

# Obtaining and Using Exposure Factor Data



**RISK ASSESSMENT TRAINING AND EXPERIENCE**  
**Exposure Assessment Course Series – EXA 406**

# What You Can Expect to Learn from this Course

- Definition of exposure factors
- Key sources of exposure factor data
- Examples of exposure factors and recommended values
- Recommended age groupings
- Importance of variability when selecting exposure factors

# INTRODUCTION AND BASIC CONCEPTS

# What Are Exposure Factors?

- **Exposure factors** are quantifications of human behaviors and characteristics that affect exposure to environmental contaminants
  - Examples: body weight, inhalation rates, ingestion rates for specific types of food
  - NCEA's **Exposure Factors Program** compiles information on exposure factors for EPA



# How Are Exposure Factors Used?

- **Exposure factors** are used as inputs to exposure estimate calculations, including the basic dose equation:

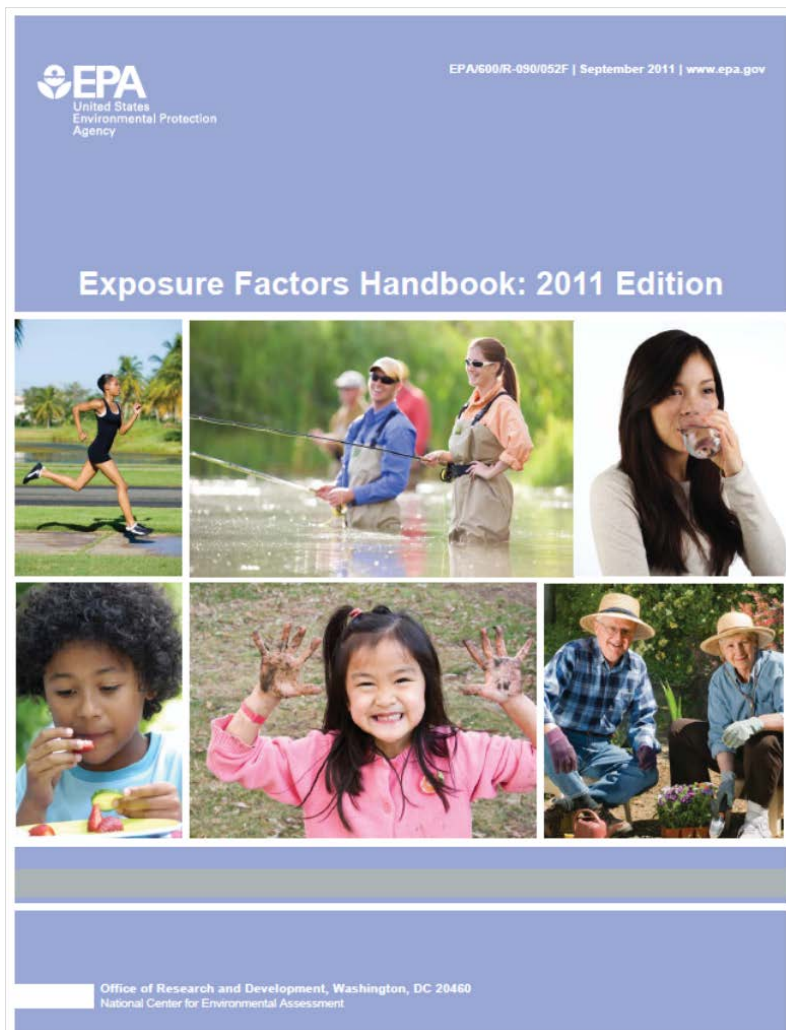
$$\text{Potential Dose} = \frac{(C \times IR \times CF \times ED \times EF)}{(AT \times BW)}$$

# History of Exposure Factor Guidance at EPA

1985	Development of Statistical Distribution or Ranges of Standard Factors Used in Exposure Assessments – provided ranges of values for body weight, skin surface area, and ventilation rates.
1989	Exposure Factors Handbook
1997	Exposure Factors Handbook – Update
2004	Example Exposure Scenarios
2005	Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants
2008	Child-specific Exposure Factors Handbook
2009	Exposure Factors Handbook – Update
2011	Exposure Factors Handbook



# Sources of Updated Exposure Factor Data



# TYPES OF EXPOSURE FACTORS



# Examples Of Exposure Factors

- Physiological exposure factors
  - Body weight
  - Inhalation rates
  - Dermal and surface area factors
  - Life expectancy
- Food and water intake rates
- Mouthing behavior and soil/dust ingestion rates
- Consumer product use
- Activity factors
- Building characteristics

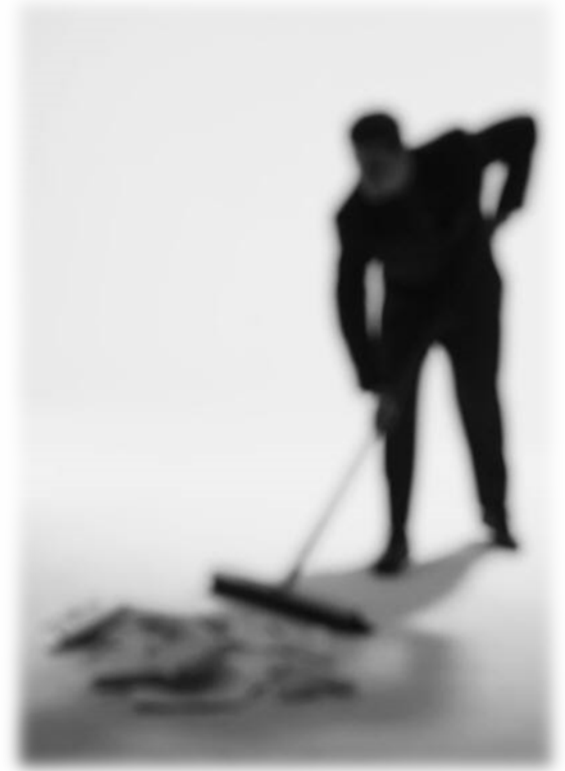
# Food and Water Intake

- Type of food
- Source – e.g., community water supply, home garden, freshwater
- Population – e.g., age, race, ethnicity
- Other factors – e.g., per capita vs. consumer-only estimates



# Mouthing Behavior and Soil/Dust Ingestion

- Relevant behaviors:
  - Hand-to-mouth contact
  - Object-to-mouth contact
- Soil/dust ingestion
  - Soil/dust adheres to food or toys
  - Soil/dust on hands
  - Soil/dust on food
- Soil-pica
- Geophagy



# Exposure to Consumer Products





# Activity Factors

- Activity patterns
- Occupational mobility
- Population mobility
- CHAD database



# Microenvironments

- **Microenvironment:** space in which contaminant concentration is assumed to be relatively well-mixed and constant during time when an individual is present
  - Microenvironments in which people spend their time influence how they will be exposed to chemicals





# Building Characteristics

- Building characteristics
  - Volume
  - Surface area
  - Foundation
- Transport rates
  - Air exchange rates
  - Water uses
  - Dust and soil
- Sources of contaminants



# SELECTING VALUES FOR EXPOSURE FACTORS

# Considerations When Selecting Values for Exposure Factors

<b>Variability (Known) Considerations</b>	<b>Uncertainty (Unknown) Considerations</b>
<ul style="list-style-type: none"><li>• Differences between children and adults</li><li>• Age groups</li><li>• Life stages</li><li>• Population groups (e.g., race/ethnicity, fishers, farmers)</li><li>• Susceptibility</li></ul>	<ul style="list-style-type: none"><li>• Confidence in data</li><li>• Original purpose of data vs. intended use</li></ul>

# Differences between Children and Adults

- Behavior and activity of children can result in higher exposures compared to adults, because children tend to:
  - Consume more food and water per unit of body weight
  - Have a higher ratio of body surface area to volume
  - Choose different foods
  - Handle food differently
  - Have different mouthing behavior
    - Hand- or object-to-mouth frequencies
  - Spend more time on the floor
  - Have greater contact with surfaces



# Selecting Age Groups for Children

Age Groups <1 Year	Age Groups >1 Year
<ul style="list-style-type: none"><li>• birth to &lt; 1 month</li><li>• 1 to &lt; 3 months</li><li>• 3 to &lt; 6 months</li><li>• 6 to &lt; 12 month</li></ul>	<ul style="list-style-type: none"><li>• 1 to &lt; 2 years</li><li>• 2 to &lt; 3 years</li><li>• 3 to &lt; 6 years</li><li>• 6 to &lt; 11 years</li><li>• 11 to &lt; 16 years</li><li>• 16 to &lt; 21 years</li></ul>

Source: Guidance on Selecting Age Groups (2005)



- **Life stages:** Temporal stages of life that have distinct anatomical, physiological, and behavioral or functional characteristics that contribute to potential differences in vulnerability to environmental exposures

Source: Offi





# Life Stages vs. Population Groups

- Life stage: Distinguishable time frame in individual's life
  - Inclusive of entire population
- Population groups: Groups that form relatively fixed portion of population



- **Susceptibility** – Increased likelihood of an adverse effect or an exposure, often discussed in terms of relationship to a factor, that can be used to describe a human population

Intrinsic Factors (biological)	Extrinsic Factors (exposure-related)
<ul style="list-style-type: none"><li>• Age and life stage</li><li>• Gender</li><li>• Race/ethnicity</li><li>• Genetic polymorphisms</li></ul>	<ul style="list-style-type: none"><li>• Socioeconomic status</li><li>• Disease status</li><li>• Nutrition status</li><li>• Lifestyle</li></ul>

# Confidence in Data

- General assessment factors to evaluate confidence in exposure factor data
  - Soundness
  - Applicability and utility
  - Clarity and completeness
  - Uncertainty and variability
  - Evaluation and peer review

Source: U.S. EPA. (2006). Guidance on Systemic Planning Using the Data Quality Objectives Process.

# Original Purpose of Data vs. Intended Use

- Consider:
  - National vs. regional vs. local scale
  - Short-term vs. long-term
  - Point estimates vs. distributions



# Per Capita vs. Consumer Only

- Consumer only: intake rate for individuals who reported eating foods during survey period
  - Use when assessing specific population for specific reason, e.g., fish consumption
- Per capita: Overall intake rate based on individuals who ate food during the survey period **and** individuals who did not
  - Use when average doses are of interest, e.g., background exposures
- Similar for frequently consumed foods; different for infrequently consumed food

# Example: Selecting Data for Fish Consumption

- Types of fish consumed: finfish, shellfish, Atlantic, Pacific, Gulf
- Per capita and consumer
- Types of consumers: general population, recreational fishers, Native American subsistence fishermen





# EFH RECOMMENDED VALUES

# Recommendations for Drinking Water Ingestion Rates

Group – per capita	Mean	95 <sup>th</sup> Percentile	Confidence Rating
	(mL/kg-day)	(mL/kg-day)	
All ages	14	42	Medium-high
Pregnant women	13	43	Low
Lactating women	21	55	Low

Source: Chapter 3, EFH 2011

# Recommendations for Hand-to-Mouth Frequency (Indoor)

Age Group	Mean	95 <sup>th</sup> Percentile	Confidence Rating
	(contacts/hr)	(contacts/hr)	
Birth to <3 months	--	--	Low
3 to <6 months	28	65	Low
6 to <12 months	19	52	Low
1 to <2 years	20	63	Low
2 to <3 years	13	37	Low
3 to <6 years	15	54	Low
6 to <11 years	7	21	Low

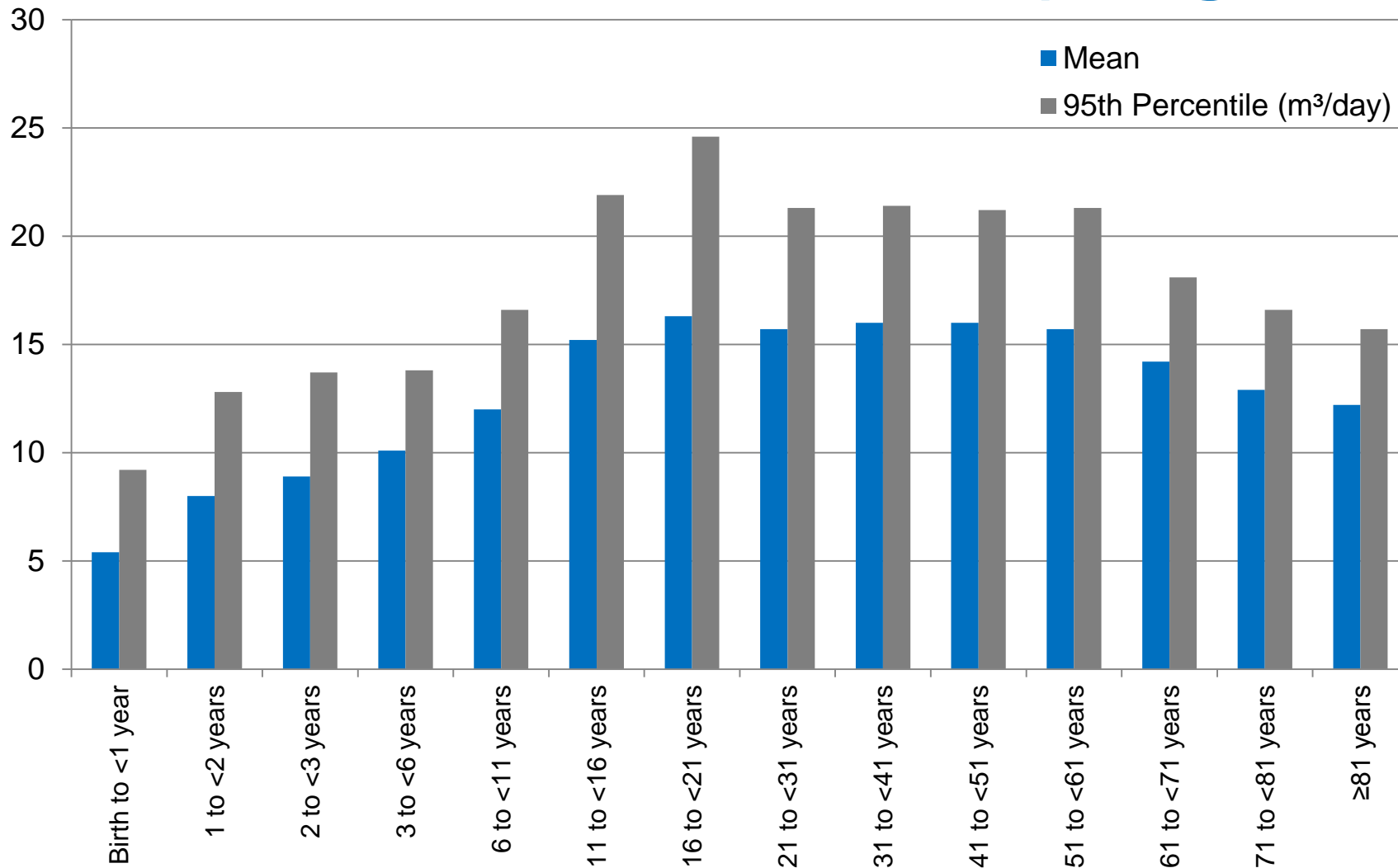
Source: Chapter 4, EFH 2011

# Recommendations for Soil and Dust Ingestion Rates

Age Group	Soil (central tendency)	Dust (central tendency)	Soil Pica	Geophagy	Confidence
	(mg/day)	(mg/day)	(mg/day)	(mg/day)	
6 weeks to <1 yr	30	30	--	--	Low
1 to <6 yrs	50	60	1,000	50,000	Low
3 to <6 yrs	--	--	--	--	Low
6 to <21 yrs	50	60	1,000	50,000	Low
Adult	20	30	--	50,000	Low

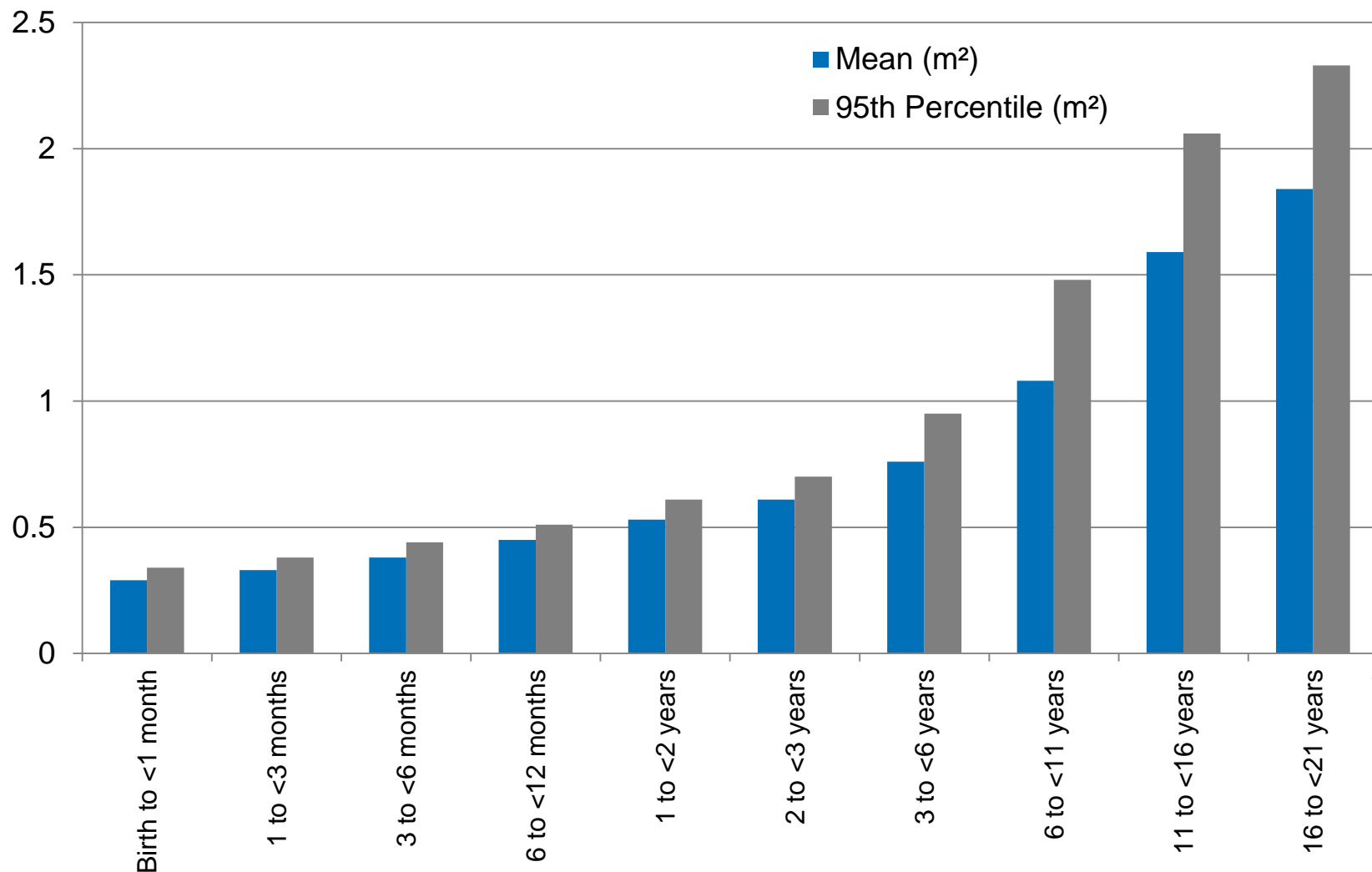
Source: Chapter 5, EFH 2011

# Recommendations for Inhalation Rates (Long-Term)



Values from: Chapter 6, EFH 2011

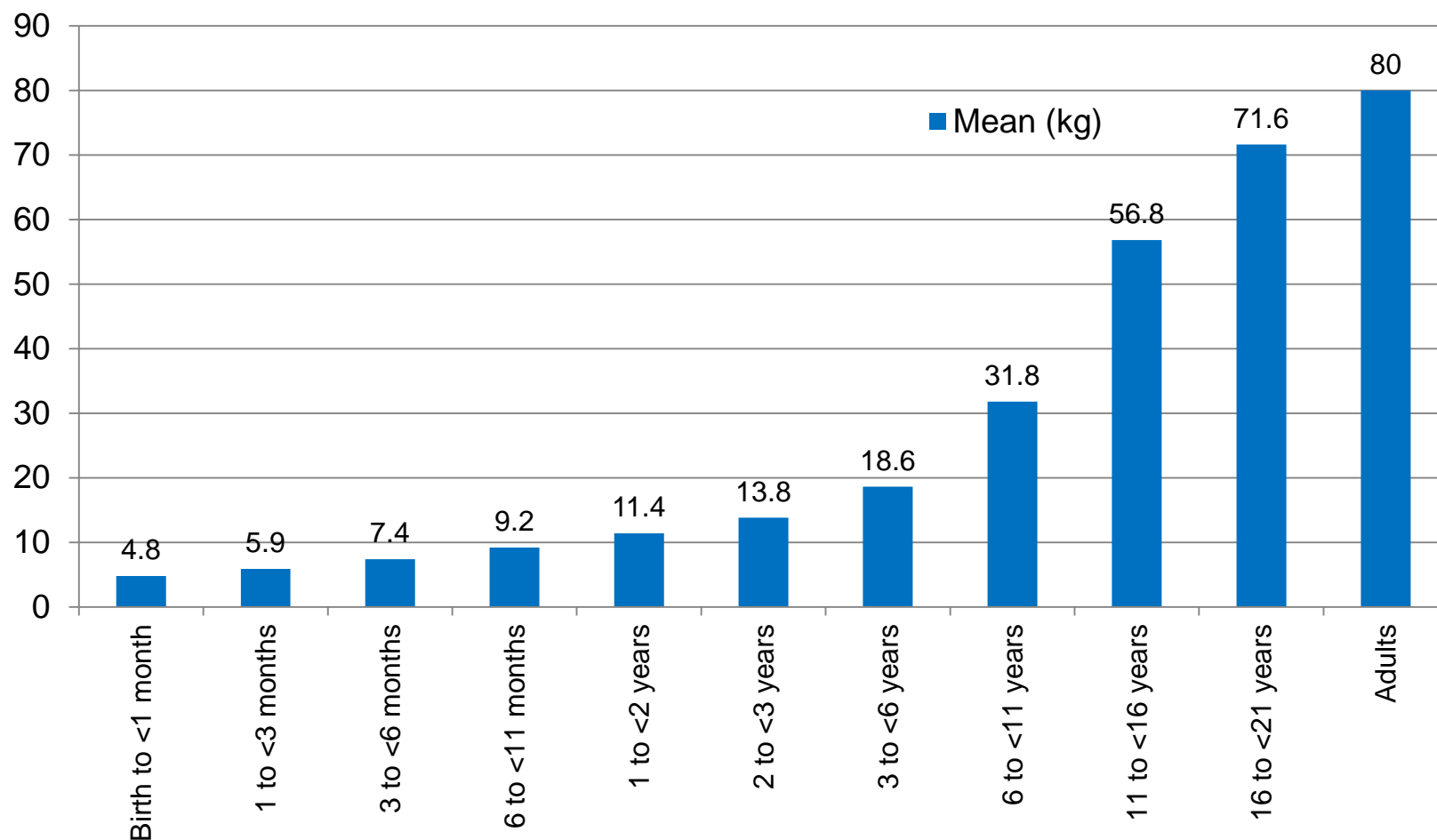
# Recommendations for Total Skin Surface Area for Dermal Exposure



\*See EFH 2011 for gender-specific values for individuals 21 and older



# Recommendations for Body Weight



Source: Chapter 8, EFH 2011

# CLASS ACTIVITY

# Applying the Concepts: Using Exposure Factor Data

$$\text{ADD} = \frac{(C \times IR \times CF \times ED \times EF)}{(AT \times BW)}$$

## Where:

ADD = Average daily dose (mg/kg-day)

C = Concentration (mg/m<sup>3</sup>, mg/kg)

IR = Intake rate (mg/day, L/day)

CF = Contact fraction (unitless)

ED = Exposure duration (minutes,  
hours, days, years)

EF = Exposure frequency (days/yr,  
events/day)

AT = Averaging time (minutes,  
hours, days, years)

BW = Body weight (kg)

Spend about 5 minutes evaluating potential exposures and calculating up to six ADDs for the scenario described in the Class Activity Handout.

# Estimated Average Exposures

## Calculating ADDs Using Mean Values

	Birth to < 1 month	1 to < 3 months	3 to < 6 months	6 to < 11 months	1 to < 2 years	Pregnant Women	Lactating Women	Units
C	0.01							mg/L
IR	184	227	362	360	271	819	1379	mL/d
CF	1							unitless
ED	365							d
EF	365							d/yr
AT	365							d
BW	4.8	5.9	7.4	9.2	11.4	73	80	kg
Unit conversions	(1 L/1000 mL) * (1 yr/365 d)							L-yr/ mL-d
<b>ADD</b>	<b>3.8E-04</b>	<b>3.8E-04</b>	<b>4.9E-04</b>	<b>3.9E-04</b>	<b>2.4E-04</b>	<b>1.1E-04</b>	<b>1.7E-04</b>	<b>mg/kg-d</b>

# Estimated High-end Exposures

## Calculating ADDs Using 95<sup>th</sup> Percentile Values

	Birth to < 1 month	1 to < 3 months	3 to < 6 months	6 to < 11 months	1 to < 2 years	Pregnant Women	Lactating Women	Units
C	0.01							mg/L
IR	839	896	1056	1055	837	2503	3434	mL/d
CF	1							unitless
ED	365							d
EF	365							d/yr
AT	365							d
BW	4.8	5.9	7.4	9.2	11.4	73	80	kg
Unit conversions	(1 L/1000 mL) * (1 yr/365 d)							L-yr/ mL-d
<b>ADD</b>	<b>1.7E-03</b>	<b>1.5E-03</b>	<b>1.4E-03</b>	<b>1.1E-03</b>	<b>7.3E-04</b>	<b>3.4E-04</b>	<b>4.3E-04</b>	<b>mg/kg-d</b>

# CONCLUSION



- Exposure factors provide information on human behavior and characteristics that allow us to quantitatively estimate exposure and dose
- EPA's recommended values for exposure factors can be found in EPA's *Exposure Factor's Handbook*
  - Updated 2011 version of EFH now available
- Assessor must consider data variability
- General assessment factors are available to determine confidence in data