EXA 406: Obtaining and Using Exposure Factor Data
Instructor Notes

Course Description: This course is designed to familiarize participants with the selection and use of exposure factor data. It will review key sources, including the *Exposure Factors Handbook* and the *Child-Specific Exposure Factors Handbook*, of data on human behaviors and characteristics that affect exposure to environmental contaminants. The types of factors that will be covered include: rates of water ingestion; non-dietary ingestion via hand-to-mouth contact; soil and dust ingestion; inhalation; intake of fruits, vegetables, fish and shellfish, meats, dairy products, and fats, and grain products; intake of home-produced foods; total food intake; ingestion of human breast milk; and dermal exposure (i.e., skin surface area and adherence of solids to the skin). Exposure factors for body weight, activity factors, use of consumer products, life expectancy, and residential characteristics will also be covered. The recommended values for these exposure factors will be highlighted along with the confidence in the recommended values. Recommended age groupings and indicators of variability will be discussed. Related topics will include the physiological differences between adults and children and other demographic factors that affect exposure.

Expected Course Duration: Approximately 45 minutes.

Terminal Learning Objective: Develop familiarity with the selection and use of exposure factor data.

Enabling Learning Objectives:

- Understand what exposure factors are, how they are used in exposure assessment, and where to obtain values for exposure factors.
- Understand the different types of exposure factors, EPA's recommended age groupings for populations, and the importance of variability when selecting values for exposure factors.
- Gain familiarity with EPA's recommended values for key exposure factors.

Course Materials

- EXA 406 Reading Packet
- EXA 406 Class Activity handout

Course Overview/List of Slides

TITLE SLIDE

What You Can Expect to Learn from this Course (Slide 1)

- In other EXA courses, you were introduced to general concepts of exposure assessment. This included using exposure scenarios as a framework for conceptualizing and quantifying exposures for a risk assessment.
- Exposure scenarios, as well as some exposure models, require that the exposure assessor identify data or estimated/modeled values to estimate corresponding exposures. During this course we will learn the definition of exposure factors and strategies to populate models with exposure factor data.
- We will discuss example exposure factors and review some of EPA's recommended values.
- We will also review EPA's recommended age groupings for exposure factor data and the importance of variability when selecting exposure factors.

INTRODUCTION AND BASIC CONCEPTS (SLIDE 2)

- Let's start by reviewing some basic definitions and concepts.

What Are Exposure Factors? (Slide 3)

- EPA defines exposure factors as quantifications of human behaviors and characteristics that affect exposure to environmental contaminants (U.S. EPA, 2011).
- Examples of exposure factors include body weight, inhalation rate, and ingestion rates of different types of food. We will discuss these and other types of exposure factors in greater detail later in this course.
- EPA/NCEA has an Exposure Factors Program. The goal of this program is to provide up-to-date and accurate data on exposure factors that are used in assessing exposure to environmental chemicals throughout the United States. Included in the information developed by this program are recommended values for important exposure factors. Ranges of values are provided for different demographic groups.
- Sources: U.S. EPA (2011); EPA website http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=20563

How Are Exposure Factors Used? (Slide 4)

- In other EXA courses, we've discussed the basic exposure equation.
- We have also discussed the basic dose equation, which takes into account the effect of intake rate, absorption, and duration of exposure to estimate a body-weight-normalized, average dose over time.

- Exposure factors are the quantities that are incorporated into the dose equation that allow us to quantitatively estimate exposure and dose. So, they are the values that are used in the exposure calculations.
- Exposure factors do not include chemical-specific values such as the concentration and absorption fraction. Instead, exposure factors quantify on human behaviors and characteristics that affect exposure to environmental contaminants.

History of Exposure Factor Guidance at EPA (Slide 5)

- Let's briefly review EPA's efforts to document exposure factors and ensure consistency.
- The first EPA document on exposure factors was published in 1985. This document provided ranges of values for body weight, skin surface area, and ventilation rates (U.S. EPA, 1985). A few years later, EPA published the first draft of the Exposure Factors Handbook (U.S. EPA, 1989).
- Less than 10 years later in 1997, EPA published the version of the Exposure Factors Handbook that has been used until very recently (U.S. EPA, 1997). A draft update to this document was published in 2009; this version was reviewed and an updated, revised version of the Handbook was issued in 2011 (U.S. EPA, 2011).
- Some additional documents have also been published as a result of work conducted in the Exposure Factors Program. These include the Child-Specific Exposure Factors Handbook (U.S. EPA, 2008), which provides information on child-specific exposures, and Example Exposure Scenarios, which provides examples of how exposure factors information is used to estimate exposure, and a variety of other supporting documents.
- In 2005, guidance was published on how to select age groups when assessing childhood exposure to contaminants (U.S. EPA, 2005). These recommendations were used in preparing the Child-Specific Exposure Factors Handbook (U.S. EPA, 2008) and the revised Exposure Factors Handbook (U.S. EPA, 2011).

Sources of Updated Exposure Factor Data (Slide 6)

- EPA's most up-to-date information on exposure factors is available in the 2011 version of the Exposure Factors Handbook and in the final 2008 Child-Specific Exposure Factors Handbook.
- Other sources of exposure factor data are available that are specific to EPA regions and EPA program offices.
- Organizations other than EPA have also collected information. Some states and other groups have collected information on fish consumption. For example, the state of Alaska conducted a traditional diet survey in an attempt to quantify the intake of subsistence foods, such as fish, among residents of villages in rural Alaska. Industry groups have also collected information on product usage.
- Sources: ATSDR, (2004); U.S. EPA, (2008); Ballew et al., (2004)

TYPES OF EXPOSURE FACTORS (SLIDE 7)

- Now that we've talked about what exposure factors are and how they are used, let's discuss some of the types of exposure factors that are commonly used by EPA and others in exposure assessment.

Examples Of Exposure Factors (Slide 8)

- This slide lists some of the main categories of exposure factors.
- Let's first discuss the first four exposure factors listed here, which are categorized as "physiological exposure factors" for the purposes of this course.

? How do you think body weight could affect the individual or population's dose of a chemical?

  - All other things being equal, lower body weight will result in a higher exposure dose (where dose is expressed as mg/kg-day or in similar units). So, for children, the dose per unit of body weight will exceed that of adults for the same total intake of chemical mass (for example).
  - Average body weight for males and females differ. Typically, a default body weight of 80 kg is used for "adult" exposures without specification of sex. An assessor has the option of assessing male and female exposures separately, and if he does so, the female body weight is typically assigned a lower value.

? Why is it important to take into account different inhalation rates?

  - Activities that an individual is engaged in will affect inhalation rate.
  - A key consideration here is the distinction between long-term rates and short-term rates, and the use of activity-specific rates, when appropriate.
  - Users should consider the scenario and select factors accordingly.
  - Should an assessor wish to be conservative, higher values that are protective of most active members of the target populations can be selected.

- It is also important to consider dermal and surface area factors. Surface area affects the amount of skin that can be exposed to chemicals: if more skin is exposed, the potential for dermal absorption is higher. Other dermal factors include the quantity of soil or solids that adheres to the skin surface. These data are activity-specific.
- Life expectancy—how long someone lives—is another key exposure factor, particularly when calculating lifetime average daily dose. Average life expectancies differ by gender and ethnicity.
- Source: (U.S. EPA, 2011)
- We'll talk about the five remaining exposure factors in this list in the following few slides.

Food and Water Intake (Slide 9)

- Intake or consumption rates for food and water are, of course, critical to estimating ingestion exposures.

- Intake rates can be defined by individual food types, such as beef, fish, carrots, apples, or by categories of these, such as total vegetables, total fruits, above-ground produce, or root vegetables.
- Intake can vary by the source of food. For example, the *Exposure Factors Handbook* provides different intake rates for fruits and vegetables for the general population and for individuals who produce their own fruits, vegetables, and meats. Fish intake rates are presented for the general population, individuals who catch their own fish, and recreational anglers. So, it could be important to consider quantities of specific foods consumed on a seasonally-specific basis.
- Intake rates are also different across different populations. For this reason, intake rates are presented for different age groups, races, ethnic groups, and some occupational groups, such as fishermen. It is important to select exposure values that are appropriate for the population of concern.
- There are other factors that affect intake rates. For example, the *Exposure Factors Handbook* presents "consumer only" and per capita intake rates for some exposure factors. We'll discuss the difference between consumer only and per capita in a subsequent slide.

- Consumption rates of drinking water are needed for some exposure scenarios – for example, if the scenario involves ingesting water from a well impacted by contamination in groundwater. The consumption of drinking water from surface water sources might also be of concern (although water treatment often mitigates concerns about contaminated drinking water from surface sources).
- Human milk consumption is an important exposure pathway for infants and should be considered for some contaminants and scenarios.
- Source: (U.S. EPA, 2011)

Mouthing Behavior and Soil/Dust Ingestion (Slide 10)

- Mouthing refers to all activities in which objects (including fingers) are touched by or put into the mouth during activities that are ***not*** eating or drinking.
- This behavior is commonly a concern because it can lead to ingestion of soil and dust containing pollutants.
  - It doesn't always involve ***soil or dust*** ingestion, though. For example, individuals can be exposed directly to chemical residues through hand-to-mouth contact, leading to ingestion of the residue.
- Soil/dust ingestion is a potential source of exposure to toxic chemicals, particularly for children. Inadvertent soil/dust ingestion among children can occur through hand-to-mouth and object-to-mouth activity. Adults can also be exposed by ingesting soil that adheres to food or any objects that they handle.
- Exposure factor data include separate values for amounts of soil and indoor dust ingested by children and adults.
- In addition, inadvertent ingestion of soil needs to be differentiated from soil-pica and geophagy. Soil-pica is the recurrent ingestion of unusually high amounts of soil. Geophagy is the intentional ingestion of soil material and is usually associated with cultural practices. Central tendency estimates for soil ingestion for individuals 1 year of

age and older are 50 mg/day. Soil-pica behavior can result in ingestion of 1,000 mg/day, and geophagy behavior can result in ingestion of 50,000 mg/day. Soil-pica and geophagy are considered uncommon events and represent the high end of exposures.

- Source: (U.S. EPA, 2011)

Exposure to Consumer Products (Slide 11)

- Consumer products are another potential source of exposure to toxic chemicals. The Exposure Factors Handbook provides information about the use of typical consumer products found in US households, as well as information about how these products are used. These data are used primarily to estimate exposure frequency and duration as well as the amount of products used per event.
- Exposure to consumer products can be active or passive. "Active" exposure could occur when cosmetic products or cleaning and painting products are used as directed. "Passive" exposure can occur when individuals come in contact with a product or byproduct through other means. Examples of passive exposure include touching countertops treated with a cleanser or pesticide, hand-to-mouth contact with treated clothing, or inhalation of vapors that have off-gassed from products like carpet, cabinetry, or recently painted surfaces.
- Source: (U.S. EPA, 2011)

Activity Factors (Slide 12)

- The activities in which a population is engaged are very important determinants of how individuals will be exposed. Are they indoors or outdoors? Are they at work or at home? Are they awake or sleeping?
- The Exposure Factors Handbook provides information about the activity patterns the US population follows, and typical amounts of time spent doing specific activities.
- It also provides data on occupational mobility, including how long people typically stay at a job and the distribution of job types across the population.
- The EFH also provides data on population mobility; in other words, how long an individual stays in a particular house.
- In addition to the EFH, EPA's Consolidated Human Activity Database (CHAD) and the National Human Activity Pattern Survey (NHAPS) provide information on activity patterns.
- Source: (U.S. EPA, 2011)

Microenvironments (Slide 13)

- The spaces in which people spend their time influence how they will be exposed to chemicals.
- Specific exposure realms are sometimes referred to as microenvironments. This term is commonly used when discussing inhalation exposures. A microenvironment can be

defined as a space with a contaminant concentration that is assumed to be relatively well-mixed, homogeneous, and temporally constant while an individual is located within the microenvironment.

- Examples of microenvironments often included in EPA assessments are cars, schools, and work places.
- The EFH also presents data on the amount of time that an individual spends in various microenvironments.

Building Characteristics (Slide 14)

- Let's consider one type of microenvironment: buildings.
- The Exposure Factors Handbook provides information about residential and non-residential buildings, including volumes and sizes of buildings and individual rooms. Information is also available about air exchange rates. Building characteristics such as water usage can also be found in the EFH.

? Consider the differences between these two types of residential buildings. How might the structures of these buildings influence how residents are exposed?

  - Fewer windows and doors to the outside are typically included in apartments, so the air exchange rate is less than in the house. This means that chemicals used in the apartment might be present within the living space longer.

- Source: (U.S. EPA, 2011)

SELECTING VALUES FOR EXPOSURE FACTORS (SLIDE 15)

- Now that we've discussed what exposure factors are and some of the important types of factors, let's talk about how to select the values of factors.

Considerations When Selecting Values for Exposure Factors (Slide 16)

- The values for a given exposure factor can vary widely. In discussing these exposure factors, we have already touched on a few of the items that we see listed in this slide that affect the appropriate value for an exposure factor.
- Population variability should be considered, including differences in age, lifestage, population, and susceptibility. These affect our selection of values for exposure factors.
- We need to also consider the data uncertainty as we select exposure factor data to use in our exposure assessment. This includes assessing confidence in the data and comparing the original purpose of the data to our intended use.
- To assess confidence in exposure factor data, EPA has defined five general assessment factors that should be considered when selecting exposure factor data. We will discuss these in greater detail in a bit.
- Source: (U.S. EPA, 2011)
- But, let's start out by talking about variability, specifically in terms of age and lifestage.

Differences between Children and Adults (Slide 17)

- Physiological and behavioral differences between children, including infants, and adults mean that children and adults will have different exposures.
- For example, children can experience higher exposures to some chemicals than adults because they consume more of some foods per unit of body weight and have a higher ratio of body surface area to volume than adults.
- Infants and children handle food more than adults, so anything that is on a child's hands is more likely to be ingested. Children put their hands and other objects in their mouths much more frequently than adults. This is called hand-to-mouth activity or object-to-mouth activity. Here again, whatever is on their hands or objects is likely to get into their mouths. Exposure factor data are available to assess exposure via hand-to-mouth and object-to-mouth activity.
- Infants and children spend more time on the floor and so are more likely to be exposed orally or dermally to whatever is on the floor – either indoors or outdoors. For example, children typically ingest more soil and dust than adults.
- In addition to the floor, children explore surfaces more than adults, so as with floors, whatever is on the surface is likely to get into a child's mouth.
- For all of these reasons (and others), the behavior of children can increase their exposure to environmental contaminants. Therefore, if possible, it is important to consider children separately from adults in exposure assessments. Values selected for exposure factors should be specific to children.
- Source: (U.S. EPA, 2008)

Selecting Age Groups for Children (Slide 18)

- As we discussed in the previous slide, children and adults are exposed differently to chemicals. So, too, are children of different ages.
- Rapid changes in behavior and physiology can lead to differences in exposure as a child grows up. Exposures among infants, toddlers, adolescents, and teenagers can vary widely.
- To this end, EPA has provided guidance on selecting age groups when conducting exposure assessments. The age groups we see depicted on this slide were defined based on EPA's understanding of when developmental changes occur that could affect exposure. This was published in 2005 in EPA's Guidance on Selecting Age Groups.
- As we can see on the left side of the slide, narrow age groups have been identified for life stages in which rapid developmental changes occur. Broader age groups, shown on the right side, are identified when the rate of development decreases. Notice that EPA recommends that individuals aged 18 up to (but not including) 21 years be included in the 16 to under 21 age group rather than being assessed as adults.
- When it is possible and appropriate, values for exposure factors should be determined separately for these age groups.

- However, it is not always practical or necessary to evaluate exposures for every age group in a population. The assessor might group age categories together based on the purpose and the scope of the assessment.
- Sources: (U.S. EPA, 2008, 2005)

Life Stages (Slide 19)

- Childhood stages of life are not the only stages that should be considered in exposure assessments.
- Life stages are defined by EPA as temporal stages of life that have distinct anatomical, physiological, and behavioral or functional characteristics that contribute to potential differences in vulnerability to environmental exposures.
- In addition to children, other important life stages to consider include pregnancy, nursing, and old age.
- Therefore, exposure assessments need to consider all life stages of a population.
- Sources: (U.S. EPA, 2006); http://yosemite.epa.gov/ochp/ochpweb.nsf/content/lifestage.htm

Life Stages vs. Population Groups (Slide 20)

- It is important to distinguish between the terms life stage and population group. EPA, and specifically the Office of Children's Health Protection, has defined these two terms.
- A **life stage** refers to a distinguishable time frame in an individual's life. Examples of life stages in childhood are conception through fetal development, infancy, toddlerhood, and adolescence. Life stages are inclusive of the entire population.
- A **population group**, on the other hand, refers to a relatively fixed portion of the population. For example, ethnic groups are types of population groups. Occupational workers or farmers would also be considered distinct population groups. There are other terms used to describe population groups, and often we refer to these groups as populations. It's also important to recognize that EPA does not currently use the term subpopulation (and instead simply refers to different ***populations***).
- Individuals are exposed differently at different life stages, and different population groups can also be exposed differently.
- Exposure assessments should consider life stages and population groups, but differentiate between the two.
- Source: http://yosemite.epa.gov/ochp/ochpweb.nsf/content/lifestage.htm

Susceptibility (Slide 21)

- Just as lifestage or population group can affect exposure, lifestage or population group can also affect an individual's or a population's susceptibility to chemicals or pollutants. Susceptibility is an increased likelihood of an adverse effect or exposure (U.S. EPA, 2006).

- There are intrinsic and extrinsic factors that affect an individual's or population's susceptibility to pollutants.
- **Intrinsic**, or **biological**, susceptibility factors include things like age, life stage, gender, race/ethnicity, and genetic polymorphisms. These biological factors cannot be changed.
    - As we discussed in the previous slide, specific life stages may be more susceptible to exposure. For example, infants and toddlers are more vulnerable to pollutants because of toxicodynamic differences, such as when exposures occur during periods of susceptibility, and toxicokinetic differences that affect how easily a chemical is absorbed, metabolized, and excreted. Older adults are also more susceptible because as we age, our bodies' abilities to defend against diseases and respond to injuries diminish. Critical windows of exposure need to be identified as part of the risk assessment process.
- **Extrinsic**, or **exposure-related**, factors include socioeconomic status, disease status, nutrition status, and lifestyle. In many cases, these factors can be changed.
    - Individuals with pre-existing diseases can be more susceptible to pollutants. An example would be individuals with asthma who are more susceptible to adverse respiratory effects from exposure to air pollutants. Although these data are often difficult to collect and are not in the EFH, assessors should be aware that these factors may affect population susceptibility.

? What other extrinsic susceptibility factors could influence exposure?

- Availability of nutritious foods to build immune system
- Lifestyle factors such as amount of exercise and diet

- Source: http://www.epa.gov/nheerl/research/human_health_risk/susceptible.html

Confidence in Data (Slide 22)

- It is important to consider the sources and characteristics of the underlying data when selecting exposure factors for an assessment.
- To assess confidence in exposure factor data, EPA defined five "general assessment factors" that should be considered when setting exposure factors. These factors were used when EPA scientists compiled the *Exposure Factors Handbook*. The factors are soundness, applicability and utility, clarity and completeness, uncertainty and variability, and evaluation and review.
    - Soundness is the extent to which the scientific and technical procedures, measures, methods, or models employed to generate the information are reasonable for, and consistent with, the intended application.
    - Applicability and utility cover the extent to which the information is relevant for the intended use. We'll talk more about the original purpose of data versus the intended use of the data in the next slide.
    - Clarity and completeness refers to how well the data, assumptions, methods, quality assurance procedures, sponsoring organizations, and information generation processes are documented.
    - EPA also evaluates the extent to which uncertainty and variability in procedures, measures, methods, or models are qualitatively and quantitatively evaluated and characterized.

- Evaluation and peer review refers to the extent of independent verification, validation, and peer review of procedures, measures, methods, and models.
- Sources: (U.S. EPA, 2011, 2009, 2006)

Original Purpose of Data vs. Intended Use (Slide 23)

- There are some additional issues that should be considered when evaluating exposure factor data. We need to evaluate the original purpose of the data collected in comparison to our intended use of the data for our exposure assessment.
- Some data are collected on a national scale, so their applicability to site- or regional-specific situations needs to be evaluated by the user. Other data are limited to some specific regions and applicability to other areas should be done with caution.
- Most of the data collected on exposure factors are based on short-term observations. Data can be extrapolated to long-term behaviors in some cases, but this should be done with caution.
- Recommended values in the Exposure Factor Handbooks are presented as single point estimates, often representing the mean and 95th percentile of a distribution of values. These values come from a larger distribution of data that are usually available in the *Exposure Factors Handbook* or from the original sources of the data.
  - Using upper percentile consumer-only estimates to represent usual intake in the general population might not be appropriate and can result in unreasonably high estimates.
- In summary, it is critical that a risk assessor consider how the results of an exposure assessment will be used in a risk assessment when selecting values for exposure factors.
- Source: (U.S. EPA, 2011)

Per Capita vs. Consumer Only (Slide 24)

- Some exposure factors (e.g., food intake rates) are provided on a per capita and/or consumer only basis. "Consumer only" rates are intake rates pertaining only to those individuals who reported eating the foods during the surveyed period. Per capita rates are defined as rates representative of the whole population, which includes individuals who ate the food during the survey period as well as individuals who did not.
- Per capita intake rates should be used in exposure assessments for which average dose estimates are of interest, such as general population background exposures. Consumer only rates are more pertinent for assessing specific populations for specific reasons, such as assessing fish consumers by using fish consumption rates for consumers only.
- For food items that are frequently consumed across the general population, per capita and consumer only estimates are similar. For food items that are infrequently consumed, per capita and consumer only estimates can be significantly different because of the high number of consumers who will report not eating a food.

Example: Selecting Data for Fish Consumption (Slide 25)

- It is important to consider the sources of data when selecting exposure factors for an assessment. The data used to develop an exposure factor value used in estimating an exposure must be relevant to the exposure scenario in question. A good example is the value used for the exposure factor for fish consumption.
- The EFH provides recommended intake values for different types of fish, including finfish, shellfish, fish caught in the Atlantic Ocean, fish caught in the Pacific Ocean, and fish caught in Gulf regions.
- Per capita and consumer fish intake rates are available in the EFH. Fish intake is an example of an exposure factor for which per capita and consumer intake rates are different. Fish is not consumed frequently by everyone in the US, so many consumers will report not eating fish.
- Fish intake values are also available for different populations, including the general population as well as recreational fishers and Native American subsistence fishers.
- In general, intake rates for fishers and their families are higher than intake rates for the general population.
- One study estimated that fish intake rates for individuals belonging to Columbia River Tribes in the Pacific northwest could be as high as 170 g/day for adults and 98 g/day for children five years old and younger. 170 g/day is equivalent to having a fish meal every day of approximately 6 ounces. (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)
- This value may be reasonable for this or a similar subsistence fisher population, but it will overestimate long term fish intake for most groups.
- Sources: U.S. EPA, (2011); CRITFC, (1994)

EFH RECOMMENDED VALUES (SLIDE 26)

- Now that we have described the types of exposure factors that EPA has developed, let's look at some of EPA's recommended values for exposure factors.
- In the EFH and CSEFH, EPA has developed recommended values for a wide range of exposure factors, including those discussed in this course. These are values that EPA suggests are appropriate for use in exposure scenarios and conducting exposure assessment. However, these recommendations are not binding. Assessors should evaluate whether recommended values are appropriate for their assessment and use alternative data from the EFH or other sources as appropriate.

Recommendations for Drinking Water Ingestion Rates (Slide 27)

- Data on drinking water can be found in chapter 3 of the EFH. General population drinking water rates come from EPA's analysis of NHANES data for 18,000 people across the US from 2003-2006.

- In addition to NHANES, EPA used data from USDA's Continuing Survey of Food Intake by Individuals, or CSFII, to develop recommended drinking water intake rates for pregnant and lactating women.
- EPA's recommended drinking water intake rates represent consumption of water as a beverage, or direct intake, and water used in preparing foods and beverages, or indirect intake.
- Using the general assessment factors we discussed previously, EPA determined that the overall confidence rating for the recommendations for drinking water ingestion is medium to high.
- It's interesting to note that the highest recommended drinking water ingestion rates are for nursing women.
- Source: (U.S. EPA, 2011)

Recommendations for Hand-to-Mouth Frequency (Indoor) (Slide 28)

- Information on children's hand-to-mouth and object-to-mouth frequency can be found in Chapter 4 of the EFH.
- These rates come from two meta-analyses that used data from multiple studies and included over a thousand hours of behavior observation.
- Overall, the confidence rating for the recommendations for hand-to-mouth and object-to-mouth frequency is low.
- You can see that HTM and OTM activity decreases dramatically as a child gets older.
- Source: (U.S. EPA, 2011)

Recommendations for Soil and Dust Ingestion Rates (Slide 29)

- Recommended soil and dust ingestion rates are provided in Chapter 5 of the EFH.
- The recommended rates came from 13 key studies on children and adults.
- Soil can be from outdoors or indoors, i.e., containerized soil such as that used in potted plants.
- Dust can be tracked in from outdoors, indoor settled dust, or air-suspended particulate matter.
- Overall, EPA's confidence rating in soil and dust ingestion rates is low.
- The recommended intake rates are substantially higher (by orders of magnitude) for individuals engaging in soil pica behavior and geophagy.
- As mentioned earlier, soil-pica is the recurrent ingestion of unusually high amounts of soil (i.e., on the order of 1,000 - 5,000 mg/day or more), and geophagy is the intentional ingestion of soil material that is usually associated with cultural practices.
- Source: (U.S. EPA, 2011)

Recommendations For Inhalation Rates (Long-Term) (Slide 30)

- Inhalation rates can be found in Chapter 6 of the EFH.
- Data for the recommended inhalation rates came from four key studies, including one on children.
- The studies on which the 2011 recommended inhalation rates are based are considered to be an improvement over the studies used for inhalation rates in previous versions of the EFH because they involved larger data sets and considered correlation between body weight and inhalation rate.
- EPA's confidence in the recommended inhalation rates is medium.
- You can see that recommended inhalation rates increase with age until later in life, when inhalation rates decrease.
- Source: (U.S. EPA, 2011)

Recommendations for Total Skin Surface Area for Dermal Exposure (Slide 31)

- Recommended values for dermal exposure factors such as body surface area are available in Chapter 7 of the EFH.
- These rates are based on EPA's analysis of NHANES data. Multiple NHANES study years were used to increase the sample size so multiple stratifications by age could be provided.
- EPA's confidence in body surface area estimates is medium for total body surface area and low for surface area of individual body parts.
- As with inhalation rates, surface area values increase with age until a person reaches the elderly years when surface area values decrease.
- Source: (U.S. EPA, 2011)

Recommendations For Body Weight (Slide 32)

- EPA's recommendations for body weight can be found in Chapter 8 of the EFH.
- EPA has recently changed its recommended general default for adult body weight from 70 kg to 80 kg.
- However, assessors are encouraged to use values which most accurately reflect the exposed population. If 80 kg or any other value other than 70 kg is used, assessors need to consider the dose-response relationship for the chemical of concern. If an inconsistency exists, the assessor should adjust the dose-response relationship.
- The confidence rating for body weight recommendations is high.
- You'll notice that the 95th percentile value for body weight is not included on this chart; this value is not used in a typical exposure assessment.
- Source: (U.S. EPA, 2011)

CLASS ACTIVITY (SLIDE 33)

- Let's put what we just learned into practice. Please refer to the class activity handout. [Give class time to get handouts.]

Applying the Concepts: Using Exposure Factor Data (Slide 34)

- In the time that we have left, we're going to go through an exercise that will give you the chance to use exposure factors data to estimate average daily doses. Here's the situation:
- A spill of Chemical A from a former industrial site has resulted in contamination of the groundwater below the site, and the plume of contaminant has traveled offsite. The plume is now under Mayberry, a residential neighborhood that includes homes as well as a daycare center. The concentration of Chemical A in groundwater under Mayberry is 0.01 mg/L.
- Use the following assumptions in your calculation:
  - Oral exposure to Chemical A has been shown to cause adverse effects at low levels in children less than 2 years old. Exposures are believed to be possible for children in utero, and the substance can partition to the breast milk of lactating women.
  - The sole source of drinking water for Mayberry is well water. All of the children attending the day care are residents of Mayberry.
  - There are no site-specific data on drinking water consumption by residents of Mayberry.
  - The estimated exposures will be used by the local public health agency in determine possible health risks for the residents. (Calculation of risks is not part of the current exercise.)
  - We are interested here in estimating typical and high-end exposures. Therefore, you
    - Use per capita estimates.
    - Use mean or 95^{th} percentile estimates. (Hint: For body weight, only mean estimates are provided for the general population. Use the 50^{th} percentile estimate for pregnant women.)
- The simplified average daily dose equation is shown on this slide and in your hand out for reference.
- Let's spend about 5 minutes developing appropriate exposure scenarios and calculating average daily exposures for the situation described in your handout. Choose no more than ***six*** average daily dose estimates to calculate.

Estimated Average Exposures (Slide 35)

- This slide shows the estimated ADDs that you would calculate if you used mean values and assumed conservative exposure conditions, such as consumption of drinking water each day of the year (that is, exposure frequency of 365 days per year). [Discuss as appropriate.]
- Now, let's take a look at some exposure estimates calculated using 95^{th} percentile values for ingestion of drinking water.

Estimated High-end Exposures (Slide 36)

- This slide depicts the estimated ADDs that you would calculate if you used 95th percentile values for intake rates.
- In this situation, the important population groups to consider were children under 2 years of age, as well as pregnant and lactating women.
- Intake rates and body weights for these populations were made available to you in the class activity handout.
- In the handout, we provided tables with exposure factors data that are more age- and population-specific than what was presented in the slides. The values in the slides are only a subset of EPA's recommended exposure factors. At the start of an assessment, always consider whether or not to use age- or population-specific data in your analysis.
- Let's take a closer look at the results that we got.

? The highest children's mean ADD is for children 3 to less than 6 months of age. Why is this?

  - The drinking water intake rate for that group of children is the highest.

? The highest mean ADD for all population groups is also for children 3 to less than 6 months of age. Why is this value higher than the exposure estimate for pregnant and lactating women?

  - Even though pregnant and lactating women consume more drinking water, their body weights are high enough that their exposure estimates are actually lower than estimates for younger children.

? In this situation, all of the drinking water consumed was contaminated, so our contact fraction was 1. How might we have modified the equation if only half of the water consumed had been contaminated?

  - The contact fraction would have been 0.5.

? EPA generally recommends using mean body weight values instead of 95th percentile values. Why is this?

  - Generally, a lower body weight makes an exposure estimate more conservative.

CONCLUSION (SLIDE 37)

Conclusion (Slide 38)

- 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*. The 2011 version of the Handbook is now available online. Assessors may also find exposure factors data that are specific to EPA regions in EPA program offices, and some states and industry groups have also collected exposure factors information.
- When selecting exposure factors, the assessor must account for data variability and data uncertainty.

- Data variability may be attributed to differences between children and adults, age groups, life stages, population groups, and population susceptibilities.
- The assessor must also determine how much uncertainty there is regarding an exposure factors dataset. EPA's general assessment factors are available to help determine the level of confidence that an assessor should have in using a dataset. The assessor must also evaluate the original purpose of the data collected in comparison to the intended use of the data in his or her assessment.
- Source: (U.S. EPA, 2011)

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