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 started with the garage door closed.

- **Table 9-25** provides data for the range of minutes/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 (minutes/day) spent playing on the grass by number of respondents. The majority of respondents spent more than 120 minutes/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 minutes/day for all age groups.

- **Table 9-29** provides number of times/month swimming in a freshwater swimming pool by number of respondents. The majority of respondents swim in freshwater pools 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 minutes/month for age group 1-4 years and 60 minutes/month for age gropus 5-11 and 12-17 years.

- **Table 9-31** presents the range of the average amount of time (minutes/month) actually spent in the water by swimmers. The majority of swimmers spent an average of 50-60 minutes/month in the water.

Tables 9-32 through 9-44 provide statistics for 24-hour cumulative time (minimum, mean, maximum) spent in 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 for 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 outdoor 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.
- **Table 9-46** provides data for time (minutes) spent smoking by number of respondents.
- **Table 9-47** provides percentile data for the same activity shown in Table 9-44.

Advantages of the NHAPS dataset are that it is representative of the U.S. population and it has been adjusted to be balanced geographically, seasonally, and for day/time. Also, it is representative of all ages, gender, and 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.

Funk et al. (1998) - Quantifying the Distribution of Inhalation Exposure in Human Populations - Funk et al. (1997) 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), while the second focused on children (6-11 years old) (Funk et al., 1998). The targeted groups were noninstitutionalized English speaking Californians with 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 varied from day to day and season to season.

All the activities that were documented were separated into two groups, "at home" (any activity at principal residence), or "away." Each activity was assigned to one of three ventilation levels (Ve), low, moderate, or high. Resting activities were placed in the low Ve, and moderate exertion activities were assigned to moderate Ve. Activities requiring high levels of physical exertion were placed in the high Ve group. Ambiguous activities that were encountered were assigned to moderate ventilation levels. Among the adolescents and children studied, means were determined for the aggregate age groups, as shown in Table 9-48.

Several statistical methods, such as Chi-quare, Kolmogorov,-Smirnov, and Anderson-Darling, were used to determine whether the time spent in an activity group had a known distribution (Funk et al., 1998). All the activities that were identified in the CARB study were assigned to the three ventilation levels. Most of the activities performed by children were low to moderate Ve as shown in Table 9-49.

The aggregate time periods spent at home in each activity are shown in Table 9-50. Aggregate time spent at home performing different activities was compared between genders. There were no significant differences between adolescent male and females in any of the activity groups (Funk et al., 1998) (Table 9-51). In children ages 6-11 years there were differences 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 (Funk et al., 1998) (Table 9-52).

Large proportions of the respondents in the study did not participate in high ventilation 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.

Hubal et al. (2000) - Children's Exposure Assessment: A Review of Factors Influencing Children's Exposure, and the Data Available to Characterize and Assess that Exposure - Hubal et al. (2000) reviewed available data to characterize and assess environmental exposures to children. As part of that review, available activity patterns data were evaluated. Hubal reviewed the EPA National Exposure Research Laboratory's Consolidated Human Activity Database (CHAD), which contains data from several studies on human activities. For children and adolescents younger than 18 years, CHAD contains 4,300 person-days of information and 3,009 person-days of microactivity data for 2,640 children less than 12 years old (Hubal et al., 2000) (Table 9-53). Specific examples of the type of microactivity data available in CHAD for children are shown in Tables 9-54 and 9-55. The number of hours spent in various microenvironments are shown in Table 9-54 and time spent in various activities indoors at home in Table 9-55.

The authors noted that 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." CHAD is available on the EPA Intranet (Hubal et al., 2000).

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 9-56.

9.3.1 Recommendations for Activity Patterns

This chapter presents several studies that provide data on activity patterns. Table 9-57 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 to follow. These activities are time spent indoors versus outdoors, showering, swimming, residential time spent indoors and outdoors, time spent playing on sand and gravel, and time spent playing on grass.

Time Spent Indoors Versus Outdoors - Assessors often require knowledge of time individuals spend indoors versus outdoors. Ideally, this issue would be addressed on a site-specific basis since the times are likely to vary considerably depending on the climate, residential setting (i.e., rural versus urban), personal traits (i.e., age, health) and personal habits.

Activities can vary significantly with differences in age. Table 9-58 summarizes the studies that present information on time 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. Timmer et al. (1985) presented data on time spent in various activities for boys and girls ages 3-17 years. This national study focused on activities performed indoors such as household work, personal care, eating, sleeping, school, studying, attending church, watching television, and engaging in household conversations. The average times spent in each activity, and half the times spent in each activity which could have occurred indoors or outdoors, were summed. The results are presented in Table 9-59 For various age groups. Although there is good agreement between the Robinson Thomas 1991 and Timmer 1985 studies, the recommendations are based on the Timmer study because it provides data for younger children. The recommendations are based on the Timmer data shown in Table 9-58.

Showering - The recommended shower frequency of one shower per day is based on the NHAPS data summarized in Table 9-17. This table showed that 341 of the 451 total participants indicated taking at least one shower the previous day.

Recommendations for showering duration are based on the study of Tsang and Klepeis (1996). A recommended value for average showering time is 10 minutes (Table 9-18) based on professional judgement.

Swimming - Data for swimming frequency is taken from the NHAPS Study (Tsang and Klepeis, 1996). Of the 653 participants, who answered yes to the question “in the past month, did you swim in a freshwater pool?", 241 were ages 1-17 years. The results to this question are summarized in 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 they swam one time per month. Thus, the recommended swimming frequency is one event/ 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/month); and the 99th percentile value is 181 minutes. This value (181) indicates that more than 180 minutes were spent.

Residential Time Spent Indoors and Outdoors - The recommendations for time spent indoors at one's residence for children 1-17 years old is 18 hours/day. This is based on the NHAPS data summarized in Table 9-41 for number of minutes spent indoors in a residence (all rooms). The average of the 50th percentile values for all age groups is 1,061 minutes per day (17.7 hours/day); and a 90th percentile value of 1,361 minutes per day (22.6 hours/day).

The recommended value for time spent outdoors outside one's residence is 2 hours per day based on NHAPS data shown on Table 9-43 for time spent outdoors (outside the residence). The 50th percentile values range from 100-150 minutes/day and the 90th percentile values range from 300-400 minutes/day as shown in Table 9-43.

Playing on Sand or Gravel, and on Grass - The recommended value for time spent playing on sand or gravel is 60 minutes/day. This value is based on 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 minutes/day category. However, for the other time categories, the majority of respondents are captured in the 50-60 minutes/day category.

The recommended value for time spent playing on grass is 60 minutes/day based on the 50th percentile data shown in Table 9-28 and the 50-60 minutes/day category data in Table 9-27.

9.3.2 Summary of Recommended Activity Factors

Table 9-59 includes a summation of the recommended activity pattern factors presented in this section and the studies which provided data on the specific activities. The type of activities include indoor activities, outdoor activities, taking a shower, swimming, time spent playing on sand or gravel, and time spent playing on grass.

9.4 REFERENCES FOR CHAPTER 9

Chance, W.G.; Harmsen, E. (1998) Children are different: environmental contaminants and children's health. Canadian Journal of Public Health, Vol. 89, Supplement. pp. 59-513.

Davis, S. (1995) Soil ingestion in children with pica. Final Report. EPA Cooperative Agreement. CR816334.01.

Funk, L.; Sedman, R.; Beals, J.A.J.; Fountain, R. (1998) Quantifying the distribution of inhalation exposure in human populations: distributions of time spent by adults, adolescents, and children at home, at work, and at school. Risk Analysis. 18(1):47-56.

Hubal, E.A.; Sheldon, L.S.; Burke, J.M.; McCurdy, T.R.; Berry, M.R.; Rigas, M.L.; Zartarian, V.G.; Freeman, N.G. (2000) Children's exposure assessment: a review of factors influencing children's exposure and the data available to characterize and assess that exposure. Research Triangle Park, NC: U.S. Environmental Protection Agency, National Exposure Research Laboratory.

Robinson, J.P; Thomas, J. (1991) Time spent in activities, locations, and microenvironments: a California-National Comparison Project report. Las Vegas, NV: U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory.

Timmer, S.G.; Eccles, J.; O'Brien, K. (1985) How children use time. In: Juster, F.T.; Stafford, F.P.; eds. Time, goods, and well-being. Ann Arbor, MI: University of Michigan, Survey Research Center, Institute for Social Research, pp. 353-380.

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

U.S. EPA. (1992) Dermal exposure assessment: principles and applications. Washington, DC: Office of Health and Environmental Assessment. EPA No. 600/8-91-011B. Interim Report.

U.S. EPA. (1997) Exposure Factors Handbook. Washington, DC: National Center for Environmental Assessment, Office of Research and Development. EPA/600/P-95/002Fa,b,c.

Wiley, J.A.; Robinson, J.P.; Cheng, Y.; Piazza, T.; Stork, L.; Plasden, K. (1991) Study of children's activity patterns. California Environmental Protection Agency, Air Resources Board Research Division. Sacramento, CA.

Table 9-1. Mean Time Spent (minutes) Performing Major Activities Grouped by Age, Sex and Type of Day

Activity	Age (3-11 years)				Age (12-17 years)			
	Duration of Time (mins/day)				Duration of Time (mins/day)			
	Weekdays		Weekends		Weekdays		Weekends	
	Boys (n=118)	Girls (n=111)	Boys (n=118)	Girls (n=111)	Boys (n=77)	Girls (n=83)	Boys (n=77)	Girls (n=83)
Market Work	16	0	7	4	23	21	58	25
Household Work	17	21	32	43	16	40	46	89
Personal Care	43	44	42	50	48	71	35	76
Eating	81	78	78	84	73	65	58	75
Sleeping	584	590	625	619	504	478	550	612
School	252	259	--	--	314	342	--	--
Studying	14	19	4	9	29	37	25	25
Church	7	4	53	61	3	7	40	36
Visiting	16	9	23	37	17	25	46	53
Sports	25	12	33	23	52	37	65	26
Outdoors	10	7	30	23	10	10	36	19
Hobbies	3	1	3	4	7	4	4	7
Art Activities	4	4	4	4	12	6	11	9
Playing	137	115	177	166	37	13	35	24
TV	117	128	181	122	143	108	187	140
Reading	9	7	12	10	10	13	12	19
Household Conversations	10	11	14	9	21	30	24	30
Other Passive Leisure	9	14	16	17	21	14	43	33
NA[a]	22	25	20	29	14	17	10	4
Percent of Time Accounted for by Activities Above	94%	92%	93%	89%	93%	92%	88%	89%

a NA = Unknown
Source: Timmer et al., 1985.

Table 9-2. Mean Time Spent (minutes) in Major Activities Grouped by Type of Day for Five Different Age Groups

	Time Duration (mins)										Significant Effects[a]
	Weekday					Weekend					
Age (years)	3-5	6-8	9-11	12-14	15-17	3-5	6-8	9-11	12-14	15-17	
Activities											
Market Work	--	14	8	14	28	--	4	10	29	48	
Personal Care	41	49	40	56	60	47	45	44	60	51	A,S,AxS (F>M)
Household Work	14	15	18	27	34	17	27	51	72	60	A,S, AxS (F>M)
Eating	82	81	73	69	67	81	80	78	68	65	A
Sleeping	630	595	548	473	499	634	641	596	604	562	A
School	137	292	315	344	314	--	--	--	--	--	
Studying	2	8	29	33	33	1	2	12	15	30	A
Church	4	9	9	9	3	55	56	53	32	37	A
Visiting	14	15	10	21	20	10	8	13	22	56	A (Weekend only)
Sports	5	24	21	40	46	3	30	42	51	37	A,S (M>F)
Outdoor activities	4	9	8	7	11	8	23	39	25	26	
Hobbies	0	2	2	4	6	1	5	3	8	3	
Art Activities	5	4	3	3	12	4	4	4	7	10	
Other Passive Leisure	9	1	2	6	4	6	10	7	10	18	A
Playing	218	111	65	31	14	267	180	92	35	21	A,S (M>F)
TV	111	99	146	142	108	122	136	185	169	157	A,S, AxS (M>F)
Reading	5	5	9	10	12	4	9	10	10	18	A
Being read to	2	2	0	0	0	3	2	0	0	0	A
NA	30	14	23	25	7	52	7	14	4	9	A

a Effects are significant for weekdays and weekends, unless otherwise specified A = age effect, P<0.05, for both weekdays and weekend activities; S = sex effect P<0.05, F>M, M>F = females spend more time than males, or vice versa; and AxS = age by sex interaction, P<0.05.
Source: Timmer et al., 1985.

Table 9-3. Mean Time Spent Indoors and Outdoors Grouped by Age and Day of the Week

Age Group (yrs)	Time Indoors Weekday (hrs/day)	Time Indoors Weekend (hrs/day)	Time Outdoors Weekday (hrs/day)	Time Outdoors Weekend (hrs/day)
3-5	1.94	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 Category	Mean duration (mins/day)			
	CARB (n = 1762)[b]	S.E.[a]	National (n = 2762)[b]	S.E.
Indoor	1255[c]	28	1279[c]	21
Outdoor	86[d]	5	74[d]	4
In-Vehicle	98[d]	4	87[d]	2
Total Time Spent	1440		1440	

[a] S.E. = Standard Error of Mean
[b] 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.
[c] Difference between the mean values for the CARB and national studies is not statistically significant.
[d] 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 (minutes/day) in Various Microenvironments Grouped by Total Population and Gender (12 years and over) in the National and CARB Data

	National Data Mean Duration (mins/day) (standard error)[a]					
Microenvironment	N = 1284[b] Male	"Doer"[c] Male	N = 1478[b] Female	"Doer" Female	N = 2762[b] Total	"Doer" Total
Autoplaces	5 (1)	90	1 (0)	35	3 (0)	66
Restaurant/bar	22 (2)	73	20 (2)	79	21 (1)	77
In-vehicle	92 (3)	99	82 (3)	94	87 (2)	97
In-Vehicle/other	1 (1)	166	1 (0)	69	1 (0)	91
Physical/outdoors	24 (3)	139	11 (2)	101	17 (2)	135
Physical/indoors	11 (1)	84	6 (1)	57	8 (1)	74
Work/study-residence	17 (2)	153	15 (2)	150	16 (1)	142
Work/study-other	221 (10)	429	142 (7)	384	179 (6)	390
Cooking	14 (1)	35	52 (2)	67	34 (1)	57
Other activities/kitchen	54 (3)	69	90 (4)	102	73 (2)	88
Chores/child	88 (3)	89	153 (5)	154	123 93)	124
Shop/errand	23 (2)	56	38 (2)	74	31 (1)	67
Other/outdoors	70 (6)	131	43 (4)	97	56 (4)	120
Social/cultural	71 (4)	118	75 (4)	110	73 (3)	118
Leisure-eat/indoors	235 (8)	241	215 (7)	224	224 (5)	232
Sleep/indoors	491 (14)	492	496 (11)	497	494 (9)	495

	CARB Data Mean Duration (mins/day) (standard error)[a]					
Microenvironment	N = 867[b] Male	"Doer"[c] Male	N = 895[b] Female	"Doer" Female	N = 1762[b] Total	"Doer" Total
Autoplaces	31 (8)	142	9 (2)	50	20 (4)	108
Restaurant/bar	45 (4)	106	28 (3)	86	36 (3)	102
In-vehicle	105 (7)	119	85 (4)	100	95 (4)	111
In-Vehicle/other	4 (1)	79	3 (2)	106	3 (1)	94
Physical/outdoors	25 (3)	131	8 (1)	86	17 (2)	107
Physical/indoors	8 (1)	63	5 (1)	70	7 (1)	68
Work/study-residence	14 (3)	126	11 (2)	120	13 (2)	131
Work/study-other	213 (14)	398	156 (11)	383	184 (9)	450
Cooking	12 (1)	43	42 (2)	65	27 (1)	55
Other activities/kitchen	38 (3)	65	60 (4)	82	49 (2)	74
Chores/child	66 (4)	75	134 (6)	140	100 (4)	109
Shop/errand	21 (3)	61	41 (3)	78	31 (2)	70
Other/outdoors	95 (9)	153	44 (4)	82	69 (5)	117
Social/cultural	47 (4)	112	59 (5)	114	53 (3)	112
Leisure-eat/indoors	223 (10)	240	251 (10)	263	237 (7)	250
Sleep/indoors	492 (17)	499	504 (15)	506	498 (12)	501

a Standard error of the mean
b Weighted number
c Doer = Respondents who reported participating in each activity/location spent in microenvironments.
Source: Robinson and Thomas, 1991.

Table 9-6. Mean Time Spent (minutes/day) in Various Microenvironments by Type of Day for the California and National Surveys (sample population ages 12 years and older)

Weekday Microenvironment	Mean Duration (standard error)[a] (mins/day)		Mean Duration for "Doer"[b] (mins/day)	
	CARB (n=1259)[c]	NAT (n=1973)[c]	CARB	NAT
1 Autoplaces	21 (5)	3 (1)	108	73
2 Restaurant/Bar	29 (3)	20 (2)	83	73
3 In-Vehicle/Internal Combustion	90 (5)	85 (2)	104	95
4 In-Vehicle/Other	3 (1)	1 (0)	71	116
5 Physical/Outdoors	14 (2)	15 (2)	106	118
6 Physical/Indoors	7 (1)	8 (1)	64	68
7 Work/Study-Residence	14 (2)	16 (2)	116	147
8 Work/Study-Other	228 (11)	225 (8)	401	415
9 Cooking	27 (2)	35 (2)	58	57
10 Other Activities/Kitchen	51 (3)	73 (3)	76	87
11 Chores/Child	99 (5)	124 (4)	108	125
12 Shop/Errand	30 (2)	30 (2)	67	63
13 Other/Outdoors	67 (6)	51 (4)	117	107
14 Social/Cultural	42 (3)	62 (3)	99	101
15 Leisure-Eat/Indoors	230 (9)	211 (6)	244	218
16 Sleep/Indoors	490 (14)	481 (10)	495	483

Weekend Microenvironment	Mean Duration (standard error)[a] (mins/day)		Mean Duration for "Doer"[b] (mins/day)	
	CARB (n=503)[c]	NAT (n=789)[c]	CARB	NAT
1 Autoplaces	19 (4)	3 (1)	82	62
2 Restaurant/Bar	55 (6)	23 (2)	127	84
3 In-Vehicle/Internal Combustion	108 (8)	91 (6)	125	100
4 In-Vehicle/Other	5 (3)	0 (0)	130	30
5 Physical/Outdoors	23 (3)	23 (4)	134	132
6 Physical/Indoors	7 (1)	9 (2)	72	80
7 Work/Study-Residence	10 (2)	15 (3)	155	165
8 Work/Study-Other	74 (11)	64 (6)	328	361
9 Cooking	27 (2)	34 (2)	60	55
10 Other Activities/Kitchen	44 (3)	73 (4)	71	90
11 Chores/Child	103 (7)	120 (5)	114	121
12 Shop/Errand	35 (4)	35 (3)	81	75
13 Other/Outdoors	74 (7)	67 (7)	126	132
14 Social/Cultural	79 (7)	99 (6)	140	141
15 Leisure-Eat/Indoors	256 (12)	257 (11)	273	268
16 Sleep/Indoors	520 (20)	525 (17)	521	525

[a] Standard Error of Mean
[b] Doer = Respondent who reported participating in each activity/location spent in microenvironments.
[c] Weighted Number
Source: Robinson and Thomas, 1991.

Table 9-7. Mean Time Spent (minutes/day) in Various Microenvironments by Age Groups for the National and California Surveys

Microenvironment	National Data Mean Duration (Standard Error)[a]			
	Age 12-17 years N=340[b]	"Doer"[c]	Age 18-24 years N=340	"Doer"
Autoplaces	2 (1)	73	7 (2)	137
Restaurant/bar	9 (2)	60	28 (3)	70
In-vehicle/internal combustion	79 (7)	88	103 (8)	109
In-vehicle/other	0 (0)	12	1 (1)	160
Physical/outdoors	32 (8)	130	17 (4)	110
Physical/indoors	15 (3)	87	8 (2)	76
Work/study-residence	22 (4)	82	19 (6)	185
Work/study-other	159 (14)	354	207 (20)	391
Cooking	11 (3)	40	18 (2)	39
Other activities/kitchen	53 (4)	64	42 (3)	55
Chores/child	91 (7)	92	124 (9)	125
Shop/errands	26 (4)	68	31 (4)	65
Other/outdoors	70 (13)	129	34 (4)	84
Social/cultural	87 (10)	120	100 (12)	141
Leisure-eat/indoors	237 (16)	242	181 (11)	189
Sleep/indoors	548 (31)	551	511 (26)	512
Microenvironment	**CARB Data Mean Duration (Standard Error)[a]**			
	Age 12-17 years N=183[b]	"Doer"[c]	Age 18-24 years N=250	"Doer"
Autoplaces	16 (8)	124	16 (4)	71
Restaurant/bar	16 (4)	44	40 (8)	98
In-vehicle/internal combustion	78 (11)	89	111 (13)	122
In-vehicle/other	1 (0)	19	3 (1)	60
Physical/outdoors	32 (7)	110	13 (3)	88
Physical/indoors	20 (4)	65	5 (2)	77
Work/study-residence	25 (5)	76	30 (11)	161
Work/study-other	196 (30)	339	201 (24)	344
Cooking	3 (1)	19	14 (2)	40
Other activities/kitchen	31 (4)	51	31 (5)	55
Chores/child	72 (11)	77	79 (8)	85
Shop/errands	14 (3)	50	35 (7)	71
Other/outdoors	58 (8)	78	80 (15)	130
Social/cultural	63 (14)	109	65 (10)	110
Leisure-eat/indoors	260 (27)	270	211 (19)	234
Sleep/indoors	557 (44)	560	506 (30)	510

[a] Standard error.
[b] All N's are weighted number.
[c] Doer = Respondents who reported participating in each activity/location spent in microenvironments.
Source: Robinson and Thomas, 1991.

Table 9-8. Mean Time (minutes/day) Children Ages 12 Years and Under Spent in Ten Major Activity Categories for All Respondents

Activity Category	Mean Duration (mins/day)	% Doing	Mean Duration for Doers[b] (mins/day)	Median Duration for Doer (mins/day)	Maximum Duration for Doers (mins/day)	Detailed Activity with Highest Avg. Minutes (code)
Work-related[a]	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] Includes eating at school or daycare, an activity not grouped under the "education activities" (codes 50-59, 549).
[b] "Doers" indicate the respondents who reported participating in each activity category.
[c] Personal care includes night sleepand 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 Ten Major Activity Categories Grouped by Age and Gender

Activity Category	Mean Duration (minutes/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 N's	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 Ten Major Activity Categories Grouped by Seasons and Regions

Activity Category	Mean Duration (minutes/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 (minutes/day)

Location Category	Mean Duration (mins)	% Doing	Mean Duration for Doers (mins)	Median Duration for Doers (mins)	Maximum Duration for Doers (mins)	Detailed Location with Highest Avg. Time
Home	1,078	99	1,086	1,110	1,440	Home - bedroom
School/Childcare	109	33	330	325	1,260	School or daycare facility
Friend's/Other's House	80	32	251	144	1,440	Friend's/other's house - bedroom
Stores, Restaurants, Shopping Places	24	35	69	50	475	Shopping mall
In-transit	69	83	83	60	1,111	Traveling in car
Other Locations	79	57	139	105	1,440	Park, playground
Don't Know/Not Coded	<1	1	37	30	90	--
All Locations	1,440					

Source: Wiley et al., 1991.

Table 9-12. Mean Time Children Spent in Six Location Categories Grouped by Age and Gender

	Mean Duration (minutes/day)									
	Boys					Girls				
Location Category	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
Home	1,157	1,134	1,044	1,020	1,094	1,151	1,099	1,021	968	1,061
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]	1,439	1,440	1,439	1,440	1,439	1,438	1,440	1,440	1,440	1,440
Sample Sizes (Unweighted)	172	151	145	156	624	141	151	124	160	576

[a] The column totals may not sum to 1,440 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 Category	Mean Duration (minutes/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	1,091	1,042	1,097	1,081	1,078	1,078	1,078	1,078	1,078
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]	1,439	1,439	1,440	1,439	1,439	1,439	1,440	1,440	1,439
Sample Sizes (Unweighted N's)	318	204	407	271	1,200	224	263	713	1,200

[a] The column totals may not sum to 1,440 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 Exposures	Mean Duration (minutes/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 N's)	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.

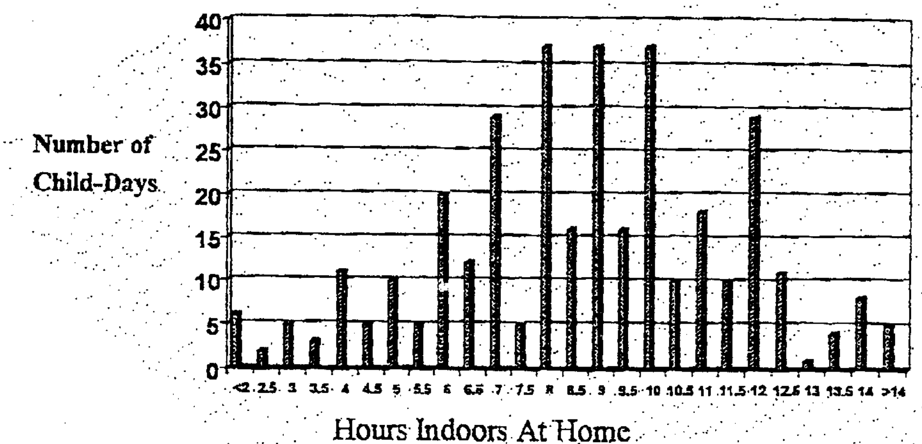


Figure 9-1. Distribution of the Number of Hours per Day Study Children Spent Indoors at Home

Source: Davis 1995.

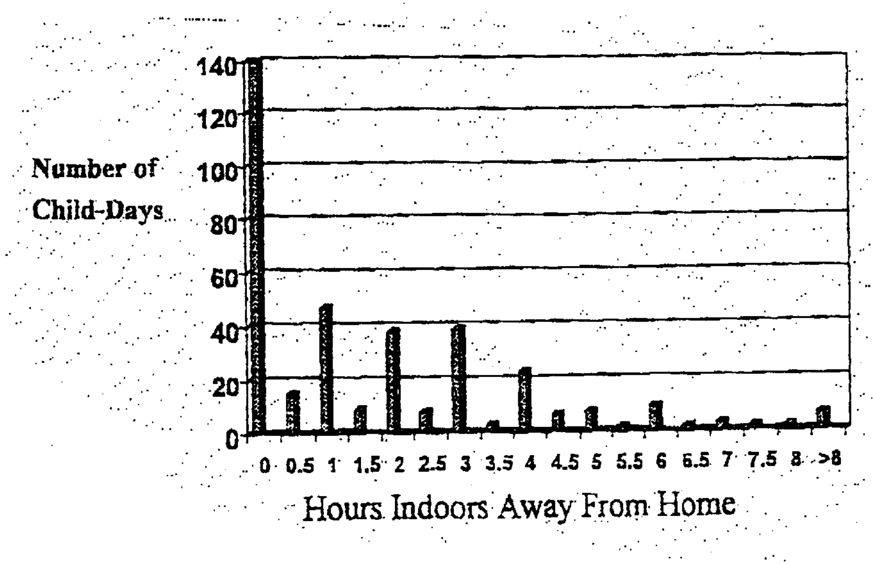


Figure 9-2. Distribution of the Number of Hours per Day Study Children Spent Indoors Away from Home

Source: Davis 1995.

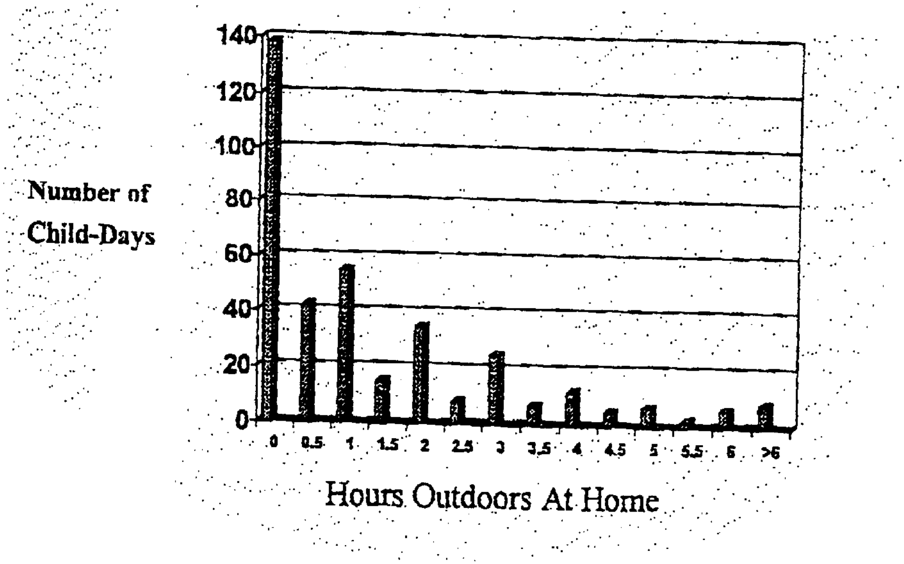


Figure 9-3. Distribution of the Number of Hours per Day Study Children Spent Outdoors at Home

Source: Davis 1995.

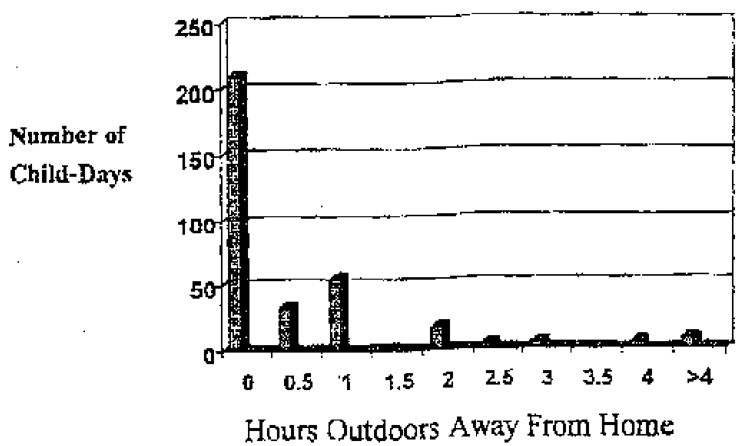


Figure 9-4. Distribution of the Number of Hours per Day Study Children Spent Outdoors Away at Home

Source: Davis 1995.

Table 9-15. Mean Time Spent Indoors and Outdoors Grouped by Age

Age Groups	Time Indoors (hours/day)	Time Outdoors (hours/day)
0-2	20	4
3-5	18.8	5.2
6-8	19.7	4.4
9-11	19.9	4.1

Table 9-16. Range of Recommended Defaults for Dermal Exposure Factors

	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	9 years	30 years	9 years	30 years	9 years	30 years

[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 at Specified Daily Frequencies by the Number of Respondents

		TImes/Day									
	Total N	0	1	2	3	4	5	8	10	11:1-0+	DK
Age (years)											
1-4	41	*	30	9	1	*	*	*	*	*	1
5-11	140	*	112	26	1	*	*	*	*	*	1
12-17	270	*	199	65	6	*	*	*	*	*	*

Note: * Signifies missing data; Dk= don't know; N = sample size.
Source: Tsang and Klepeis,1996

Table 9-18. Time (minutes) Spent Taking a Shower and Spent in the Shower Room
After Taking a Shower by the Number of Respondents

	Total N	Minutes/Shower							
		-	0-10	10-20	20-30	30-40	40-50	50-60	60-61
Times (minutes) Spent Taking Showers by the Number of Respondents									
Age									
1-4	41	1	13	14	10	1	*	2	*
5-11	140	1	60	52	18	3	2	4	*
12-17	270	2	94	104	40	13	9	7	1
Time (minutes) Spent in the Shower Room Immediately After Showering by the Number of Respondents									
Age (years)									
1-4	41	*	5	31	3	1	*	1	*
5-11	140	3	9	110	14	3	*	*	1
12-17	270	1	17	206	29	10	3	2	1

NOTE: * - Missing data; DK = don’t know; N = sample size; Refused = Refused to answer. A value of 61 for number of minutes signifies that more than 60 minutes were spent.
Source: Tsang and Klepeis, 1996.

Table 9-19. Time (minutes) Spent Taking a Shower and Spent in the Shower Immediately After Showering

Table 9-19. Time (minutes) Spent Taking a Shower and Spent in the Shower Immediately After Showering

Category	Population Group	Total N	Percentiles											
			1	2	5	10	25	50	75	91	95	98	99	100
Number of Minutes Spent Taking a Shower (minutes/shower)														
Age (years)	1-4	40	5	5	5	5	5	10	17.5	30	50	60	60	60
Age (years)	5-11	139	3	4	5	5	10	15	20	30	40	60	60	60
Age (years)	12-17	268	5	5	5	7	10	15	25	35	45	60	60	61
Number of Minutes Spent in the Shower Room Immediately After Showering (minutes/shower)														
Age (years)	1-4	41	0	0	0	0	1	5	10	15	20	45	45	45
Age (years)	5-11	137	0	0	0	1	2	5	10	15	20	30	30	60
Age (years)	12-17	2619	0	0	0	1	3	5	10	20	30	40	52	61

NOTE: N = doer sample size. Percentiles are the percentage of doers below or equal to a given number of minutes. 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 Altogether in the Shower or Bathtub and Time Spent in the Bathroom Immediately After by Number of Respondents

	Total N	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															
Age (years)															
1-4	198	*	*	35	84	50	2	13	7	1	1	1	*	4	*
5-11	265	2	*	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															
Age (years)															
1-4	198	2	59	123	12	*	1	1	*	*	*	*	*	*	*
5-11	265	5	33	198	23	3	1	*	1	*	*	*	*	1	*
12-17	239	1	17	165	34	16	1	3	2	*	*	*	*	*	*

Note: * Signifies missing data. DK = respondents answered "don't know". Refused = respondents refused to answer. N = doer sample size in specified range of number of minutes spent. A value of "121" for number of minutes signifies that more than 120 minutes were spent.
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

Category	Population Group	N	Percentiles											
			1	2	5	10	25	50	75	90	95	98	99	100
Total Number of Minutes Spent Altogether in the Shower or Bathtub (minutes/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
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 (minutes/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

Note: A value of "121" for number of minutes signifies that more than 120 minutes were spent. 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 9-22. Range of Number of Times Washing the Hands at Specified Daily Frequencies by the Number of Respondents

	Total N	Number of Times/Day								
		-	0-0	1-2	3-5	6-9	10-19	20-29	30+	DK
Age (years)										
1-4	263	*	15	62	125	35	11	2	3	10
5-11	348	1	5	61	191	48	21	4	2	15
12-17	326	3	6	46	159	64	30	7	2	9

Note: * Signifies missing data. N = doer sample size in a specified range or number of minutes spent. DK= respondents answered "don't know". Refused = respondents refused to answer.
Source: Tsang and Klepeis,1996

Table 9-23. Number of Minutes Spent Working or Being Near Excessive Dust in the Air (minutes/day)

Category	Population Group	N	Percentiles											
			1	2	5	10	25	50	75	90	95	98	99	100
Age (years)	1-4	22	0	0	0	2	5	75	121	121	121	121	121	121
Age (years)	5-11	50	0	0.5	2	4	15	75	121	121	121	121	121	121
Age (years)	12-17	52	0	1	2	5	5	20	120	121	121	121	121	121

Note: A valueof "121" for number of minutes signifies that more than 120 minutes were spent. 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 9-24. Range of Number of Times per Day a Motor Vehicle was Started in a Garage or Carport and Started with the Garage Door Closed

	Total N	Times/day 1-2	3-5	6-9	10+	Dk
Range of the Number of Times an Automobile or Motor Vehicle was Started in a Garage or Carport at Specified Daily Frequencies by the Number of Respondents						
Age(years)						
1-4	111	68	39	2	2	*
5-11	150	93	49	6	*	2
12-17	145	86	42	12	1	4
Range of the Number of Times Motor Vehicle Was Started with Garage Door Closed at Specified Daily Frequencies by the Number of Respondents						
Age (years)						
1-4	111	99	8	2	*	2
5-11	150	141	6	*	*	3
12-17	145	127	9	4	1	4

Note: "*" Signifies missing data; "DK" = respondent answered don't know; Refused - the respondent refused to answer; N = doer sample size.
Source: Tsang and Klepeis, 1996

Table 9-25. Number of Minutes Spent Playing on Sand, Gravel, Dirt, or Grass

	Total N	Minutes/Day *-*	0-0	0-10	10-20	20-30	30-40	40-50	50-60	70-80	80-90	90-100	110-120	121
Number of Minutes Spent Playing on Sand or Gravel in a Day by the Number of Respondents														
Age (years)														
1-4	216	13	115	15	9	15	2	3	15	1	5	*	7	16
5-11	200	7	96	11	12	14	*	5	25	1	2	1	6	20
12-17	41	1	23	1	2	4	*	*	3	*	*	1	3	3
Number of Minutes Spent Playing in Outdoors on Sand, Gravel, Dirt, or Grass When Fill Dirt Was Present by the Number of Respondents														
Age (years)														
*	3	*	*	1	*	*	*	*	1	*	*		*	1
1-4	216	11	118	14	10	13	1	4	18	4	*		7	16
5-11	200	15	103	14	8	15	*	1	17	1	*		9	17
12-17	41	3	19	3	2	7	*	*	4	1	*		2	*
18-64	237	23	138	19	9	13	*	1	20	1	1		3	9
> 64	3	1	2	*	*	*	*	*	*	*	*		*	*

Note: "*" = Signifies missing data. "DK" = Don't know. Refused = refused to answer. N = Doer sample size in specified range of number of minutes spent. A value of "121" for number of minutes signifies that more than 120 minutes were spent.
Source: Tsang and Klepeis, 1996.

Table 9-26. Number of Minutes Spent Playing in Sand, Gravel, Dirt or Grass (minutes/day)

			Percentiles												
Category	Population Group	N	1	2	5	10	25	50	75	90	95	98	99	100
Number of Minutes Spent Playing on Sand or Gravel (minutes/day)															
Age (years)	1-4	203	0	0	0	0	0	0	30	120	121	121	121	121
Age (years)	5-11	193	0	0	0	0	0	3	60	121	121	121	121	121
Age (years)	12-17	40	0	0	0	0	0	0	45	120	121	121	121	121
Number of Minutes Spent Playing on Sand, Gravel, Dirt, or Grass When Fill Dirt Was Present (minutes/day)															
Age (years)	1-4	205	0	0	0	0	0	0	30	120	121	121	121	121
Age (years)	5-11	185	0	0	0	0	0	0	30	120	121	121	121	121
Age (years)	12-17	38	0	0	0	0	0	0.5	30	60	120	120	120	120

NOTE: A value of "121" for number of minutes signifies that more than 120 minutes were spent. 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 9-27. Range of Number of Minutes Spent Playing on Grass in a Day by the Number of Respondents

		Minutes/Day														
	Total N	*-*	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
Age (years)																
1-4	216	10	24	19	21	25	1	4	35	*	1	8	*	1	18	49
5-11	200	15	24	10	10	19	2	3	38	1	*	8	1	*	20	49
12-17	41	2	5	1	2	8	*	1	8	*	*	1	*	*	8	5

NOTE: "*" signifies missing data. A value of "121" for number of minutes signifies that more than 120 minutes were spent. N = doer sample size. Percentiles are the percentage of doers below or equal to a given number of minutes. Refused = respondent refused to answer.
Source: Tsang and Klepeis,1996.

Table 9-28. Number of Minutes Spent Playing on Grass (minutes/day)

			Percentiles												
Category	Population Group	N	1	2	5	10	25	50	75	90	95	98	99	100
Age (years)	1-4	206	0	0	0	0	15	60	120	121	121	121	121	121
Age (years)	5-11	185	0	0	0	0	30	60	121	121	121	121	121	121
Age (years)	12-17	39	0	0	0	0	30	60	120	121	121	121	121	121

NOTE: A value of "121" for number of minutes signifies that more than 120 minutes were spent. 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 9-29. Number of Times Swimming in a Month in Freshwater Swimming Pool by the Number of Respondents

		Times/Month															
	Total N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Age (years)																	
1-4	63	11	14	7	3	3	4	1	3	1	4	*	2	1	1	2	*
5-11	100	16	15	7	9	6	4	2	4	*	7	*	5	*	*	11	2
12-17	84	21	13	7	4	8	4	2	3	1	8	*	1	*	*	2	*
		Times/Month															
	18	20	23	24	25	26	28	29	30	31	32	40	42	45	50	60	DK
Age (years)																	
1-4	*	2	*	*	*	*	*	1	2	*	1	*	*	*	*	*	*
5-11	*	3	*	1	2	*	*	*	5	*	*	*	*	*	1	*	*
12-17	1	4	*	*	*	1	*	*	2	*	*	*	*	*	*	1	1

Note: * Signifies missing data; "DK" = respondent answered don't know; N= sample size; Refused = respondent refused to answer.
Source: Tsang And Klepeis, 1996

Table 9-30. Number of Minutes Spent Swimming in a Month in Freshwater Swimming Pool (minutes/month)

Category	Population Group	N	Percentiles 1	2	5	10	25	50	75	90	95	98	99	100
Age (years)	1-4	60	3	3	7.5	15	20	42.5	120	180	181	181	181	181
Age (years)	5-11	95	2	3	20	30	45	60	120	180	181	181	181	181
Age (years)	12-17	83	4	5	15	20	40	60	120	180	181	181	181	181

Note: A Value of 181 for number of minutes signifies that more than 180 minutes were spent. 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 9-31. Range of the Average Amount of Time Actually Spent in the Water by Swimmers by the Number of Respondents

		Minutes/Month														
	Total N	*-*	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	110-120	150-150	180-180	181-181
Age (years)																
1-4	63	3	5	12	12	1	4	8	*	*	2	*	7	1	3	5
5-11	100	5	3	2	12	5	4	25	*	*	7	*	16	2	11	8
12-17	84	1	3	7	10	2	6	15	*	1	8	1	14	4	6	6

Note: * Signifies missing data. DK = respondents answered don't know. Ref = respondents refused to answer. N = doer sample size in specified range of number of minutes spent. Values of 120 , 150 , and 180 for number of minutes signify that 2 hours, 2.5 hours, and 3 hours, respectively, were spent.
Source: Tsang and Klepeis,1996.

Table 9-32. Statistics for 24-Hour Cumulative Number of Minutes Spent Playing Indoors and Outdoors

Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	Percentiles 5	25	50	75	90	95	98	99
Statistics for 24-Hour Cumulative Number of Minutes Spent in Indoor Playing															
Age (years)	1-4	11	130	80.2	24.2	15	270	15	60	115	180	255	270	270	270
Age (years)	5-11	11	93.6	64.3	19.4	30	195	30	30	60	175	180	195	195	195
Age (years)	12-17	4	82.5	45	22.5	30	120	30	45	90	120	120	120	120	120
Statistics for 24-Hour Cumulative Number of Minutes Spent in Outdoor Playing															
Age (years)	1-4	4	83.25	89.66	44.83	15	210	15	20	54	146.5	210	210	210	210
Age (years)	5-11	9	148.333	144.265	48.088	5	360	5	55	60	280	360	360	360	360
Age (years)	12-17	1	15	*	*	15	15	15	15	15	15	15	15	15	15

Note: A "*" Signifies missing data. "DK" = The respondent replied "don't know". N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.
Source: Tsang and Klepeis, 1996.

Table 9-33. Statistics for 24-Hour Cumulative Number of Minutes Spent Sleeping/Napping

Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	Percentiles 5	25	50	75	90	95	98	99
Age (years)	1-4	499	732.363	124.328	5.5657	270	1320	540	655	720	810	900	930	1005	1110
Age (years)	5-11	702	625.058	100.656	3.799	120	1110	480	570	630	680	725	780	840	875
Age (years)	12-17	588	563.719	110.83	4.5706	150	1015	395	484	550	630	705	750	810	900

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.
Source: Tsang and Klepeis, 1996.

Table 9-34. Statistics for 24-Hour Cumulative Number of Minutes Spent Attending Full Time School

Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	Percentiles 5	25	50	75	90	95	98	99
Age (years)	1-4	56	365.036	199.152	26.6128	20	710	30	172.5	427.5	530	595	628	665	710
Age (years)	5-11	297	387.811	98.013	5.6873	60	645	170	360	390	435	485	555	600	630
Age (years)	12-17	271	392.28	84.986	5.1625	10	605	200	375	405	435	460	485	510	555

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.
Source: Tsang and Klepeis, 1996.

Table 9-35. Statistics for 24-Hour Cumulative Number of Minutes Spent in Active Sports and for Time Spent in Sports/Exercise

Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	Percentiles 5	25	50	75	90	95	98	99
Statistics for 24-Hour Cumulative Number of Minutes Spent in Active Sports															
Age (years)	1-4	105	115.848	98.855	9.6472	10	630	30	45	90	159	250	330	345	390
Age (years)	5-11	247	148.87	126.627	8.0571	2	975	20	60	120	188	320	390	510	558
Age (years)	12-17	215	137.46	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 (a)															
Age (years)	1-4	114	118.982	109.17	10.2247	10	670	25	45	90	159	250	330	390	630
Age (years)	5-11	262	153.496	130.58	8.0673	2	975	20	60	120	200	330	415	525	580
Age (years)	12-17	237	134.717	122.228	7.9396	5	1065	15	60	110	179	265	360	470	520

a Includes active sports, exercise, hobbies.

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.
Source: Tsang and Klepeis, 1996.

Table 9-36. Statistics for 24-Hour Cumulative Number of Minutes Spent in Outdoor Recreation and Spent Walking

Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	Percentiles 5	25	50	75	90	95	98	99
Statistics for 24-Hour Cumulative Number of Minutes Spent in Outdoor Recreation															
Age (years)	1-4	13	166.54	177.06	49.109	15	630	15	30	130	180	370	630	630	630
Age (years)	5-11	21	206.14	156.17	34.078	30	585	60	90	165	245	360	574	585	585
Age (years)	12-17	27	155.07	128.28	24.687	5	465	5	60	135	225	420	420	465	465
Statistics for 24-Hour Cumulative Number of Minutes Spent Walking															
Age (years)	1-4	58	24.3276	26.3268	3.4569	1	160	2	10	15	35	60	60	70	160
Age (years)	5-11	155	18.2129	21.0263	1.6889	1	170	1	5	10	25	40	60	65	100
Age (years)	12-17	223	25.8341	32.3753	2.168	1	190	2	6	15	30	60	100	135	151

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.
Source: Tsang and Klepeis, 1996.

Table 9-37. Statistics for 24-Hour Cumulative Number of Minutes Spent in Bathing (a)

								Percentiles							
Group Name	Group Code	N	Mean	Stdev	Stderr	Min	Max	5	25	50	75	90	95	98	99
Age (years)	1-4	330	29.9727	19.4226	1.0692	1	170	10	15	30	31	54.5	60	85	90
Age (years)	5-11	438	25.7511	35.3164	1.6875	1	690	5	15	20	30	45	60	60	75
Age (years)	12-17	444	23.1216	18.7078	0.8878	1	210	5	10	18	30	45	60	65	90

a Includes baby and child care, personal care services, washing and personal hygiene (bathing, showering, etc.)

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.

Source: Tsang and Klepeis, 1996.

Table 9-38. Statistics for 24-Hour Cumulative Number of Minutes Eating or Drinking

								Percentiles							
Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	5	25	50	75	90	95	98	99
Age (years)	1-4	492	93.4837	52.8671	2.3834	2	345	20	60	90	120	160	190	225	270
Age (years)	5-11	680	68.5412	38.9518	1.4937	5	255	15	40	65	90	120	142.5	165	195
Age (years)	12-17	538	55.8587	34.9903	1.5085	2	210	10	30	50	75	105	125	150	170

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.
Source: Tsang and Klepeis, 1996.

Table 9-39. Statistics for 24-Hour Cumulative Number of Minutes Spent Indoors at School and Indoors at a Restaurant

								Percentiles							
Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	5	25	50	75	90	95	98	99
Statistics for 24-Hour Cumulative Number of Minutes Spent Indoors at School															
Age (years)	1-4	43	288.465	217.621	33.187	5	665	10	60	269	500	580	595	665	665
Age (years)	5-11	302	396.308	109.216	6.285	5	665	170	365	403	445	535	565	625	640
Age (years)	12-17	287	402.551	125.512	7.409	15	855	120	383	420	450	500	565	710	778
Statistics for 24-Hour Cumulative Number of Minutes Spent Indoors at a Restaurant															
Age (years)	1-4	61	62.705	47.701	6.1075	4	330	10	35	55	85	115	120	130	330
Age (years)	5-11	84	56.69	38.144	4.1618	5	180	10	30	45	85	120	120	140	180
Age (years)	12-17	122	69.836	78.361	7.0945	2	455	10	30	45	65	165	250	325	360

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.

Source: Tsang and Klepeis, 1996.

Table 9-40. Statistics for 24-Hour Cumulative Number of Minutes Spent Outdoors on School Grounds/Playground, at a Park/Golf Course, and at a Pool/River/Lake

								Percentiles							
Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	5	25	50	75	90	95	98	99
Statistics for 24-Hour Cumulative Number of Minutes Spent Outdoors on School Grounds/Playground															
Age (years)	1-4	9	85	61.084	20.36	10	175	10	30	65	140	175	175	175	175
Age (years)	5-11	64	88.016	95.638	11.96	5	625	10	30	60	120	170	220	315	625
Age (years)	12-17	76	78.658	88.179	10.12	3	570	5	25	55	105	165	225	370	570
Age (years)	18-64	101	119.812	127.563	12.69	1	690	5	30	85	165	240	360	540	555
Age (years)	> 64	7	65	47.258	17.86	5	150	5	30	60	95	150	150	150	150
Statistics for 24-Hour Cumulative Number of Minutes Spent Outdoors at a Park/Golf Course															
Age (years)	1-4	21	149.857	176.25	38.4609	21	755	25	50	85	150	360	425	755	755
Age (years)	5-11	54	207.556	184.496	25.1068	25	665	35	70	125	275	555	635	660	665
Age (years)	12-17	52	238.462	242.198	33.5869	15	1065	15	60	147.5	337.5	590	840	915	1065
Statistics for 24-Hour Cumulative Number of Minutes Spent Outdoors at a Pool/River/Lake															
Age (years)	1-4	14	250.571	177.508	47.441	90	630	90	130	167.5	370	560	630	630	630
Age (years)	5-11	29	175.448	117.875	21.889	25	390	30	60	145	293	365	375	390	390
Age (years)	12-17	22	128.318	94.389	20.124	40	420	58	60	82.5	210	225	235	420	420

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.

Source: Tsang and Klepeis, 1996.

Table 9-41. Statistics for 24-Hour Cumulative Number of Minutes Spent at Home in the Kitchen Bathroom, Bedroom, and in a Residence (All Rooms)

Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	Percentiles 5	25	50	75	90	95	98	99
Statistics for 24-Hour Cumulative Number of Minutes Spent at Home in the Kitchen															
Age (years)	1-4	335	73.719	54.382	2.9712	5	392	15	30	60	100	140	180	225	240
Age (years)	5-11	477	60.468	52.988	2.4262	1	690	10	30	50	75	120	150	180	235
Age (years)	12-17	396	55.02	58.111	2.9202	1	450	5	15	36	65	125	155	240	340
Statistics for 24-Hour Cumulative Number of Minutes Spent in the Bathroom															
Age (years)	1-4	328	35.939	46.499	2.5675	1	600	10	15	30	40	60	75	125	270
Age (years)	5-11	490	30.9673	38.609	1.7442	1	535	5	15	27	35	52.5	60	100	200
Age (years)	12-17	445	29.0517	32.934	1.5612	1	547	5	15	20	35	60	65	90	100
Statistics for 24-Hour Cumulative Number of Minutes Spent at Home in the Bedroom															
Age (years)	1-4	488	741.988	167.051	7.562	30	1440	489	635	740	840	930	990	1095	1200
Age (years)	5-11	689	669.144	162.888	6.2055	35	1440	435	600	665	740	840	915	1065	1140
Age (years)	12-17	577	636.189	210.883	8.7792	15	1375	165	542	645	750	875	970	1040	1210
Statistics for 24-Hour Cumulative Number of Minutes Spent Indoors in a Residence (all rooms)															
Age (years)	1-4	498	1211.64	218.745	9.8022	270	1440	795	1065	1260	1410	1440	1440	1440	1440
Age (years)	5-11	700	1005.13	222.335	8.4035	190	1440	686	845	975	1165	1334	1412.5	1440	1440
Age (years)	12-17	588	969.5	241.776	9.9707	95	1440	585	811.5	950	1155	1310	1405	1440	1440

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.

Source: Tsang and Klepeis, 1996.

Table 9-42. Statistics for 24-Hour Cumulative Number of Minutes Spent Traveling Inside a Vehicle

								Percentiles									
Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	5	25	50	75	90	95	98	99
Age (years)	1-4	335	68.116	75.531	4.1267	1	955	10	30	47	85	150	200	245	270
Age (years)	5-11	571	71.033	77.62	3.2483	1	900	10	25	51	90	140	171	275	360
Age (years)	12-17	500	81.53	79.8	3.5687	1	790	10	30	60	100	165.5	232.5	345	405

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.

Source: Tsang and Klepeis, 1996.

Table 9-43. Statistics for 24-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

								Percentiles							
Group Name	Group Code	N	Mean	Stdev	Stderr	Min	Max	5	25	50	75	90	95	98	99
Statistics for 24-Hour Cumulative Number of Minutes Spent Outdoors (outside the residence)															
Age (years)	1-4	201	195.652	163.732	11.5488	3	715	30	75	135	270	430	535	625	699
Age (years)	5-11	353	187.564	158.575	8.4401	4	1250	20	80	150	265	365	479	600	720
Age (years)	12-17	219	135.26	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															
Age (years)	1-4	54	164.648	177.34	24.133	1	980	10	60	120	175	370	560	630	980
Age (years)	5-11	159	171.34	177.947	14.112	5	1210	15	55	115	221	405	574	660	725
Age (years)	12-17	175	156.903	174.411	13.184	5	1065	10	45	100	210	385	570	735	915

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.

Source: Tsang and Klepeis, 1996.

Table 9-44. Statistics for 24-Hour Cumulative Number of Minutes Spent in Malls, Grocery Stores, or Other Stores

								Percentiles							
Group Name	Group Code	N	Mean	Stdev	Stderr	Min	Max	5	25	50	75	90	95	98	99
Age (years)	1-4	110	90.036	77.887	7.4263	5	420	10	40	65	105	210	250	359	360
Age (years)	5-11	129	77.674	68.035	5.9901	3	320	5	30	60	110	180	225	255	280
Age (years)	12-17	140	88.714	101.361	8.5666	1	530	5	20	45	123.5	222.5	317.5	384	413

Note: "DK" = The respondent replied "don't know". Refused = Refused data. N = doer sample size. Mean = Mean 24-hour cumulative number of minutes for doers. Stdev = standard deviation. Stderr = standard error. Min = minimum number of minutes. Max = maximum number of minutes. Percentiles are the percentage of doers below or equal to a given number of minutes.

Source: Tsang and Klepeis, 1996.

Table 9-45. Statistics for 24-hour Cumulative Number of Minutes Spent with Smokers Present

Category	Population Group	N	Mean	Stdev	Stderr	Min	Max	Percentiles							
								5	25	50	75	90	95	98	99
Age (years)	1-4	155	366.56	324.46	26.062	5	1440	30	90	273	570	825	1010	1140	1305
Age (years)	5-11	224	318.07	314.02	20.981	1	1440	25	105	190	475	775	1050	1210	1250
Age (years)	12-17	256	245.77	243.61	15.226	1	1260	10	60	165	360	595	774	864	1020

Table 9-46. Range of Time (minutes) Spent Smoking Based on the Number of Respondents

	Total N	Number of Minutes											
		-	0-60	60-120	120-180	180-240	240-300	300-360	360-420	420-480	480-540	540-600	600-660
Age (years)													
1-4	499	344	29	23	14	8	10	7	8	7	8	7	5
5-11	703	479	40	38	32	23	10	9	6	12	6	11	6
12-17	589	333	75	31	30	20	22	15	13	7	13	5	3

	Number of Minutes												
	660-720	720-780	780-840	840-900	900-960	960-1020	1020-1080	1080-1140	1140-1200	1200-1260	1260-1320	1320-1380	1380-1440
Age (years)													
1-4	3	5	6	3	2	3	2	2	1	*	1	*	1
5-11	7	2	5	2	*	1	5	2	2	3	*	*	2
12-17	7	3	5	3	1	1	*	*	*	2	*	*	*

Note: * = Missing Data; DK =Don't know; N = Number of Respondents; Refused = Respondent Refused to Answer.
Source: Tsang And Klepeis, 1996.

Table 9-47. Number of Minutes Spent Smoking (minutes/day)

			Percentiles											
Category	Population Group	N	1	2	5	10	25	50	75	90	95	98	99	100
Age (years)	1-4	499	0	0	0	0	0	0	75	455	735	975	1095	1440
Age (years)	5-11	703	0	0	0	0	0	0	82	370	625	975	1140	1440
Age (years)	12-17	589	0	0	0	0	0	0	130	377	542	810	864	1260

Note: 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 9-48. Gender and Age Groups

Gender-Age Group	Subgroup	n	Age Range
Adolescents	Males	98	12-17 years
	Females	85	12-17 years
Children[a]	Young males	145	6-8 years
	Young females	124	6-8 years
	Old males	156	9-11 years
	Old females	160	9-11 years

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 9-49. 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	Oudoor 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 9-50. Aggregate Time Spent (minutes/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 Ve category (minutes/day).
b Significantly differ from adolescents ($p < 0.05$).
c Represents time spent at-home by individuals participating in high ventilation levels.

Source: Funk et al., 1998.

Table 9-51. Comparison of Mean Time (minutes/day) Spent At-Home by Gender[a] (Adolescents)

Activity Group	Male		Female	
	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 9-52. Comparison of Mean Time (minutes/day) Spent At-Home by Gender and Age for Children[a]

Activity Group	Males				Females			
	6-8 Years		9-11 Years		6-8 Years		9-11 Years	
	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 Ve category (minutes/day)
b Participants in high Ve activities

Source: Funk et al., 1998.

Table 9-53. Number of Person-Days/Individuals[a] for Children in CHAD[a] Database

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] CHAD - Consolidated Human Activity Database is available on U.S. EPA Intranet.
[b] The California study referred to in this table is the Wiley 1991 study.
[c] The Cincinnati study referred to in this table is the Johnson 1989 study.

The number of person-days of data are the same as the number of individuals for all studies except for the Cincinnati study. Since up to three 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.

Source: Hubal et al., 2000.

Table 9-54. Number of Hours Per Day Children Spend in Various Microenvironments by Age
Average ± Std. Dev. (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 9-55. Average Number of Hours Per Day Children Spend Doing Various Macroactivities *While Indoors at Home* by Age
(Percent of Children Reporting >0 Hours for Microenvironment/macroactivity)

Age (year)	Eat	Sleep or Nap	Shower or Bathe	Play Games	Watch TV or Listen to Radio	Read, Write, Homework	Think, Relax, 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 9-56. 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 reproducing these 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 US	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 4 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 3-17 years old.	High
• Representativeness of the population	The study focused on activities of children.	High
• Characterization of variability	Variability was characterized by age, gender, and 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 since 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 9-56. Confidence in Activity Patterns Recommendations (cont'd)

Considerations	Rationale	Rating
TIME SPENT SHOWERING		
<u>Study Elements</u>		
• Level of peer review	The study received high level of peer review.	High
• Accessibility	Currently, raw data are available to only 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 focused on time spent showering.	High
• Data pertinent to US	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 which, in addition to 24-hour diaries, collected 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 9,386 total participants consisting of all ages.	High
• 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 are based on 24-hour recall.	Medium
<u>Other Elements</u>		
• Number of studies	One; the study was a national study.	Low
• Agreement between researchers	Recommendation is based on only one study but it is a widely accepted study and average value is comparable to a second key study.	High
Overall Rating		**High**

Table 9-56. Confidence in Activity Patterns Recommendations (cont'd)

Considerations	Rationale	Rating
SHOWER FREQUENCY		
Study Elements		
• Level of peer review	The study received high level of peer review.	High
• Accessibility	Currently, raw data is available to only 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 US	The data represents 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 which, in addition to 24-hour diaries, collected information on temporal conditions and demographic data such as geographic location and socioeconomic status for various U.S. subgroups. Responses were weighted according to this demographic data.	High
• Study size	The study consisted of 9,386 total participants consisting of all age groups	High
• 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		**High**

Table 9-56. Confidence in Activity Patterns Recommendations (cont'd)

Considerations	Rationale	Rating
TIME SPENT SWIMMING		
<u>Study Elements</u>		
• Level of peer review	Study received high level of peer review.	High
• Accessibility	Currently, raw data is available to only 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 US	The data represents 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 which, in addition to 24-hour diaries, collected information on temporal conditions and demographic data such as geographic location and socioeconomic status for various U.S. subgroups. Responses were weighted according to this demographic data.	High
• Study size	The study consisted of 9,386 total participants consisting of all age groups	High
• 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
<u>Other Elements</u>		
• 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		**High**

Table 9-56. Confidence in Activity Patterns Recommendations (cont'd)

Considerations	Rationale	Rating
RESIDENTIAL TIME SPENT INDOORS AND OUTDOORS		
Study Elements		
• Level of peer review	The study received high level of peer review.	High
• Accessibility	Currently, raw data is available to only 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 US	The data represents 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	Data were collected between October 1992 and September 1994.	High
• Validity of approach	The study used a valid methodology and approach which, in addition to 24-hour diaries, collected information on temporal conditions and demographic data such as geographic location and socioeconomic status for various U.S. subgroups. Responses were weighted according to this demographic data.	High
• Study size	The study consisted of 9,386 total participants consisting of all age groups	High
• 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 distribitions for time spent indoors and outdoors at ones residence. 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		**High**

Table 9-56. Confidence in Activity Patterns Recommendations (cont'd)

Considerations	Rationale	Rating
TIME SPENT PLAYING ON GRASS		
Study Elements		
• Level of peer review	The study received high level of peer review.	High
• Accessibility	Currently, raw data are available to only 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 US	The data represents 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 which, in addition to 24-hour diaries, collected information on temporal conditions and demographic data such as geographic location and socioeconomic status for various U.S. subgroups. Responses were weighted according to this demographic data.	High
• Study size	The study consisted of 9,386 total participants consisting of all age groups.	High
• 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.	Not Ranked
Overall Rating		**High**

Table 9-56. Confidence in Activity Patterns Recommendations (cont'd)

Considerations	Rationale	Rating
TIME SPENT PLAYING ON GRASS		
Study Elements		
• Level of peer review	The study received high level of peer review.	High
• Accessibility	Currently, raw data are available to only 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 US	The data represents 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 which, in addition to 24-hour diaries, collected information on temporal conditions and demographic data such as geographic location and socioeconomic status for various U.S. subgroups. Responses were weighted according to this demographic data.	High
• Study size	The study consisted of 9,386 total participants consisting of all age groups.	High
• 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.	Not Ranked
Overall Rating		**High**

Table 9-57. Summary of Activity Pattern Studies

Summary of Activity Patterns Studies				
Study	Age Groups (yrs)	Sample Size	Population	Activities
Timmer (1985)	3-5, 6-8, 9-11, 12-14, 15-17	922	National	18 microenvironments
Robinson & Thomas (1991)	12-adults	1,762 (California) 2,762 (national)	California and national	16 microenvironments
Wiley (1991)	0-2, 3-5, 6-8, 9-11	1,200	California	10 microenvironments
Davis (1995)	10-60 (months)	92	Washington State	Activities grouped into indoors and outdoors
Tsang & Kleipeis (1996)	1-4, 5-11, 12-17	Varies with age groups and activities	U.S. national	23 microenvironments
Funk (1998)	6-11, 12-17	768	California	Activities grouped into low, medium, and high ventilation levels
Hubal (2000)	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	2,640	Based on Wiley (1991), Johnson (1989), and Tsang & Kleipeis (1996)	Activities grouped into indoors at home, indoors at school, outdoors at home, outdoors at part, and in vehicle

Table 9-58. Summary of Mean Time Spent Indoors and Outdoors from Several Studies

Age (years)	Time Indoors (hours/day)[1]	Time Outdoors (hours/day)[1]	Study
3-5	19	2.8	Timmer 1985
6-8	20	2.2	
9-11	20	1.8	
12-14	20	1.8	
15-17	19	1.9	
12 and older	21 (national) 21 (California)	1.2 (national 1.4 (California)	Robinson and Thomas 1991
0-2	20	4	Wiley 1991
3-5	18.8	5.2	
6-8	19.7	4.4	
9-11	19.9	4.1	

[1] Mean of weekday and weekend rounded up to two significant figures.

Table 9-59. Summary of Recommended Values for Activity Factors

Type	**Value**	**Study**
Time Indoors	Ages 3-5 years (19 hours/day) Ages 6-14 years (20 hours/day) Ages 12-17 years (19 hours/day)	Timmer et al., 1985
Time Outdoors	Ages 3-5 years (2.8 hours/day) Ages 6-8 years (2.2 hours/day) Ages 9-14 years (1.8 hours/day) Ages 15-17 years (1.9 hours/day)	
Taking Showers	10 min/day shower duration 1 shower event/day	Tsang and Klepeis, 1996 Tsang and Klepeis, 1996
Swimming	1 event/month 60 minutes/event	Tsang and Klepeis, 1996
Residential Indoors Outdoors	 18 hr/day 2 hr/day	Tsang and Klepeis, 1996
Playing on Sand or Gravel	60 min/day	Tsang and Klepeis, 1996
Playing on Grass	60 min/day	Tsang and Klepeis, 1996

TABLE OF CONTENTS

10. CONSUMER PRODUCTS 10-1
10.1 BACKGROUND 10-1
10.2 CONSUMER PRODUCTS USE STUDIES 10-1
10.3 RECOMMENDATIONS 10-2
10.4 REFERENCES FOR CHAPTER 10 10-3

LIST OF TABLES

Table 10-1. Consumer Products Found in the Typical U.S. Household 10-4
Table 10-2. Number of Minutes Spent in Activities Working with or Near Household Cleaning Agents Such as Scouring Powders or Ammonia (minutes/day) 10-7
Table 10-3 Number of Minutes Spent Using Any Microwave Oven (minutes/day) 10-7
Table 10-4. Number of Respondents Using a Humidifier at Home 10-7
Table 10-5. Number of Respondents Indicating that Pesticides Were Applied by the Professional at Home to Eradicate Insects, Rodents, or Other Pests at Specified Frequencies 10-8
Table 10-6. Number of Respondents Reporting Pesticides Applied by the Consumer at Home To Eradicate Insects, Rodents, or Other Pests at Specified Frequencies 10-8

10. CONSUMER PRODUCTS

10.1 BACKGROUND

Consumer products may contain toxic or potentially toxic chemical constituents to which children may be exposed as a result of their use. For example, methylene chloride and other solvents and carriers are common in consumer products and may have 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, frequency of use, and duration of use for various consumer products typically found in households. There are limited data available on consumer product use for the general population and especially for children. Children can be in environments where household consumer products (Table 10-1) such as cleaners, solvents, and paints are used. As such, children can be passively exposed to chemicals in these products. The studies presented in the following sections represent readily available surveys for which data were collected on the frequency and duration of use and amount of use of cleaning products, painting products, household solvent products, cosmetic and other personal care products, household equipment, pesticides, and tobacco. The reader is referred to the *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

Tsang and Klepeis (1996) - National Human Activity Pattern Survey (NHAPS) - The U.S. EPA collected information for the general population on the duration and frequency of selected activities and the time spent in selected microenvironments via 24-hour diaries. Over 9000 individuals from all age groups in 48 contiguous states participated in NHAPS. The survey was conducted between October 1992 and September 1994. Individuals were interviewed to categorize their 24-hour routines (diaries) and/or answer follow-up exposure questions that were related to exposure events. Data were collected based on selected socioeconomic (gender, age, race, education, etc.) and geographic (census region, state, etc.) factors and time/season (day of week, month) (Tsang and Klepeis, 1996). Data were collected for a maximum of 82 possible microenvironments and 91 different activities (Tsang and Klepeis, 1996).

As part of the survey, data were also collected on duration and frequency of use of selected consumer products. These data are presented in Tables 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 ranges for the number of times an activity involving a consumer product was performed.

The advantages of NHAPS is that the data were collected for a large number of individuals, 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 the *Exposure Factors Handbook* to derive appropriate exposure factors and review its associated recommendations.

10.4 REFERENCES FOR CHAPTER 10

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

U.S. EPA (1987) Methods for assessing exposure to chemical substances - Volume 7 - Methods for assessing consumer exposure to chemical substances. Washington, DC: Office of Toxic Substances. EPA Report No. 560/5-85-007.

Table 10-1. Consumer Products Found in the Typical U.S. Household[a]

Consumer Product Category	Consumer Product
Cosmetics Hygiene Products	Adhesive bandages
	Bath additives (liquid)
	Bath additives (powder)
	Cologne/perfume/aftershave
	Contact lens solutions
	Deodorant/antiperspirant (aerosol)
	Deodorant/antiperspirant (wax and liquid)
	Depilatories
	Facial makeup
	Fingernail cosmetics
	Hair coloring/tinting products
	Hair conditioning products
	Hairsprays (aerosol)
	Lip products
	Mouthwash/breath freshener
	Sanitary napkins and pads
	Shampoo
	Shaving creams (aerosols)
	Skin creams (non-drug)
	Skin oils (non-drug)
	Soap (toilet bar)
	Sunscreen/suntan products
	Talc/body powder (non-drug)
	Toothpaste
	Waterless skin cleaners
Household Furnishings	Carpeting
	Draperies/curtains
	Rugs (area)
	Shower curtains
	Vinyl upholstery, furniture
Garment Conditioning Products	Anti-static spray (aerosol)
	Leather treatment (liquid and wax)
	Shoe polish
	Spray starch (aerosol)
	Suede cleaner/polish (liquid and aerosol)
	Textile water-proofing (aerosol)
Household Maintenance Products	Adhesive (general) (liquid)
	Bleach (household) (liquid)
	Bleach (see laundry)
	Candles
	Cat box litter
	Charcoal briquets
	Charcoal lighter fluid
	Drain cleaner (liquid and powder)
	Dishwasher detergent (powder)
	Dishwashing liquid
	Fabric dye (DIY)[b]
	Fabric rinse/softener (liquid)

Table 10-1. Consumer Products Found in the Typical U.S. Household[a] (continued)

Consumer Product Category	Consumer Product
Household Maintenance Products (continued)	Fabric rinse/softener (powder)
	Fertilizer (garden) (liquid)
	Fertilizer (garden) (powder)
	Fire extinguishers (aerosol)
	Floor polish/wax (liquid)
	Food packaging and packaged food
	Furniture polish (liquid)
	Furniture polish (aerosol)
	General cleaner/disinfectant (liquid)
	General cleaner (powder)
	General cleaner/disinfectant (aerosol and pump)
	General spot/stain remover (liquid)
	General spot/stain remover (aerosol and pump)
	Herbicide (garden-patio) (Liquid and aerosol)
	Insecticide (home and garden) (powder)
	Insecticide (home and garden) (aerosol and pump)
	Insect repellent (liquid and aerosol)
	Laundry detergent/bleach (liquid)
	Laundry detergent (powder)
	Laundry pre-wash/soak (powder)
	Laundry pre-wash/soak (liquid)
	Laundry pre-wash/soak (aerosol and pump)
	Lubricant oil (liquid)
	Lubricant (aerosol)
	Matches
	Metal polish
	Oven cleaner (aerosol)
	Pesticide (home) (solid)
	Pesticide (pet dip) (liquid)
	Pesticide (pet) (powder)
	Pesticide (pet) (aerosol)
	Pesticide (pet) (collar)
	Petroleum fuels (home((liquid and aerosol)
	Rug cleaner/shampoo (liquid and aerosol)
	Rug deodorizer/freshener (powder)
	Room deodorizer (solid)
	Room deodorizer (aerosol)
	Scouring pad
	Toilet bowl cleaner
	Toiler bowl deodorant (solid)
	Water-treating chemicals (swimming pools)
Home Building/Improvement Products (DIY)[b]	Adhesives, specialty (liquid)
	Ceiling tile
	Caulks/sealers/fillers
	Dry wall/wall board
	Flooring (vinyl)
	House Paint (interior) (liquid)
	House Paint and Stain (exterior) (liquid)
	Insulation (solid)
	Insulation (foam)

Table 10-1. Consumer Products Found in the Typical U.S. Household[a] (continued)

Consumer Product Category	Consumer Product
Home Building/Improvement Products (DIY)[b] (Continued)	Paint/varnish removers
	Paint thinner/brush cleaners
	Patching/ceiling plaster
	Roofing
	Refinishing products (polyurethane, varnishes, etc.)
	Spray paints (home) (aerosol)
	Wall paneling
	Wall paper
	Wall paper glue
Automobile-related Products	Antifreeze
	Car polish/wax
	Fuel/lubricant additives
	Gasoline/diesel fuel
	Interior upholstery/components, synthetic
	Motor oil
	Radiator flush/cleaner
	Automotive touch-up paint (aerosol)
	Windshield washer solvents
Personal Materials	Clothes/shoes
	Diapers/vinyl pants
	Jewelry
	Printed material (colorprint, newsprint, photographs)
	Sheets/towels
	Toys (intended to be placed in mouths)

[a] A subjective listing based on consumer use profiles.
[b] DIY = Do It Yourself.
Source: U.S. EPA, 1987.

Table 10-2. Number of Minutes Spent in Activities Working with or Near Household Cleaning Agents Such as Scouring Powders or Ammonia (minutes/day)

			Percentiles											
Category	Population Group	N	1	2	5	10	25	50	75	90	95	98	99	100
Age (years)	1-4	21	0	0	0	0	5	10	15	20	30	121	121	121
Age (years)	5-11	26	1	1	2	2	3	5	15	30	30	30	30	30
Age (years)	12-17	41	0	0	0	0	2	5	10	40	60	60	60	60
Age (years)	18-64	672	0	0	1	2	5	10	20	60	121	121	121	121
Age (years)	> 64	127	0	0	0	1	3	5	15	30	60	120	121	121

Note: A value of "121" for number of minutes signifies that more than 120 minutes were spent; 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 10-3 Number of Minutes Spent Using Any Microwave Oven (minutes/day)

			Percentiles											
Category	Population Group	N	1	2	5	10	25	50	75	90	95	98	99	100
Age (years)	5-11	62	0	0	0	1	1	2	5	10	15	20	30	30
Age (years)	12-17	141	0	0	0	1	2	3	5	10	15	30	30	60
Age (years)	18-64	1686	0	0	1	2	3	5	10	15	25	45	60	121
Age (years)	> 64	375	0	0	1	2	3	5	10	20	30	60	60	70

Note: A Value of "121" for number of minutes signifies that more than 120 minutes were spent; 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

		Frequency				
	Total N	Almost Every Day	3-5 Times a Week	1-2 Times a Week	1-2 Times a Month	DK
Age (years)						
1-4	111	33	16	7	53	2
5-11	88	18	10	12	46	2
12-17	83	21	7	5	49	1

Note: DK= Don't Know; Refused = Respondent Refused to Answer; N = Number of Respondents
Source: Tsang and Klepeis, 1996.

Table 10-5. Number of Respondents Indicating that Pesticides Were Applied by the Professional at Home to Eradicate Insects, Rodents, or Other Pests at Specified Frequencies

	Total N	Number of Times Over a 6-month Period Pesticides Were Applied by Professionals					
		None	1-2	3-5	6-9	10+	DK
Age (years)							
1-4	113	60	35	11	6	1	*
5-11	150	84	37	10	18	1	*
12-17	143	90	40	5	6	*	2

Note: * = Missing Data; DK= Don't know; Refused = Respondent Refused to Answer; N = Number of Respondents
Source: Tsang and Klepeis, 1996.

Table 10-6. Number of Respondents Reporting Pesticides Applied by the Consumer at Home To Eradicate Insects, Rodents, or Other Pests at Specified Frequencies

	Total N	Number of Times Over a 6-month Period Pesticides Applied by Resident					
		None	1-2	3-5	6-9	10+	DK
Age (years)							
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	*

Note: * = Missing Data; DK= Don't know; Refused = Respondent Refused to Answer; N = Number of Respondents
Source: Tsang and Klepeis, 1996.

TABLE OF CONTENTS

11. BODY WEIGHT STUDIES 11-1
11.1 INTRODUCTION 11-1
11.2 BODY WEIGHT STUDIES 11-1
11.3 RECOMMENDATIONS 11-3
11.4 REFERENCES FOR CHAPTER 11 11-5

LIST OF TABLES

Table 11-1. Smoothed Percentiles of Weight (In Kg) by Sex And Age:
Statistics From NCHS And Data From Fels Research Institute, Birth to 36 Months . 11-6
Table 11-2. Body Weights of Children[a] (Kilograms) 11-9
Table 11-3. Weight in Kilograms For Males 6 Months-19 Years of Age–number Examine, Mean, Standard Deviation,
and Selected Percentiles, by Sex and Age: United States, 1976-1980[a] 11-10
Table 11-4. Weight in Kilograms For Females 6 Months-19 Years of Age - Number Examine, Mean, Standard Deviation, And Selected Percentiles,
By Sex And Age: United States, 1976-1980[a] 11-11
Table 11-5. Best-fit Parameters for Lognormal Distributions 11-12
Table 11-6. Statistics for Probability Plot Regression Analyses
Male's Body Weights 6 Months to 20 Years of Age 11-13
Table 11-7. Body Weight Estimates (in kilograms) by Age and Gender, U.S. Population 1988-94 11-14
Table 11-8. Body Weight Estimates (in kilograms) by Age, U.S. Population 1988-94 11-15
Table 11-9. Summary of Recommended Values for Body Weight 11-16
Table 11-10. Confidence in Body Weight Recommendations 11-17

LIST OF FIGURES

Figure 11-1. Weight by Age percentiles for Girls Aged Birth-36 Months 11-7
Figure 11-2: Weight by Age Percentiles for Boys Aged Birth-36 Months 11-8
Figure 11-3. Mean Body Weights Estimates, U.S. Population, 1988-94 11-18
Figure 11-4. Median Body Weights Estimates, U.S. Population, 1988-94 11-19

11. BODY WEIGHT STUDIES

11.1 INTRODUCTION

The average daily dose 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 the *Exposure Factors Handbook* (U.S. EPA, 1997). Recommended values are based on the results of these studies.

11.2 BODY WEIGHT STUDIES

Hamill et al. (1979) - Physical Growth: National Center for Health Statistics Percentiles- A National Center for Health Statistics (NCHS) Task Force that included academic investigators and representatives from CDC Nutrition Surveillance Program selected, collated, integrated, and defined appropriate data sets to generate growth curves for the age interval: birth to 36 months developed (Hamill et al., 1979). The percentile curves were for assessing the physical growth of children in the U.S. They are based on accurate measurements made on large nationally representative samples of children (Hamill et al., 1979). Smoothed percentile curves were derived for body weight by age (Hamill et al., 1979). Curves were developed for boys and for girls. The data used to construct the curves were provided by the Fels Research Institute, Yellow Springs, Ohio. These data were from an ongoing longitudinal study where anthromopetric data from direct measurements are collected regularly from participants (~1,000) 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 aged 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 less than 6 months old.

NCHS (1987) - Anthropometric Reference Data and Prevalence of Overweight, United States, 1976-80 - Statistics on anthropometric measurements, including body weight, for the U.S. population were collected by NCHS through the second National Health and Nutrition

Examination Survey (NHANES II). NHANES II was conducted on a nationwide probability sample of approximately 28,000 persons, aged 6 months to 74 years, from the civilian, non-institutionalized population of the United States. Of the 28,000 persons, 20,322 were interviewed and examined, resulting in a response rate of 73.1 percent. The survey began in February 1976 and was completed in February 1980. The sample was selected so that certain subgroups thought to be at high risk of malnutrition (persons with low incomes, preschool children, and the elderly) were oversampled. The estimates were weighted to reflect national population estimates. The weighting was accomplished by inflating examination results for each subject by the reciprocal of selection probabilities adjusted to account for those who were not examined, and post stratifying by race, age, and sex (NCHS, 1987).

The NHANES II collected standard body measurements of sample subjects, including height and weight, that were made at various times of the day and in different seasons of the year. This technique was used because one's weight may vary between winter and summer and may fluctuate with recency of food and water intake and other daily activities (NCHS, 1987). Mean body weights and standard deviations for children, ages 6 months to 19 years, are presented in Table 11-2 for boys, girls, and boys and girls combined. Percentile data for children, by age, are presented in Table 11-3 for males, and in Table 11-4 for females. From Table 11-2, the mean body weights for girls and boys are approximately the same from ages 6 months to 14 years. Starting at years 15-19, the difference in mean body weight ranges from 6 to 11 kg.

Burmaster et al. (1997)- Lognormal Distributions for Body Weight as a Function of Age for Males and Females in the United States, 1976-1980 - Burmaster et al. (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 (Burmaster et al., 1997). The 1997 *Exposure Factors Handbook* used a pre-published version of this paper (U.S. EPA, 1997). The numbers reported in Tables 11-5 and 11-6 vary slightly from those reported in the *Exposure Factors Handbook* (U.S. EPA, 1997).

Data used in this analysis were from the second survey of the National Center for Health Statistics, NHANES II, which included 27,801 persons 6 months to 74 years of age in the U.S. (Burmaster et al., 1997). The NHANES II data had been statistically adjusted for non-response and probability of selection, and stratified by age, sex, and race to reflect the entire U.S. population prior to reporting (Burmaster et al., 1997). Burmaster et al. (1997) 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 (CDFs) were plotted for female and male body weights on both linear and logarithmic scales.

Two models were used to assess the probability density functions (PDFs) of children's body weight. Linear and quadratic regression lines were fitted to the data. A number of goodness-of-fit measures were conducted on data generated by the two models. Burmaster et al. (1997) found that lognormal distributions give 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 11-5 and 11-6. These data can be used for further analyses of body weight distribution (i.e., application of Monte Carlo analysis).

U.S. EPA, 2000 - Body Weight Estimates Based on NHANES III Data - The EPA Office of Water has estimated body weights for children, in kilograms, by age and gender using data collected during National Health and Nutrition Examination Survey III (NHANES III), 1988-1994. NHANES III collected body weight data for approximately 15,000 children between the ages of 2 months and 17 years. Table 11-7 Presents the body weight estimates in kilograms by age and gender. Table 11-8 shows the body weight estimates for the infants under the age of 3 months and/or younger, while Figures 11-3 and 11-4 compare the body weights (mean and median) between male and female among various age groups, respectively.

The limitations of these data are (1) the data were not available for infants under 2 months old, and (2) 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 11-7 and 11-8 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 11-9. Table 11-10 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 Table 11-2. If percentile values are needed, these data are presented in Table 11-3 for male children and in Table 11-4 for female children.

11.4 REFERENCES FOR CHAPTER 11

Burmaster, D.E.; Lloyd, K.J.; Crouch, E.A.C. (1997) Lognormal distributions for body weight as a function of age for males and females in the United States, 1976-1980. Risk Anal. 17(4):499-505.

Hamill, P.V.V.; Drizd, T.A.; Johnson, C.L.; Reed, R.B.; Roche, A.F.; Moore, W.M. (1979) Physical growth: National Center for Health Statistics Percentiles. American J. Clin. Nutr. 32:607-609.

National Center for Health Statistics (NCHS) (1987) Anthropometric reference data and prevalence of overweight, United States, 1976-80. Data from the National Health and Nutrition Examination Survey, Series 11, No. 238. Hyattsville, MD: U.S. Department of Health and Human Services, Public Health Service, National Center for Health Statistics. DHHS Publication No. (PHS) 87-1688.

U.S. EPA (1989) Risk assessment guidance for Superfund, Volume I: Human health evaluation manual. Washington, DC: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. EPA/540/1-89/002.

U.S. EPA (1997) Exposure Factors Handbook. Washington, DC: Office of Research and Development. EPA/600-P-95/002F.

U.S. EPA (2000) Memorandum entitled: Bodyweight estimates on NHANES III data, revised, Contract 68-C-99-242, Work Assignment 0-1 from Bob Clickner, Westat Inc. to Helen Jacobs, U.S. EPA dated March 3, 2000.

Table 11-1. Smoothed Percentiles of Weight (In Kg) by Sex And Age: Statistics From NCHS And Data From Fels Research Institute, Birth to 36 Months

	Smoothed[a] Percentile						
	5th	10th	25th	50th	75th	90th	95th
Sex and Age	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).

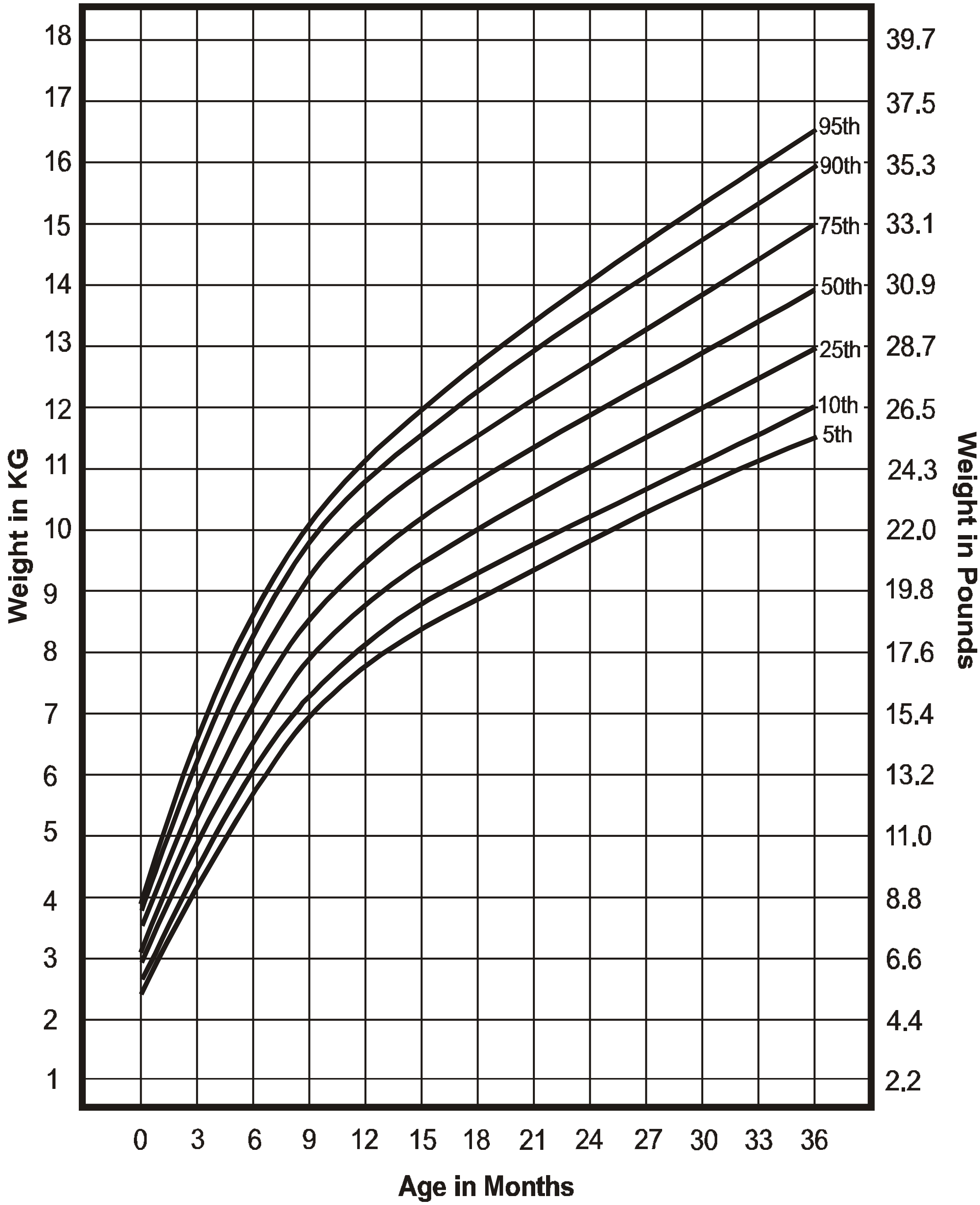


Figure 11-1. Weight by Age percentiles for Girls Aged Birth-36 Months

Source: Hamill et al. (1979).

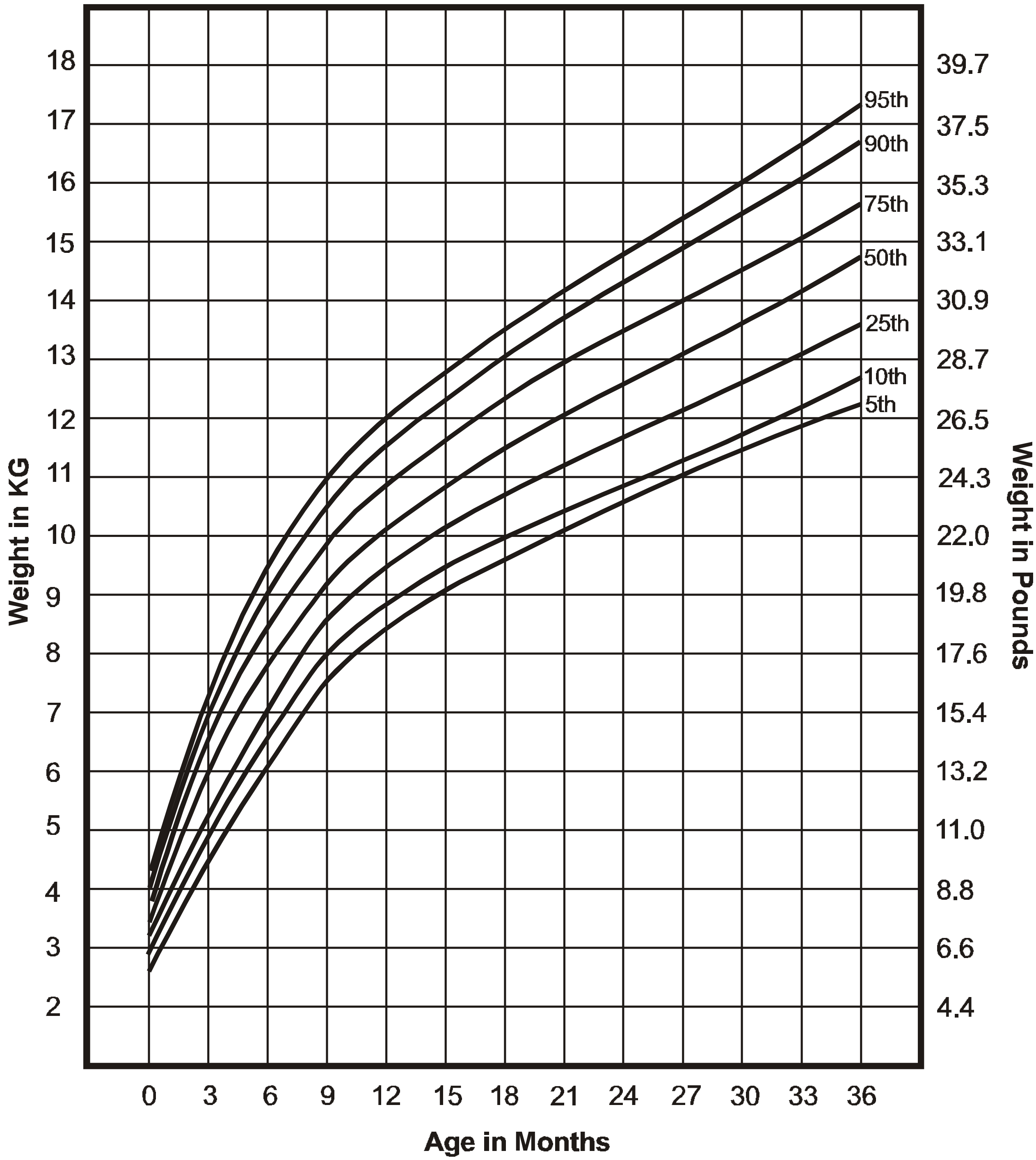
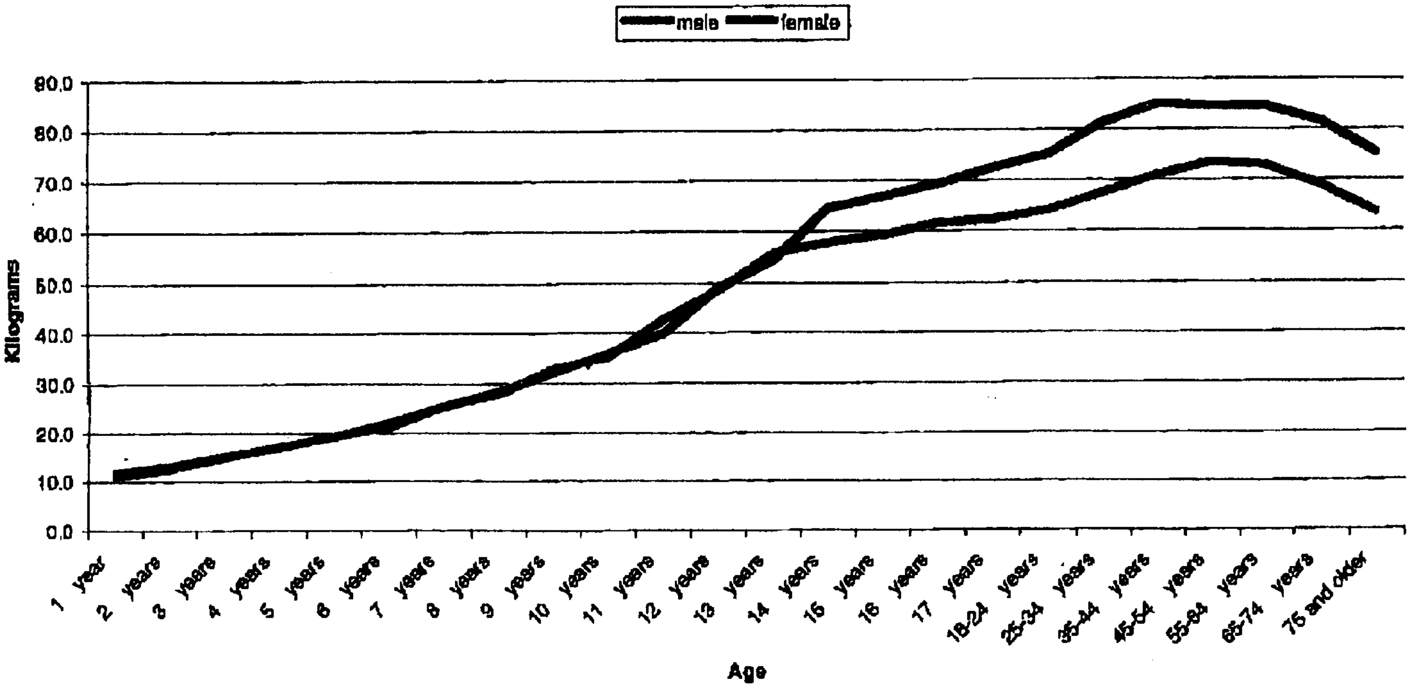


Figure 11-2: Weight by Age Percentiles for Boys Aged Birth-36 Months

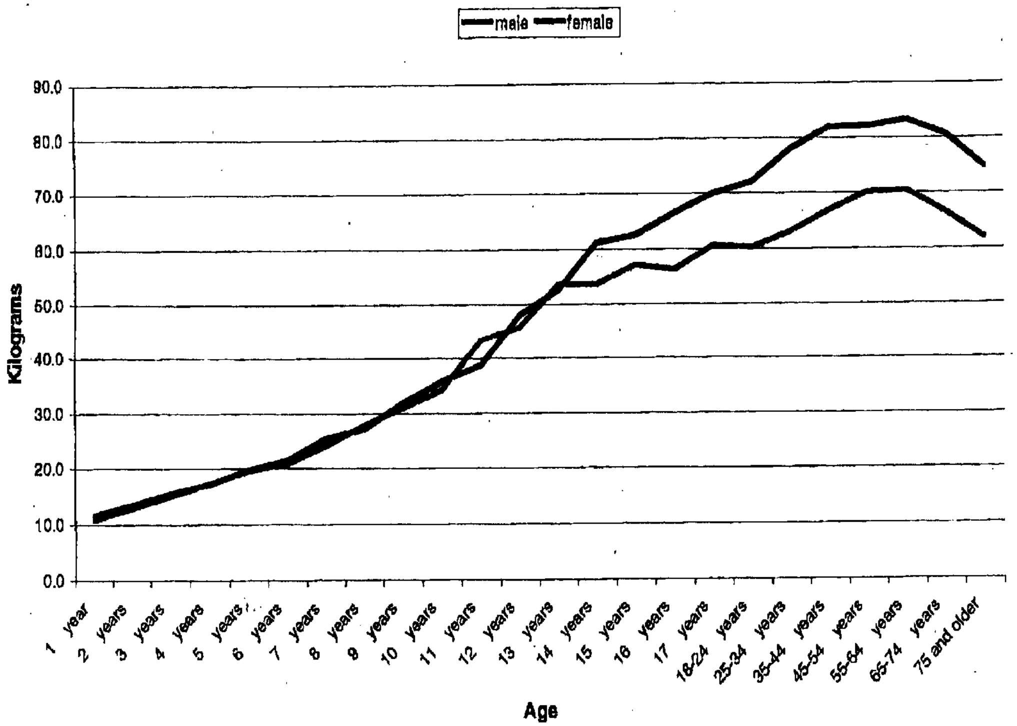
Source: Hamill et al. (1979).

Figure 11-3. Mean Body Weights Estimates, U.S. Population, 1988-94



Source: U.S. EPA (2000).

Figure 11-4. Median Body Weights Estimates, U.S. Population, 1988-94



Source: U.S. EPA (2000).

Table 11-2. Body Weights of Children[a] (Kilograms)

Age	Boys		Girls		Boys and Girls
	Mean (kg)	Std. Dev.	Mean (kg)	Std. Dev.	Mean (kg)
6-11 months	9.4	1.3	8.8	1.2	9.1
1 year	11.8	1.9	10.8	1.4	11.3
2 years	13.6	1.7	13.0	1.5	13.3
3 years	15.7	2.0	14.9	2.1	15.3
4 years	17.8	2.5	17.0	2.4	17.4
5 years	19.8	3.0	19.6	3.3	19.7
6 years	23.0	4.0	22.1	4.0	22.6
7 years	25.1	3.9	24.7	5.0	24.9
8 years	28.2	6.2	27.9	5.7	28.1
9 years	31.1	6.3	31.9	8.4	31.5
10 years	36.4	7.7	36.1	8.0	36.3
11 years	40.3	10.1	41.8	10.9	41.1
12 years	44.2	10.1	46.4	10.1	45.3
13 years	49.9	12.3	50.9	11.8	50.4
14 years	57.1	11.0	54.8	11.1	56.0
15 years	61.0	11.0	55.1	9.8	58.1
16 years	67.1	12.4	58.1	10.1	62.6
17 years	66.7	11.5	59.6	11.4	63.2
18 years	71.1	12.7	59.0	11.1	65.1
19 years	71.7	11.6	60.2	11.0	66.0

Note: 1 kg = 2.2046 pounds.
[a]Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.

Source: Adapted from National Center for Health Statistics (NCHS) (1987).

Table 11-3. Weight in Kilograms For Males 6 Months-19 Years of Age–number Examine, Mean, Standard Deviation, and Selected Percentiles, by Sex and Age: United States, 1976-1980[a]

Age	Number of Persons Examined	Mean (kg)	Standard Deviation	Percentile								
				5th	10th	15th	25th	50th	75th	85th	90th	95th
6-11 months	179	9.4	1.3	7.5	7.6	8.2	8.6	9.4	10.1	10.7	10.9	11.4
1 years	370	11.8	1.9	9.6	10.0	10.3	10.8	11.7	12.6	13.1	13.6	14.4
2 years	375	13.6	1.7	11.1	11.6	11.8	12.6	13.5	14.5	15.2	15.8	16.5
3 years	418	15.7	2.0	12.9	13.5	13.9	14.4	15.4	16.8	17.4	17.9	19.1
4 years	404	17.8	2.5	14.1	15.0	15.3	16.0	17.6	19.0	19.9	20.9	22.2
5 years	397	19.8	3.0	16.0	16.8	17.1	17.7	19.4	21.3	22.9	23.7	25.4
6 years	133	23.0	4.0	18.6	19.2	19.8	20.3	22.0	24.1	26.4	28.3	30.1
7 years	148	25.1	3.9	19.7	20.8	21.2	22.2	24.8	26.9	28.2	29.6	33.9
8 years	147	28.2	6.2	20.4	22.7	23.6	24.6	27.5	29.9	33.0	35.5	39.1
9 years	145	31.1	6.3	24.0	25.6	26.0	27.1	30.2	33.0	35.4	38.6	43.1
10 years	157	36.4	7.7	27.2	28.2	29.6	31.4	34.8	39.2	43.5	46.3	53.4
11 years	155	40.3	10.1	26.8	28.8	31.8	33.5	37.3	46.4	52.0	57.0	61.0
12 years	145	44.2	10.1	30.7	32.5	35.4	37.8	42.5	48.8	52.6	58.9	67.5
13 years	173	49.9	12.3	35.4	37.0	38.3	40.1	48.4	56.3	59.8	64.2	69.9
14 years	186	57.1	11.0	41.0	44.5	46.4	49.8	56.4	63.3	66.1	68.9	77.0
15 years	184	61.0	11.0	46.2	49.1	50.6	54.2	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

Note: 1 kg = 2.2046 pounds.
[a]Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.

Source: National Center for Health Statistics (1987).

Table 11-4. Weight in Kilograms For Females 6 Months-19 Years of Age - Number Examine, Mean, Standard Deviation, And Selected Percentiles, By Sex And Age: United States, 1976-1980[a]

Age	Number of Persons Examined	Mean (kg)	Standard Deviation	Percentile								
				5th	10th	15th	25th	50th	75th	85th	90th	95th
6-11 months	177	8.8	1.2	6.6	7.3	7.5	7.9	8.9	9.4	10.1	10.4	10.9
1 years	336	10.8	1.4	8.8	9.1	9.4	9.9	10.7	11.7	12.4	12.7	13.4
2 years	336	13.0	1.5	10.8	11.2	11.6	12.0	12.7	13.8	14.5	14.9	15.9
3 years	366	14.9	2.1	11.7	12.3	12.9	13.4	14.7	16.1	17.0	17.4	18.4
4 years	396	17.0	2.4	13.7	14.3	14.5	15.2	16.7	18.4	19.3	20.2	21.1
5 years	364	19.6	3.3	15.3	16.1	16.7	17.2	19.0	21.2	22.8	24.7	26.6
6 years	135	22.1	4.0	17.0	17.8	18.6	19.3	21.3	23.8	26.6	28.9	29.6
7 years	157	24.7	5.0	19.2	19.5	19.8	21.4	23.8	27.1	28.7	30.3	34.0
8 years	123	27.9	5.7	21.4	22.3	23.3	24.4	27.5	30.2	31.3	33.2	36.5
9 years	149	31.9	8.4	22.9	25.0	25.8	27.0	29.7	33.6	39.3	43.3	48.4
10 years	136	36.1	8.0	25.7	27.5	29.0	31.0	34.5	39.5	44.2	45.8	49.6
11 years	140	41.8	10.9	29.8	30.3	31.3	33.9	40.3	45.8	51.0	56.6	60.0
12 years	147	46.4	10.1	32.3	35.0	36.7	39.1	45.4	52.6	58.0	60.5	64.3
13 years	162	50.9	11.8	35.4	39.0	40.3	44.1	49.0	55.2	60.9	66.4	76.3
14 years	178	54.8	11.1	40.3	42.8	43.7	47.4	53.1	60.3	65.7	67.6	75.2
15 years	145	55.1	9.8	44.0	45.1	46.5	48.2	53.3	59.6	62.2	65.5	76.6
16 years	170	58.1	10.1	44.1	47.3	48.9	51.3	55.6	62.5	68.9	73.3	76.8
17 years	134	59.6	11.4	44.5	48.9	50.5	52.2	58.4	63.4	68.4	71.6	81.8
18 years	170	59.0	11.1	45.3	49.5	50.8	52.8	56.4	63.0	66.0	70.1	78.0
19 years	158	60.2	11.0	48.5	49.7	51.7	53.9	57.1	64.4	70.7	74.8	78.1

Note: 1 kg = 2.2046 pounds.
[a] Includes clothing weight, estimated as ranging from 0.09 to 0.28 kilogram.

Source: National Center for Health Statistics (1987).

Table 11-5. Best-fit Parameters for Lognormal Distributions

	Lognormal Probability Plots Linear Curve	
Age Midpoint (yr)	μ_2[a]	σ_2[a]
0.75	2.16	0.145
1.5	2.38	0.129
2.5	2.56	0.112
3.5	2.69	0.136
4.5	2.83	0.134
5.5	2.98	0.164
6.5	3.10	0.174
7.5	3.19	0.174
8.5	3.31	0.156
9.5	3.46	0.214
10.5	3.57	0.199
11.5	3.71	0.226
12.5	3.82	0.213
13.5	3.92	0.215
14.5	3.99	0.187
15.5	4.00	0.156
16.5	4.05	0.167
17.5	4.08	0.165
18.5	4.07	0.147
19.5	4.10	0.149

[a] μ_2, σ_2 - correspond to the mean and standard deviation, respectively, of the lognormal distribution of body weight (kg).

Source: Burmaster et al. (1997).

Table 11-6. Statistics for Probability Plot Regression Analyses
Male's Body Weights 6 Months to 20 Years of Age

Age Midpoint (yrs)	Lognormal Probability Plots Linear Curve	
	μ_2[a]	σ_2[a]
0.75	2.23	0.132
1.5	2.46	0.119
2.5	2.60	0.120
3.5	2.75	0.114
4.5	2.87	0.133
5.5	2.98	0.138
6.5	3.13	0.145
7.5	3.21	0.151
8.5	3.33	0.181
9.5	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, σ_2 - correspond to the mean and standard deviation, respectively, of the lognormal distribution of body weight (kg).

Source: Burmaster et al. (1997).

Table 11-7. Body Weight Estimates (in kilograms) by Age and Gender, U.S. Population 1988-94

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 11-8. Body Weight Estimates (in kilograms) by Age, U.S. Population 1988-94

			Male and Female		
Age	Sample Size	Population	Median	Mean	95% CI
Newborn	NA	NA	NA	NA	NA
1 Month	NA	NA	NA	NA	NA
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 Younger	433	741,660	6.6	6.6	6.4-6.7

NA = Not available.
CI = Confidence Intervals.

Source: U.S. EPA (2000).

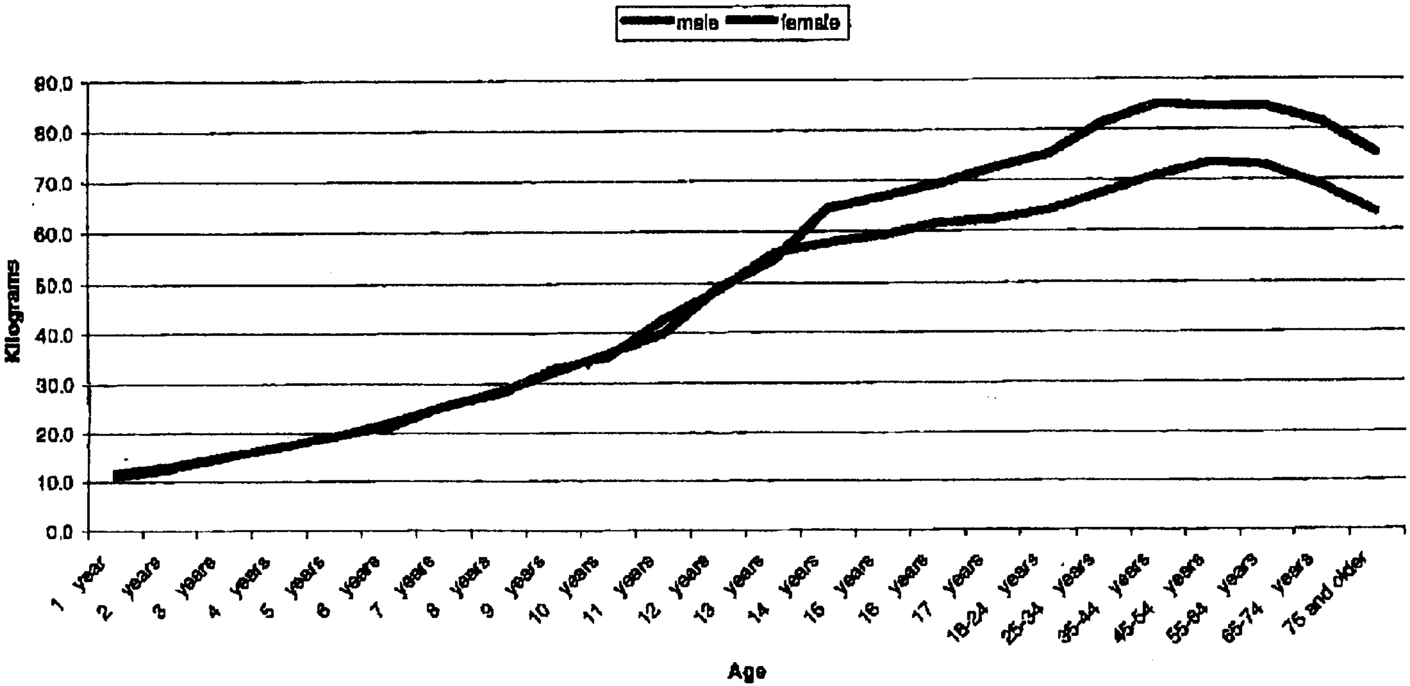
Table 11-9. Summary of Recommended Values for Body Weight

Population	Mean	Upper Percentile	Multiple Percentiles
Children	See Table 11-2	See Tables 11-3 and 11-4	See Tables 11-3 and 11-4
Infants	Not Available	See Table 11-1	See Table 11-1

Table 11-10. Confidence in Body Weight Recommendations

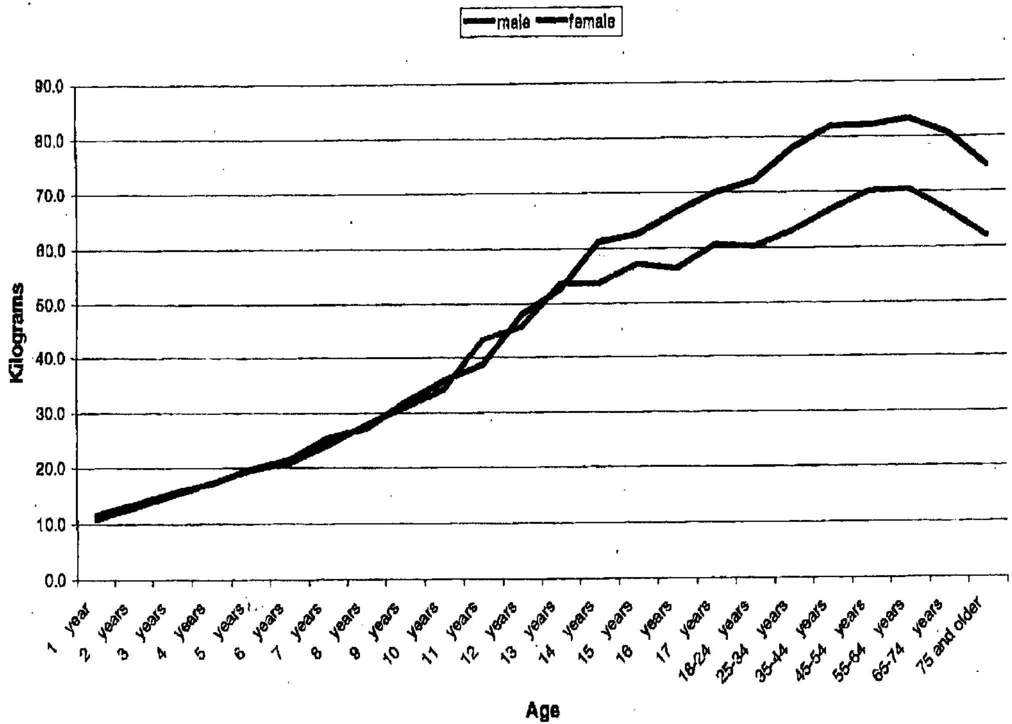
Considerations	Rationale	Rating
Study Elements		
• Level of peer review	NHANES II was the major source of data for NCHS (1987). This is a published study which received a high level of peer review. The Hamill et al. (1979) is a peer reviewed journal publication.	High
• Accessibility	Both studies are available to the public.	High
• Reproducibility	Results can be reproduced by analyzing NHANES II 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 US	The data represent the U.S. population.	High
• Primary data	The primary data were generated from NHANES II data and Fels studies, thus these data are secondary.	Medium
• Currency	The data were collected between 1976-1980.	Low
• 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.	High
• Validity of approach	Direct body weights were measured for both studies. For NHANES II, subgroups at risk for malnutrition were over-sampled. Weighting was accomplished by inflating examination results for those not examined and were stratified by race, age, and sex. 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. Author noted in Hamill et al. (1979) that the data set was large.	High
• Representativeness of the population	Data collected focused on the U.S. population for both studies.	High
• Characterization of variability	Both 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, measurement error should be low since body weights were performed in a mobile examination center using standardized procedures and equipment. Also, measurements were taken at various times of the day to account for weight fluctuations as a result of recent food or water intake. The authors of Hamill et al. (1979) report that study data are based on accurate direct measurements from an ongoing longitudinal study.	High
Other Elements		
• Number of studies	There are two studies.	Low
• Agreement between researchers	There is consistency among the two studies.	High
Overall Rating		**High**

Figure 11-3. Mean Body Weights Estimates, U.S. Population, 1988-94



Source: U.S. EPA (2000).

Figure 11-4. Median Body Weights Estimates, U.S. Population, 1988-94



Source: U.S. EPA (2000).

TABLE OF CONTENTS

12. LIFETIME 12-1

12.1 INTRODUCTION 12-1

12.2 DATA ON LIFETIME 12-1

12.3 RECOMMENDATIONS 12-2

12.4 REFERENCES FOR CHAPTER 12 12-3

LIST OF TABLES

Table 12-1. Expectation of Life at Birth, 1980 to 1993,
And Projections, 1995 to 2010 (Years) 12-4
Table 12-2. Expectation of Life by Race, Sex, And Age: 1996 12-5
Table 12-3. Confidence in Lifetime Expectancy Recommendations 12-6

12. LIFETIME

12.1 INTRODUCTION

The length of an individual's life is an important factor to consider when evaluating cancer risk because the dose estimate is averaged over an individual's lifetime. Since the averaging time is found in the denominator of the dose equation, a shorter lifetime would result in a higher potential risk estimate, and conversely, a longer life expectancy would produce a lower potential risk estimate. Children have more years of future life than 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).

12.2 DATA ON LIFETIME

Statistical data on life expectancy are published annually by the U.S. Department of Commerce in the publication: "Statistical Abstract of the United States." The latest year for which statistics are available is 1993. Available data on life expectancies for various subpopulations born in the years 1980 to 1993 are presented in Table 12-1. Data for 1993 show that the life expectancy for an average person born in the United States in 1993 is 75.5 years (U.S. Bureau of the Census, 1999). The table shows that the overall life expectancy has averaged approximately 75 years since 1982. The average life expectancy for males in 1993 was 72.2 years, and 78.8 years for females. The data consistently show an approximate 7 years difference in life expectancy for males and females from 1980 to present. Table 12-1 also indicates that the 1993 life expectancy for white males (73.1 years) is consistently longer than for Black males (64.6 years). Additionally, it indicates that the 1993 life expectancy for White females (79.5 years) is longer than for Black females (73.7), a difference of almost 6 years. Table 12-1 also shows that the projected life expectancy for children born in the year 2000 (76.4 years) is longer than for those born in the 1980s (73.7 years). Table 12-2 presents data for expectation of life for persons who were at a specific age in year 1996. These data are available by age, gender, and race and may be useful for deriving exposure estimates based on the age of a specific subpopulation. The data show that expectation of life is longer for females and for Whites.

12.3 RECOMMENDATIONS

Current data suggest that 75 years would be an appropriate value to reflect the average life expectancy of children in the current general population and is the recommended value. If gender is a factor considered in the assessment, note that the average life expectancy value for females is higher than for males. It is recommended that the assessor use the 1993 value of 72.2 years for males or 78.8 years for females. If race is a consideration in assessing exposure for male individuals, note that the life expectancy is about 8 years longer for Whites than for Blacks. It is recommended that the assessor use the 1993 values of 73.1 years and 64.6 years for White males and Black males, respectively. Table 12-3 presents the confidence rating for life expectancy recommendations.

This recommended value is different than the 70 years commonly assumed for the general population in EPA risk assessments. Assessors are encouraged to use values which most accurately reflect the exposed population. When using values other than 70 years, however, the assessors should consider if the dose estimate will be used to estimate risk by combining with a dose-response relationship which was derived assuming a lifetime of 70 years. If such an inconsistency exists, the assessor should adjust the dose-response relationship by multiplying by (lifetime/70). The Integrated Risk Information System (IRIS) does not use a 70 year lifetime assumption in the derivation of RfCs and RfDs, but does make this assumption in the derivation of some cancer slope factors or unit risks.

12.4 REFERENCES FOR CHAPTER 12

Natural Resources Defense Council. (1997) Our children at risk: the 5 worst environmental threats to their health.

U.S. Bureau of the Census. (1999) Statistical abstracts of the United States.

Table 12-1. Expectation of Life at Birth, 1980 to 1993,
And Projections, 1995 to 2010 (Years)[a]

	TOTAL			WHITE			BLACK AND OTHER[b]			BLACK		
YEAR	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
1980	73.7	70.0	77.4	74.4	70.7	78.1	69.5	65.3	73.6	68.1	63.8	72.5
1981	74.1	70.4	77.8	74.8	71.1	78.4	70.3	66.2	74.4	68.9	64.5	73.2
1982	74.5	70.8	78.1	75.1	71.5	78.7	70.9	66.8	74.9	69.4	65.1	73.6
1983	74.6	71.0	78.1	75.2	71.6	78.7	70.9	67.0	74.7	69.4	65.2	73.5
1984	74.7	71.1	78.2	75.3	71.8	78.7	71.1	67.2	74.9	69.5	65.3	73.6
1985	74.7	71.1	78.2	75.3	71.8	78.7	71.0	67.0	74.8	69.3	65.0	73.4
1986	74.7	71.2	78.2	75.4	71.9	78.8	70.9	66.8	74.9	69.1	64.8	73.4
1987	74.9	71.4	78.3	75.6	72.1	78.9	71.0	66.9	75.0	69.1	64.7	73.4
1988	74.9	71.4	78.3	75.6	72.2	78.9	70.8	66.7	74.8	68.9	64.4	73.2
1989	75.1	71.7	78.5	75.9	72.5	79.2	70.9	66.7	74.9	68.8	64.3	73.3
1990	75.4	71.8	78.8	76.1	72.7	79.4	71.2	67.0	75.2	69.1	64.5	73.6
1991	75.5	71.0	78.9	76.3	72.9	79.6	71.5	67.3	75.5	69.3	64.6	73.8
1992	75.8	72.3	79.1	76.5	73.2	79.8	71.8	67.7	75.7	69.6	65.0	73.9
1993	75.5	72.2	78.8	76.3	73.1	79.5	71.5	67.3	75.5	69.2	64.6	73.7
Projections[c]												
1995	75.8	72.5	78.9	76.5	73.4	79.6	71.9	67.9	75.7	69.6	65.2	73.9
2000	76.4	73.0	79.7	77.4	74.2	80.5	NA	NA	NA	69.7	64.6	74.7
2005	76.9	73.8	80.2	77.9	74.7	81.0	NA	NA	NA	69.9	64.5	75.0
2010	77.4	74.1	80.6	78.6	75.5	81.6	NA	NA	NA	70.4	65.1	75.5

[a]Excludes deaths of nonresidents of the United States.
[b]Racial descriptions were not provided in the data source.
[c]Based on middle mortality assumptions; for details, see U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 1130.

Source: Bureau of the Census (1999).

Table 12-2. Expectation of Life by Race, Sex, And Age: 1996

Age in 1990 (years)	Expectation of Life in Years				
		White		Black	
	Total	Male	Female	Male	Female
At birth	76.1	73.9	79.7	66.1	74.2
1	75.7	73.4	79.1	66.2	74.2
2	74.7	72.4	78.1	65.2	73.2
3	73.7	71.4	77.1	64.3	72.3
4	72.8	70.5	76.2	63.3	71.3
5	71.8	69.5	75.2	62.4	70.3
6	70.8	68.5	75.2	61.4	69.4
7	69.8	67.5	73.2	60.4	68.4
8	68.8	66.5	72.2	59.4	67.4
9	67.8	65.5	71.2	58.4	66.4
10	66.9	64.5	70.2	57.5	65.4
11	65.9	63.5	69.2	56.5	64.4
12	64.9	62.6	68.3	55.5	63.4
13	63.9	61.6	67.3	54.5	62.5
14	62.9	60.6	66.3	53.5	61.5
15	61.9	59.6	65.3	52.6	60.5
16	61.0	58.8	64.3	51.6	59.5
17	60.0	57.7	63.3	50.7	58.6
18	59.1	56.8	62.4	49.8	57.6
19	58.1	55.8	61.4	48.9	56.6

Source: U.S. Bureau of Census (1999).

Table 12-3. Confidence in Lifetime Expectancy Recommendations

Considerations	Rationale	Rating
Study Elements		
• Level of peer review	Data are published and have received extensive peer review.	High
• Accessibility	The study was widely available to the public (Census data).	High
• Reproducibility	Results can be reproduced by analyzing Census data.	High
• Focus on factor of interest	Statistical data on life expectancy were published in this study.	High
• Data pertinent to US	The study focused on the U.S. population.	High
• Primary data	Primary data were analyzed.	High
• Currency	The study was published in 1995 and discusses life expectancy trends from 1970 to 1993. The study has also made projections for 1995 until the year 2010.	High
• Adequacy of data collection period	The data analyzed were collected over a period of years.	High
• Validity of approach	Census data is collected and analyzed over a period of years.	High
• Study size	This study was based on U.S. Census data, thus the population study size is expected to be greater than 100.	High
• Representativeness of the population	The data are representative of the U.S. population.	High
• Characterization of variability	Data were averaged by gender and race but only for Blacks and Whites; no other nationalities were represented within the section.	Medium
• Lack of bias in study design (High rating is desirable)	There are no apparent biases.	High
• Measurement error	Measurement error may be attributed to portions of the population that avoid or provide misleading information on census surveys.	Medium
Other Elements		
• Number of studies	Data presented in the section are from the U.S. Bureau of the Census publication.	Low
• Agreement between researchers	Recommendation was based on only one study, but it is widely accepted.	High
Overall Rating		**High**