Exposure Dose Guidance for Determining Life Expectancy and Exposure Factor

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Purpose

This guidance contains the following topics:

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Based on the availability of updated exposure parameters, many from the 2011 Exposure Factors Handbook (EFH) published by the U.S. Environmental Protection Agency (EPA), it is necessary that assumptions used in calculating doses in our public health evaluations be updated to reflect the best available science.

The purpose of this exposure dose guidance (EDG) is to provide health assessors with the most updated guidance on appropriate life expectancy values and exposure factors (EF) to use in health evaluations.

Background

Health assessors are required to evaluate all human exposure pathways related to a release of chemicals into the environment. Exposure pathways for all media include exposure factors and life expectancy in the dose calculation equations.

Life Expectancy:

The 2005 ATSDR PHAGM recommends default values of 70 years for lifetime exposure. Since the release of the 2005 ATSDR PHAGM, updated information on life expectancy was released by the EPA in the Exposure Factors Handbooks (EPA 2011).

Exposure Factor:

The exposure factor (EF) term is an important parameter in the dose equation and is used to adjust the dose to account for either continuous or intermittent exposure. The default EF value for various scenarios (e.g., residential exposure) is usually 1, indicating that exposure occurs daily for acute, intermediate, or chronic durations. However, health assessors can change the EF term based on site-specific exposure scenarios, especially when exposure is intermittent.

Definitions

To discuss life expectancy and exposure factor, several definitions are important to know.

Exposure factor (EF): An expression of how often (frequency) and how long (duration) a person may be contacting a substance in the environment. In many instances, the exposure factor (EF) will equal 1, representing a daily exposure to the contaminant. However, some exposures may occur on an intermittent or irregular basis. For these exposures, an EF can be calculated by averaging the dose over the exposure interval. The EF is calculated by multiplying the exposure frequency (F) by the exposure duration (ED) and dividing by the time period during which the dose is to be averaged

(averaging time - AT)**.** The EF for occupational, school, trespassing, and swimming scenarios is likely to be different than 1 (see examples).

Exposure Duration (ED): The period over which the exposure takes place.

Exposure Frequency (F): How frequently exposure occurs. This parameter is often measured in days per week and weeks per year.

Averaging time (AT): The period over which the exposure is averaged to arrive at a time-weighted exposure factor. For assessing cancer risks, AT is averaged over a lifetime (78 years); for assessing noncancer risks, AT is averaged over the exposure duration (days, weeks, or years), which may or may not be a lifetime.

Residential occupancy period (ROP): The time in years between when a person moves into a residence and when the person moves out or dies.

Central Tendency Exposure (CTE): CTE refers to individuals who have average or typical exposure to a contaminant.

Reasonable Maximum Exposure (RME): RME refers to people who are at the high end of the exposure distribution (approximately the 95th percentile). The RME scenario is intended to assess exposures that are higher than average, but are still within a realistic range of exposure.

Chronic exposures: Exposures greater than 365 days. Exposure doses derived for chronic exposure scenarios should be evaluated using chronic ATSDR Minimal Risk Levels (MRL). If MRLs are not available, EPA Reference Doses (RfD), EPA Reference Concentrations (RfC) or another suitable health guidance value may be used for the evaluation.

Intermediate exposures: Exposures of 15 to 364 days. Exposure doses derived for intermediate exposure scenarios should be evaluated using intermediate MRLs or appropriate toxicity information (e.g. utilizing studies of similar duration if available).

Acute exposures: Exposures up to 14 days. Exposure doses derived for acute exposure scenarios should be evaluated using acute MRLs or appropriate toxicity information (e.g., utilizing studies of similar duration if available).

Life Expectancy

Life expectancy for U.S. populations:

- Seventy eight (78) years should be used as an average life expectancy for men and women combined (CDC 2011; EPA 2011). If sex is a factor considered in the assessment, the average lifetime values of 75 years for males and 80 years for females are recommended.

- If race or ethnicity is a factor considered in the assessment, the assessors should use the race- or ethnic-specific values that most reflect the target population (EPA 2011).

- Using 78 years instead of 70 years does not affect how health guidelines, such as chronic MRLs, RfCs, and RfDs, are derived and does not affect how cancer slope factors and inhalation unit risks are used

Additional life expectancy information can be found in the National Vital Statistics Reports 2011 and the 2011 EPA Exposure Factors Handbooks (EFH), Chapter 18—see Appendix A for selected tables (EPA 2011).

Exposure Dose Equation

Estimating an exposure dose requires identifying how much, how often (frequency), and how long (duration) a person or population may come in contact with some concentration of a substance (e.g., maximum or mean) in a specific medium.

You should strive to estimate exposure doses by using site-specific or population-specific exposure information. Doses are calculated using the following general equation:

$$\text{Exposure Dose} = \frac{(C \times IR \times EF)}{BW}$$

Where:

C = media-specific substance concentration
IR = media-specific intake rate
EF = Exposure factor (unitless)
BW = age-specific body weight (kilograms).

The exposure factor is an expression of how often and how long a person may be contacting a substance in the environment. The exposure factor is calculated using the following general equation:

$$EF = \frac{(F \times ED)}{AT}$$

Where:

$EF_{Chronic}$ = Chronic Exposure Factor (unitless)
F = Frequency of exposure (d/wk, wk/yr)
ED = Exposure duration (yr)
AT = Averaging time

- noncancer = ED (yr) x F (d/wk x wk/yr)
- cancer = ED (yr) x F (7d/wk x 52.14 wk/yr)

$EF_{Intermediate}$ = Intermediate Exposure Factor (unitless)
F = Frequency of exposure (d/wk)
ED = Exposure duration (wk)
AT = Averaging time

- noncancer = F (d/wk) x ED (wk)

EF_{Acute} = 1 (by default)*

*Note that the air EF_{acute} has an additional term of number of hours in a day that a person is exposed. Thus, the air EF_{acute} can be less than one. For example, workers exposed for 8 hours would have an EF_{acute} = 8/24 = 0.33. Examples follow. Also, the EF for children with pica behavior is 0.43 based upon pica occurring for 3 days a week.

Exposure Frequency and Duration Parameters

Residential Scenarios

Default exposure frequency and duration parameters are provided in Table 1 for residential scenarios. Values for recreational and trespass scenarios will be site specific.

Table 1. Default exposure frequency and duration parameters for residential scenarios.

Duration of Exposure	Frequency		Exposure Duration and Noncancer Averaging Time in Years		Cancer Averaging Time in Years
	d/wk	wk/yr	CTE	RME	
Chronic	7	52.14	12	33	78
Intermediate	7				
Acute	Default = 1*				

*Default soil-pica is 3 days per week (see EDG soil and sediment ingestion) (ATSDR 2016)

Occupational Scenarios

ATSDR recommends that health assessors assume a full-time worker exposure scenario of 5 days a week (5 days/7 days) for 50 weeks per year for 20 years (RME) and 5 days a week (5 days/7 days) for 50 weeks per year for 5 years (CTE), unless site-specific conditions warrant an adjustment to these standard assumptions. For part-time employees, health assessors should use 5.1 hrs/day (5.1 hr/24 hr), 5 days a week (5

days/7 days) for 50 weeks per year for 3.1 years (CTE) unless site-specific conditions warrant an adjustment.

When workers are exposed via inhalation, health assessors should incorporate an additional exposure factor term, specifically 8.5 hours a day (8.5 hr/24 hr) for full-time workers and 5.1 hrs/day (5.1 hr/24 hr) for part-time workers. Table 2 summarizes these assumptions.

Table 2. Default assumptions for occupational exposure scenarios

Typical workday, all (hrs/day)[a]	Work year (weeks)	Work tenure (years)
Full time: 8.5 hrs	RME: 50.0 CTE: 50.0	RME: 20.0 years[b] CTE: 5.0 years[c]
Part time: 5.1 hrs	CTE: 50.0	CTE: 3.1 years[d]

a *Bureau of Labor Statistics, U.S. Department of Labor, American Time Use Survey, weekday work hours, Table 2, Table 4 (June 2019):* https://www.bls.gov/news.release/archives/atus_06192019.htm
b The RME work tenure reflects the tenure of 20 years or more for the top 10% of the longest employed workers. Bureau of Labor Statistics, U.S. Department of Labor, Employee Tenure in 2020, Table 3 (September 2020): https://www.bls.gov/news.release/pdf/tenure.pdf*. Distribution of employed wage and salary workers by tenure with current employer, age, sex, race, and Hispanic and Latino ethnicity, January 2020."*
c Copeland, C. Employee Benefit Research Institute. Trends in Employee Tenure, 1983–2018, Figure 1 (February 2019): https://www.ebri.org/docs/default-source/ebri-issue-brief/ebri_ib_474_tenure-28feb19.pdf?sfvrsn=70053f2f_13
d Exposure Factors Handbook (2011), Chapter 16, "Activity Patterns." Table 16-105.

For RME exposures, health assessors should assume an individual works 20 years at the same location unless site-specific conditions warrant another exposure duration. Note that 20 years represents the 90th percentile estimate of tenure (RME) with current employer from the Bureau of Labor Statistics as of September 2018. In 2018, workers 25 years and older had a median tenure (CTE) of 5 years. ATSDR selected these values for CTE and RME occupational tenures.

Childcare facilities

Health assessors may be requested to assess exposures for children in childcare facilities. The ATSDR default assumptions are presented for daycare facilities in Table 3. Default parameters for CTE and RME exposures in Tables 3 are based on the EFH (2011) Chapter 16 and U.S. Department of Education publication (Snyder *et al*. 2018).

As a default assumption, children could be exposed in a daycare environment for five out of seven days per week. Health assessors should modify this assumption based on site-specific conditions if children are exposed for less than or more than five days a week.

Table 3. Children: time per day spent in childcare facilities¶

Age Group	Daily CTE (hr/day)	Daily RME (hr/day)	Annual CTE (wks/yr)*	Annual RME (wks/hr)*
Birth to < 1 year	5.2[a]	11.8[a]	50	52.14
1 to < 2 years	4.8[a]	9.9[a]	50	52.14
2 to < 6 years	6.4	9.6	50	52.14

¶ *Source unless otherwise noted: Exposure Factors Handbook (2011), Chapter 16, "Activity Patterns." Table 16-11.*

[a] *The CTE (central tendency estimate) and RME (reasonable maximum exposures) for children under 2 years were obtained from Table 16-18, because table 16-11 did not represent sufficient data (number of children) to generate reliable statistics for these age categories.*

[b] *The daily CTE/RME for 2- to <6-year-olds was calculated by weighting the averages for 2- to <3- and 3- to <6-year-olds in table 16-17 to adhere to the ATSDR standard age category of 2 to <6 years:*

$CTE_{2 \text{ to } <6 \text{ years}}$: 4.5 hrs/day*0.25 (2 to <3 years)+7 hrs/day*0.75 (3 to <6 years)=1.125+5.23=6.4 hrs/day

$RME_{2 \text{ to } <6 \text{ years}}$: 8.8 hrs/day*0.25 (2 to <3 years)+9.83 hrs/day*0.75 (3 to <6 years)=2.2+7.4=9.6 hrs/day

**The CTE assumption accounts for families taking 2 weeks of vacation each year. RME assumes year-round daycare for younger children. Using the custom group feature in PHAST, the user may specify additional exposure duration for special considerations, such as children attending a different duration childcare during the summer months.*

Grade schools

Health assessors may be requested to assess exposures for children in preschool, elementary, middle, and high school scenarios. The ATSDR default assumptions are presented for kindergartens and grade schools in Table 4. Default parameters for CTE and RME exposures in Table 4 are based on the EFH (2011) Chapter 16 and U.S. Department of Education publication (Snyder *et al.* 2018).

As a default assumption, children could be exposed in a school environment for five out of seven days per week. Health assessors should modify this assumption based on site-specific conditions if children are exposed for less than or more than five days a week.

Table 4. Children: time per day spent in grade school pre-kindergarten through 12¶

School Grade Level	Age (yrs)	Default School Placement	Daily (hr/day)*		Annual (wks/year)*	
			CTE	RME	CTE	RME
Pre-Kindergarten	3<5	Pre-Kindergarten	7.0	9.6	39	47
Kindergarten	5<6	Kindergarten	7.0	9.6	39	47
1st – 5th grades	6<11	Elementary	6.7	9.0	39	47
6th – 8th grades	11<14	Middle	6.7	9.3	39	47
9th – 12th grades	14<18	High	6.7	9.3	39	47

¶*Source unless otherwise noted: Exposure Factors Handbook (2011), Chapter 16, "Activity Patterns." Table 16-11.*

[a]Synder, T.D., de Brey, C., and Dillow, S.A. 2018. *Digest of Education Statistics 2018* (NCES 2016-014). National Center for Education Statistics, Institute of Education Sciences, U.S. Dept of Education. Washington, DC. (Table 203.90)

**The CTE assumption accounts for winter, spring, and summer breaks of 13 total weeks away from school yielding a CTE assumption of 39/52.14 weeks a year of school exposure; the RME assumption is that children attend summer school or school-based camps for 8 weeks of the summer at the same location, yielding an RME assumption of 47/52.14 weeks a year of school exposure. Using the custom group feature in PHAST, the user may specify additional exposure duration for special considerations, such as children attending a different duration summer school during the summer months.*

Additional information for parameters in Tables 3 and 4:

- The childcare annual CTE assumes exposures for children of workers with time away from daycare (e.g., vacation, sickness), whereas the annual RME assumes no vacation for these workers. The health assessor may choose to change this assumption if they have site-specific data that indicates that children attend the childcare facility for other durations.
- ATSDR recommends the CTE assumption account for winter, spring, and summer breaks of 13 total weeks away from school, yielding a CTE assumption of 39/52.14 weeks a year of school exposure; the RME assumption is that children attend summer school or school-based camps for 8 weeks of the summer, yielding an RME assumption of 47/52.14 weeks a year of school exposure. The user may specify additional exposure duration for special considerations, such as children attending a different duration of summer school or childcare during the summer months.
- If an assessment of a child in various exposure scenarios is required, EFH (EPA, 2011) has detailed information about the number of hours children spend indoors/outdoors at home, indoors at childcare/school, and outdoors at childcare/school. Table B-1, Appendix B provides information from the EFH, Chapter 16 (EPA, 2011) on typical time spent indoors/outdoors in childcare/preschool/school and at home for children through age 18. Additional information is also provided in Table B-2 for how much time adults spend at home compared to outdoors.

- For elementary school children chronically exposed to a carcinogen at school from kindergarten through fifth grade (i.e., the 6 to <11 years age group), we can calculate the EF for the school term assuming multi-year, chronic exposure. In this instance, the school term is 9 months, and the average (CTE) exposure duration is 6.7 hours a day, 5 days a week for 39 weeks over five years. The non-cancer risk for this pollutant can be calculated with the following equation for the exposure factor:

$$(3) \quad EF_{\text{noncancer, chronic}} = \frac{6.7\frac{hr}{d} x\ 5\frac{d}{wk} x\ 39\ wk\ x\ 5\ yr}{24\frac{hr}{d} x\ 7\frac{d}{wk} x\ 52.14\ wk\ x\ 5\ yr} = 0.15$$

While the EF for cancer risk can be calculated using this equation:

$$(4) \quad EF_{\text{cancer, chronic}} = \frac{6.7\frac{hr}{d} x\ 5\frac{d}{wk} x\ 39\ wk\ x\ 5\ yr}{24\frac{hr}{d} x\ 7\frac{d}{wk} x\ 52.14\ wk\ x\ 78\ yr} = 0.0095$$

Exposure Factors Calculations

Noncancer default exposure factors for chronic, intermediate, and acute durations are provided in Table 5 for soil, sediment, and drinking water pathways involving residential and occupational scenarios. Exposure factors used to evaluate recreational and trespass scenarios will be site specific.

Table 5. Noncancer default exposure factors for chronic, intermediate, and acute durations are provided for soil, sediment, and drinking water pathways involving residential and occupational scenarios.

Exposure Group	Exposure Period	Exposure Factor	Frequency x Duration / Averaging Time
Residential	Chronic RME	1	$\frac{7\frac{d}{wk}\ x\ 52.14\frac{wk}{yr}\ x\ 33\ yr}{7\frac{d}{wk}\ x\ 52.14\frac{wk}{yr}\ x\ 33\ yr}$
	Chronic CTE	1	$\frac{7\frac{d}{wk}\ x\ 52.14\frac{wk}{yr}\ x\ 12\ yr}{7\frac{d}{wk}\ x\ 52.14\frac{wk}{yr}\ x\ 12\ yr}$
	Intermediate	1	$\frac{7\frac{d}{wk}\ x\ 52\frac{wk}{yr}}{7\frac{d}{wk}\ x\ 52\frac{wk}{yr}}$
	Acute*	1	Default

Workers**	Chronic RME	0.68	$\frac{5\ \frac{d}{wk}\ x\ \ 50\ \frac{wk}{yr}\ x\ 20\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 20\ yr}$
	Chronic CTE	0.68	$\frac{5\ \frac{d}{wk}\ x\ \ 50\ \frac{wk}{yr}\ x\ 5\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 5\ yr}$
	Intermediate	0.71	$\frac{5\ \frac{d}{wk}\ x\ \ 50\ \frac{wk}{yr}}{7\ \frac{d}{wk}\ x\ 50\ \frac{wk}{yr}}$
	Acute	1 0.33	Default, drinking water, soil ingestion $8.5\frac{hr}{24}hr$, air

*This EF is modified for soil-pica scenarios. See the EDG for soil and sediment ingestion (ATSDR 2016)

** If workers are exposed by inhalation, the EF term includes 8.5 hr/24 hr for full-time workers or 5.1 hrs/day (5.1 hr/24 hr) for part-time workers. See exceptions to the standard EF approach for a discussion of chemicals with special EFs.

Cancer default exposure factors for chronic durations are provided in Table 6 for soil, sediment, and drinking water pathways involving residential and occupational scenarios. Exposure factors used to evaluate recreational and trespass scenarios will be site specific.

Table 6. Cancer default exposure factors for chronic durations for soil, sediment, and drinking water pathways involving residential and occupational scenarios.

Exposure Group	Exposure Period	Exposure Factor	Frequency x Duration / Averaging Time
Adult Residential*	Chronic RME	0.42	$\frac{7\ \frac{d}{wk}\ x\ \ 52.14\ \frac{wk}{yr}\ x\ 33\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 78\ yr}$
	Chronic CTE	0.15	$\frac{7\ \frac{d}{wk}\ x\ \ 52.14\ \frac{wk}{yr}\ x\ 12\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 78\ yr}$
Workers**	Chronic RME	0.18	$\frac{5\ \frac{d}{wk}\ x\ \ 50\ \frac{wk}{yr}\ x\ 20\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 78\ yr}$

	Chronic CTE	0.044	$\frac{5\ \frac{d}{wk}\ x\ 50\ \frac{wk}{yr}\ x\ 5\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 78\ yr}$

*The cancer EF for children changes with ATSDR's standard age groups. For example, the cancer EF for children 2 to 6 years old is 0.0513 (4/78) and for children 6 to 11 years is 0.064 (5/78).
** If workers are exposed by inhalation, the EF term includes 8.5 hr/24 hr for full-time workers or 5.1 hrs/day (5.1 hr/24 hr) for part-time workers. See exceptions to the standard EF approach for a discussion of chemicals with special EFs.

Chronic Exposure Factors

Residential scenarios

- For chronic exposures, the exposure frequency for residential scenarios is usually daily (365 days a year). The exposure duration and averaging time can vary from 1 year to 78 years. For the noncancer assessment, the EF usually equals 1. Using the 95th percentile ROP as an example (i.e., ED of 33 yrs), the EF for noncancer chronic residential exposure is:

  EFchronic = 1

  $$\frac{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 33\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 33\ yr}$$

  In the same scenario, the EF for **cancer assessment** is:

  $EF_{chronic} = 0.42$

  $$\frac{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 33\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 78\ yr}$$

- The duration of exposure is often determined by the site-specific exposure scenario. For example, if residents drank contaminated water for 15 years, the duration of exposure for calculating the EF is 15 years. EF for noncancer chronic residential exposure is:

  $EF_{chronic} = 1$

  $$\frac{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 15\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 15\ yr}$$

In the same scenario, the EF for **cancer assessment** is:

$$EF_{chronic} = 0.19 \quad \frac{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 15\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 78\ yr}$$

- For residential inhalation exposures, health assessors should assume a 24-hour per day continuous exposure resulting in an EF = 1 for noncancer.

- If needed, the 95th percentile Residential Occupancy Period (ROP) (time between a person moving into a residence and the time the person moves out or dies) is 33 years and the 50th percentile ROP is 12 years (EPA 2011, Johnson and Capel 1992).

- Additional information about duration of residence and ROP can be found in the 2011 EPA EFH, Chapter 16—see Appendix A for selected tables (EPA 2011).

Commercial/industrial scenarios

- Health assessors should use an exposure frequency of 5 days a week for 50 weeks per year unless site-specific conditions warrant another exposure frequency.

- For inhalation exposures, health assessors should include an additional exposure factor term, specifically 8.5 hours a day (8.5 hr/24 hr), 5 days a week (5 days/7 days) unless site-specific conditions warrant a different frequency. For part-time workers, use 5.1 hours a day (5.1 hr/24 hr).

- Health assessors should assume an individual works 20 years at the same location unless site-specific conditions warrant another exposure duration. Note, 20 years represents the 90th percentile estimate of tenure with current employer from the Bureau of Labor Statistics, U.S. Department of Labor. See the footnotes for Table 2 for more information about occupational tenure. ..

Chronic recreational and trespass scenarios

- When a recreational or trespass scenario is possible, health assessors should use site-specific information to determine exposure frequency, duration, and averaging times.

- The 2011 EPA EFH (Chapter 16, Table 1) provides the most current information describing several types of time use data for adults and children. There are recommended values for:
  1) time spent indoors and outdoors;
  2) time spent swimming; and
  3) time spent playing on various types of surfaces, such as dirt, sand/gravel, and grass (EPA 2011).

- If an intermittent recreational or trespass scenario occurs regularly over a period of years (e.g., a 9-month recreational exposure that occurs for a period of years), the scenario should be adjusted over the total duration of exposure and is considered a chronic exposure.

- For inhalation exposures, health assessors should calculate the daily inhalation based on the exposure scenario. For example, if a person is assumed to trespass for 4 hours a day, an inhalation EF of 4 hours/24 hours should be used).

Acute and Intermediate Exposure Factors

If the chronic MRL is not exceeded then health assessors usually will not have to look at acute and intermediate scenarios. If the chronic MRL is exceeded, health assessors should evaluate both acute and intermediate exposure to determine if a health hazard is present.

When exposure occurs daily during the exposure duration, then no adjustments are made to the dose because the EF is 1. In this case, the chronic, intermediate, and acute exposures (or doses) are the same. However, when the target population has intermittent exposure over the exposure duration, it is usually appropriate to convert this intermittent exposure to a continuous, daily exposure. ATSDR published guidelines in the Federal Register about how to adjust for intermittent exposure (ATSDR 1996) and these guidelines are important when deciding how to use EF to adjust the dose or air concentration, particularly when exposures are less than a year.

Intermediate Exposures

ATSDR defines intermediate exposure as exposure to a chemical for a period of 15 to 364 days. For example, exposures that occur for 3 weeks or for 36 weeks (i.e., 9 months) are both classified as intermediate exposures.

For intermittent exposures of intermediate duration, the dose or air concentration is adjusted to the duration of the scenario.

- For example, if the exposure is 5 days a week for 8 weeks, the dose or air concentration is averaged over the 8 weeks by using an EF of [5d/7d*8wk/8wk)]. The dose is not adjusted to a yearly dose when evaluating an intermediate exposure. The adjusted dose is then compared to an intermediate MRL (if available).

- Similarly, if exposure occurs for 36 weeks (i.e., 9 months) then the dose is adjusted to 36 weeks of exposure using an EF of [5d/7d*36wk/36wk].

Air

For inhalation exposures, health assessors should calculate the daily inhalation concentration based on the exposure scenario. For example, if children are exposed via inhalation for 9 hours a day at school, 5 days a week, for 9 months, this intermediate exposure should be adjusted as follows:

$$EF_{intermediate} = 0.238 \quad \frac{9\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}\ x\ 36\ wk}{24\ \frac{hr}{d}\ x\ 7\ \frac{d}{wk}\ x\ 36\ wk}$$

More information about using exposure factor to adjust inhalation exposure can be found in this EDG in the section, "Exceptions to the standard EF approach"

Soil/Drinking Water

Similarly, if children are exposed to contaminated soils 5 days a week during a 3-month summer program, their intermediate exposure should be adjusted as follows:

$$EF_{intermediate} = 0.714 \quad \frac{5\ \frac{d}{wk}\ x\ 12\ wk}{7\ \frac{d}{wk}\ x\ 12\ wk}$$

Note that the adjustment is made over the exposure duration and is not averaged over 12 months. The adjusted dose should be compared to an intermediate MRL (if available) or appropriate toxicity information.

Acute Exposures

ATSDR defines acute exposure as exposure to a chemical for a duration of 14 or less days. Acute exposures that occur for this time period should be adjusted for the exposure duration of the scenario. The adjusted dose should be compared to an acute MRL.

Air

For the air pathway, the exposure should also be adjusted to a continuous, 24-hour exposure over the exposure duration.

For example, if children are exposed via inhalation for 9 hours a day for 5 days this acute exposure should be adjusted as follows:

$$EF_{acute} = 0.375 \quad \frac{9\ \frac{hr}{d}\ x\ 5\ d}{24\ \frac{hr}{d}\ x\ 5\ d}$$

Note that ATSDR's MRL guidance states that acute exposures should be adjusted to a 24-hr (daily) continuous exposure and not to a weekly exposure. Exceptions to the rule for adjusting the acute, inhalation exposure to a 24-hr continuous exposure is hydrogen sulfide, chloroform, sulfur dioxide, and formaldehyde based on their acute inhalation MRL derivation. If the target population has intermittent, inhalation exposure to these chemicals, the concentration should not be adjusted to a continuous 24-hr concentration. The reason the concentration is not adjusted is because the acute, inhalation MRL was derived using the unadjusted, study concentration.

Soil/Drinking Water

Similarly, if children are exposed to contaminated soils for 5 days a week while on vacation, their acute exposure should be adjusted as follows:

$$EF_{acute} = \frac{5\ d}{5\ d}$$

$$EF_{acute} = 1$$

Intermediate and acute recreational and trespass scenarios

When a recreational or trespass scenario is possible, health assessors should use site-specific information to determine exposure frequency, duration, and averaging times.

If an intermittent recreational or trespass scenario occurs as a one-time event (e.g., a vacation or summer camp scenario), the scenario should be adjusted over the duration of exposure and is considered either an acute (less than 14 days) or intermediate (15 to 364 days) exposure.

Air

For inhalation exposures, health assessors should calculate the daily inhalation exposure concentration based on the exposure scenario (e.g., if a receptor is assumed to attend a week-long summer day camp for 8 hours a day, an inhalation EF of 8 hr/24 hr x 7 d/7 d should be used).

Exceptions to the standard EF approach

When site exposure is intermittent (e.g., 8 hr/day), the air concentration is usually adjusted to a continuous exposure by including 8 hr/24 hr as part of the EF term.

The key to deciding whether to adjust an intermittent air concentration to a continuous exposure concentration depends upon whether an intermittent to continuous adjustment was made when deriving the MRL or RfC. When an intermittent exposure is not adjusted to a continuous exposure then the intermittent site concentration should not be adjusted to a continuous exposure when calculating the HQ or when evaluating the risk of harmful effects.

Exceptions to the rule for adjusting an intermittent inhalation exposure to a continuous exposure include acute duration exposures to these chemicals: ammonia, hydrogen sulfide, chloroform, sulfur dioxide, formaldehyde, 2-butanone, and acetone. For all of these chemicals, the intermittent air concentration is not adjusted to a continuous exposure when deriving the acute inhalation MRL. For example, the acute inhalation MRL for ammonia is based on a 2-hour exposure to 50 ppm, which resulted in mild irritation to the eyes, nose, and throat in humans. The MRL worksheet states that the concentration was not adjusted to a continuous 24-hr concentration because the effects observed were local irritation effects and thus were not time-dependent (but rather concentration-dependent). Two reasons have been cited in the MRL worksheet for reasons why the less than 24 hour study concentration was not adjusted to a continuous 24 hour exposure. Adjustments are done when the critical effect is due to

(1) a point contact effect (for example, irritation of mucous membranes),
(2) a chemical quickly reaches equilibrium (for example, in the blood) and quickly diminishes when exposure stops, or
(3) a chemical is evenly distributed in the body

Ammonia, hydrogen sulfide, sulfur dioxide, formaldehyde, and 2-butanone are examples of 'point-of-contact' irritants. Chloroform is an example of a chemical that quickly reaches steady state concentrations in the blood and quickly diminishes when exposure stops. Acetone is an example of a chemical that is evenly distributed in the body. For more information, see the MRL worksheet in ATSDR's toxicological profile for these chemicals

Intermittent exposure to chloroform and formaldehyde are also not adjusted to continuous exposure for intermediate and chronic durations. The site-specific EPC should not be adjusted from intermittent to continuous because the intermediate and chronic MRLs for these two chemicals used the unadjusted study concentration to derive the MRL. The noncancer EF for these two chemicals should be 1.

When calculating cancer risk, however, intermittent exposure should be adjusted to continuous exposure because the inhalation unit risk for these carcinogens assumes constant, 24-hr exposure. See the MRL worksheet for each chemical for more information.

Table 7. List of chemicals and duration where the exposure factor should be 1 for inhalation exposure, even for scenarios with intermittent exposure. The table also shows when standard EF adjustments should be used.

Chemical	Acute		Intermediate		Chronic		
	HG	EF	HG	EF	HG	$EF_{non\text{-}cancer}$	EF_{cancer}
Hydrogen Sulfide	Y	1	Y	Standard	Y	Standard	NA
Chloroform	Y	1	Y	1	Y	1	Standard
Formaldehyde	Y	1	Y	1	Y	1	Standard
Sulfur Dioxide	Y	1	N	1	N	1	NA
Ammonia	Y	1	N	Standard	Y	Standard	NA
2-butanone	Y	1	N	Standard	N	Standard	NA
Acetone	Y	1	N	Standard	N	Standard	NA

HG = health guideline available; Y = Yes; N = no
Standard = make standard EF adjustments; NA = not applicable because not a carcinogen

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Examples

$$EF = \frac{(F \times ED)}{AT}$$

Where:

$EF_{Chronic}$ = Exposure Factor (unitless)
F = Frequency of exposure (d/wk, wk/yr)
ED = Exposure duration (wk, yr)
AT = Averaging time

- noncancer = ED (yr) x F (d/wk x wk/yr)
- cancer = ED (yr) x F (7d/wk x 52.14 wk/yr)

$EF_{Intermediate}$ = Intermediate Exposure Factor (unitless)
F = Frequency of exposure (d/wk)
ED = Exposure duration (wk)
AT = Averaging time

- noncancer = F (d/wk) x ED (wk)

Sediment

Children are exposed to sediment while playing along a stream some distance from home 3 days a week for 5 months. The exposure is determined to be a one-season exposure, so evaluation of chronic exposure is not appropriate. Therefore, the EF for acute and intermediate exposures is calculated and will be compared to acute and intermediate MRLs, if available, and to appropriate toxicity information. The contaminant of concern is **not carcinogenic**.

$$EF_{intermediate} = 0.428 \qquad \frac{3\ \frac{d}{wk}\ x\ 20\ wk}{7\ \frac{d}{wk}\ x\ 20\ wk}$$

$$EF_{acute} = 1 \qquad \frac{3\ \frac{d}{wk}}{3\ \frac{d}{wk}}$$

Daycare

Children (2 to 6 yr of age) are exposed to chemicals in air at a daycare center 9.6 hours a day for 5 days week. Exposure could have occurred for 4 years to a carcinogen. 9.6 hours/day is the RME value for hr/day and 52.14 wks/year is the RME annual number of weeks.

<u>Noncancer EF</u>

$$EF_{chronic} = 0.285 \qquad \frac{9.6\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 4\ yr}{24\ \frac{hr}{d}\ x\ 7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 4\ yr}$$

$$EF_{intermediate} = 0.285 \qquad \frac{9.6\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}\ x\ 52\ \frac{wk}{yr}}{24\ \frac{hr}{d}\ x\ 7\ \frac{d}{wk}\ x\ 52\ \frac{wk}{yr}}$$

$EF_{acute} = 0.40$

$$\frac{9.6\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}}{24\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}}$$

Cancer EF

$EF_{chronic,\ children,\ 2 < 6\ yr} = 0.0146$

$$\frac{9.6\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}\ x\ \ 52.14\ \frac{wk}{yr}\ x\ 4\ yr}{24\ \frac{hr}{d}\ x\ 7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 78\ yr}$$

Trespassers

Trespassers are exposed to soil twice a week for 4 months to a noncarcinogen:

$EF_{intermediate} = 0.286$

$$\frac{2\ \frac{d}{wk}\ x\ 16\ wk}{7\ \frac{d}{wk}\ x\ 16\ wk}$$

$EF_{acute} = 1$

$$\frac{2\ \frac{d}{wk}}{2\ \frac{d}{wk}}$$

Occupational

You have air data from a business showing PCE concentrations above the RfC. You decide that workers could be exposed for 8.5 hrs/day, 5 days/wk for 50 weeks per year. Air concentrations are high enough that you want to look at the possibility of acute exposures causing harmful effects.

Noncancer EF

$EF_{noncancer,\ chronic} = 0.229$

$$\frac{8.5\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}\ x\ \ 50\ \frac{wk}{yr}\ x\ 20\ yr}{24\ \frac{hr}{d}\ x\ 7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 20yr}$$

$$EF_{\text{noncancer, intermediate}} = 0.243 \quad \frac{8.5\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}\ x\ 50\ \frac{wk}{yr}}{24\ \frac{hr}{d}\ x\ 7\ \frac{d}{wk}\ x\ 50\ \frac{wk}{yr}}$$

$$EF_{\text{noncancer, acute}} = 0.354 \quad \frac{8.5\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}}{24\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}}$$

Cancer EF

$$EF_{\text{cancer}} = 0.062 \quad \frac{8.5\ \frac{hr}{d}\ x\ 5\ \frac{d}{wk}\ x\ 50\ \frac{wk}{yr}\ x\ 20\ yr}{24\ \frac{hr}{d}\ x\ 7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 78\ yr}$$

Exposure Factors and Cancer/ Noncancer Endpoints

The EF term is an important consideration when evaluating cancer and noncancer endpoints. For cancer endpoints, the actual duration is used in the exposure duration term in the numerator and 78 years (lifetime) is used as part of the averaging time in the denominator. For example, to estimate the cancer risk for a scenario where persons were exposed daily for 20 years, the EF equation is:

$$EF_{\text{cancer}} = \frac{(F\ x\ ED)}{AT} = 0.256 \quad \frac{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 20\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 78\ yr}$$

For noncancer endpoints, the actual duration of exposure is used in both the exposure duration and averaging time.

$$EF_{\text{noncancer}} = \frac{(F\ x\ ED)}{AT} = 1 \quad \frac{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 20\ yr}{7\ \frac{d}{wk}\ x\ 52.14\ \frac{wk}{yr}\ x\ 20\ yr}$$

Therefore, lifetime doses for cancer and noncancer endpoints can be different depending upon the exposure duration and averaging times. Noncancer doses should be calculated as a 1-yr annual dose because the basis for the chronic MRL is durations of 1 year or greater. For cancer risk evaluations, either lifetime exposure or some fraction of a lifetime exposure can be used depending upon the site-specific exposure scenario or the use of standard defaults based on residential occupancy periods.

Impact

Using the best available science to update life expectancy values and exposure factors (exposure durations and frequency of exposure) will improve the consistency of exposure dose estimates in ATSDR- and State-prepared health assessments and consultations.

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Appendix A:
Selected Tables from National Center for Health Statistics 2011 Report and EPA Exposure Factor Handbook 2011

Table A-1. Expectation of life by age, race, and sex: United States, preliminary 2008 and 2009

[Data are based on a continuous file of records from the states. Calculations of life expectancy employ populations estimated as of July 1 for 2009 and 2008; see "Technical Notes." Race categories are consistent with the 1977 Office of Management and Budget (OMB) standards. Multiple-race data were reported by 34 states and the District of Columbia in 2009 and 2008; see "Technical Notes." The multiple-race data for these states were bridged to the single-race categories of the 1977 OMB standards for comparability with other states; see "Technical Notes"]

Age (years) and race	Both sexes		Male		Female	
	2009	2008[1]	2009	2008[1]	2009	2008[1]
All races[2]						
0	78.2	78.0	75.7	75.5	80.6	80.5
1	77.7	77.6	75.3	75.1	80.0	80.0
5	73.8	73.7	71.4	71.2	76.1	76.1
10	68.8	68.7	66.4	66.2	71.2	71.1
15	63.9	63.8	61.5	61.3	66.2	66.1
20	59.0	58.9	56.7	56.5	61.3	61.2
25	54.3	54.2	52.0	51.9	56.4	56.4
30	49.5	49.4	47.3	47.2	51.6	51.5
35	44.8	44.7	42.7	42.6	46.8	46.7
40	40.1	40.0	38.0	37.9	42.0	41.9
45	35.5	35.4	33.5	33.4	37.3	37.2
50	31.1	31.0	29.1	29.0	32.8	32.7
55	26.8	26.7	25.0	24.9	28.4	28.3
60	22.7	22.6	21.1	20.9	24.1	24.0
65	18.8	18.7	17.3	17.2	20.0	19.9
70	15.1	15.0	13.8	13.7	16.1	16.0
75	11.7	11.7	10.7	10.6	12.5	12.5
80	8.8	8.8	8.0	7.9	9.4	9.4
85	6.4	6.5	5.8	5.8	6.8	6.8
90	4.6	4.6	4.1	4.1	4.8	4.8
95	3.2	3.2	2.9	2.9	3.3	3.3
100	2.2	2.3	2.0	2.1	2.2	2.3
White						
0	78.6	78.4	76.2	75.9	80.9	80.8
1	78.0	77.8	75.6	75.4	80.3	80.2
5	74.1	73.9	71.7	71.5	76.3	76.3
10	69.1	68.9	66.8	66.5	71.4	71.3
15	64.1	64.0	61.8	61.6	66.4	66.3
20	59.3	59.2	57.0	56.8	61.5	61.4
25	54.5	54.4	52.3	52.2	56.6	56.6
30	49.8	49.6	47.6	47.5	51.8	51.7
35	45.0	44.9	43.0	42.8	47.0	46.9
40	40.3	40.2	38.3	38.1	42.2	42.1

45	35.7	35.6	33.8	33.6	37.5	37.4
50	31.2	31.1	29.4	29.2	32.9	32.8
55	26.9	26.8	25.2	25.0	28.5	28.3
60	22.8	22.6	21.2	21.0	24.1	24.0
65	18.8	18.7	17.4	17.3	20.0	19.9
70	15.1	15.0	13.9	13.7	16.1	16.0
75	11.7	11.6	10.6	10.6	12.5	12.4
80	8.8	8.8	7.9	7.9	9.3	9.3
85	6.4	6.4	5.7	5.7	6.7	6.8
90	4.5	4.5	4.1	4.1	4.7	4.8
95	3.1	3.2	2.8	2.9	3.2	3.3
100	2.2	2.2	2.0	2.0	2.2	2.2
Black						
0	74.3	74.3	70.9	70.9	77.4	77.4
1	74.2	74.3	70.9	71.0	77.2	77.4
5	70.3	70.5	67.0	67.1	73.3	73.5
10	65.4	65.5	62.1	62.2	68.4	68.5
15	60.5	60.6	57.1	57.2	63.5	63.6
20	55.7	55.8	52.4	52.6	58.6	58.7
25	51.0	51.1	47.9	48.0	53.7	53.9
30	46.3	46.5	43.3	43.5	49.0	49.1
35	41.7	41.8	38.8	39.0	44.2	44.3
40	37.1	37.3	34.3	34.5	39.6	39.6
45	32.7	32.8	30.0	30.1	35.0	35.1
50	28.5	28.6	25.8	26.0	30.7	30.8
55	24.5	24.6	22.0	22.2	26.6	26.7
60	20.9	20.9	18.6	18.7	22.7	22.7
65	17.5	17.5	15.5	15.5	18.9	18.9
70	14.3	14.3	12.6	12.6	15.4	15.4
75	11.3	11.3	9.9	10.0	12.2	12.2
80	8.8	8.8	7.7	7.8	9.4	9.5
85	6.7	6.8	5.9	6.0	7.1	7.1
90	5.0	5.1	4.4	4.6	5.2	5.3
95	3.7	3.8	3.3	3.5	3.8	3.8
100	2.7	2.8	2.5	2.6	2.7	2.8

[1]Life expectancies for 2008 have been updated and may differ from those previously published; see "Technical Notes."

[2] Includes races other than white and black.

NOTE: Data are subject to sampling or random variation.

Source: National Center for Health Statistics. National Vital Statistics Reports, Vol. 59, No. 4, March 16, 2011. US Department of Health and Human Services. Available on line at http://www.cdc.gov/nchs/data/nvsr/nvsr59/nvsr59_04.pdf

Table 18-3. Expectation of Life at Birth, 1970 to 2007 (years)[a]

Year[b]	Total			White			Black		
	Total	Males	Females	Total	Males	Females	Total	Males	Females
1970	70.8	67.1	74.7	71.7	68.0	75.6	64.1	60.0	68.3
1975	72.6	68.8	76.6	73.4	69.5	77.3	66.8	62.4	71.3
1980	73.7	70.0	77.4	74.4	70.7	78.1	68.1	63.8	72.5
1982	74.5	70.8	78.1	75.1	71.5	78.7	69.4	65.1	73.6
1983	74.6	71.0	78.1	75.2	71.6	78.7	69.4	65.2	73.5
1984	74.7	71.1	78.2	75.3	71.8	78.7	69.5	65.3	73.6
1985	74.7	71.1	78.2	75.3	71.8	78.7	69.3	65.0	73.4
1986	74.7	71.2	78.2	75.4	71.9	78.8	69.1	64.8	73.4
1987	74.9	71.4	78.3	75.6	72.1	78.9	69.1	64.7	73.4
1988	74.9	71.4	78.3	75.6	72.2	78.9	68.9	64.4	73.2
1989	75.1	71.7	78.5	75.9	72.5	79.2	68.8	64.3	73.3
1990	75.4	71.8	78.8	76.1	72.7	79.4	69.1	64.5	73.6
1991	75.5	72.0	78.9	76.3	72.9	79.6	69.3	64.6	73.8
1992	75.8	72.3	79.1	76.5	73.2	79.8	69.6	65.0	73.9
1993	75.5	72.2	78.8	76.3	73.1	79.5	69.2	64.6	73.7
1994	75.7	72.4	79.0	76.5	73.3	79.6	69.5	64.9	73.9
1995	75.8	72.5	78.9	76.5	73.4	79.6	69.6	65.2	73.9
1996	76.1	73.1	79.1	76.8	73.9	79.7	70.2	66.1	74.2
1997	76.5	73.6	79.4	77.2	74.3	79.9	71.1	67.2	74.7
1998	76.7	73.8	79.5	77.3	74.5	80.0	71.3	67.6	74.8
1999	76.7	73.9	79.4	77.3	74.6	79.9	71.4	67.8	74.7
2000	76.8	74.1	79.3	77.3	74.7	79.9	71.8	68.2	75.1
2001	76.9	74.2	79.4	77.4	74.8	79.9	72.0	68.4	75.2
2002	76.9	74.3	79.5	77.4	74.9	79.9	72.1	68.6	75.4
2003	77.1	74.5	79.6	77.6	75.0	80.0	72.3	68.8	75.6
2004	77.5	74.9	79.9	77.9	75.4	80.4	72.8	69.3	76.0
2005	77.4	74.9	79.9	77.9	75.4	80.4	72.8	69.3	76.1
2006	77.7	75.1	80.2	78.2	75.7	80.6	73.2	69.7	76.5
2007	77.9	75.4	80.4	78.4	75.9	80.8	73.6	70.0	76.8

[a] Based on middle mortality assumptions; for details, source: U.S. Census Bureau (2008).

[b] Life expectancies for 2000–2007 were calculated using a revised methodology and may differ from those previously published; see Xu et al. (2010).

Source: Xu et al. (2010).

Table 18-4. Expectation of Life by Race, Sex, and Age: 2007

Exact Age in Years	All Races[a]			White			Black		
	Both Sexes	Males	Females	Both Sexes	Males	Females	Both Sexes	Males	Females
0	77.9	75.4	80.4	78.4	75.9	80.8	73.6	70.0	76.8
1	77.5	74.9	79.9	77.8	75.4	80.2	73.6	70.1	76.8
5	73.6	71.0	76.0	73.9	71.4	76.3	69.7	66.2	72.9
10	68.6	66.1	71.0	68.9	66.5	71.3	64.7	61.3	67.9
15	63.7	61.1	66.1	64.0	61.6	66.3	59.8	56.3	63.0
20	58.8	56.4	61.2	59.2	56.8	61.5	55.1	51.7	58.1
25	54.1	51.8	56.3	54.4	52.2	56.6	50.4	47.2	53.3
30	49.4	47.1	51.5	49.7	47.5	51.7	45.8	42.7	48.5
35	44.6	42.5	46.7	44.9	42.8	46.9	41.2	38.2	43.8
40	39.9	37.8	41.9	40.2	38.1	42.1	36.7	33.8	39.1
45	35.4	33.3	37.2	35.6	33.6	37.4	32.3	29.5	34.7
50	30.9	29.0	32.7	31.1	29.2	32.8	28.1	25.4	30.4
55	26.7	24.9	28.2	26.8	25.1	28.4	24.2	21.7	26.3
60	22.5	20.9	23.9	22.6	21.0	24.0	20.6	18.3	22.4
65	18.6	17.2	19.9	18.7	17.3	19.9	17.2	15.2	18.7
70	15.0	13.7	16.0	15.0	13.8	16.0	14.1	12.4	15.2
75	11.7	10.6	12.5	11.7	10.6	12.4	11.2	9.9	12.1
80	8.8	7.9	9.4	8.8	7.9	9.3	8.7	7.7	9.4
85	6.5	5.8	6.8	6.4	5.7	6.8	6.7	6.0	7.1
90	4.6	4.1	4.8	4.6	4.1	4.8	5.1	4.6	5.3
95	3.2	2.9	3.3	3.2	2.9	3.3	3.8	3.5	3.9
100	2.3	2.1	2.3	2.2	2.0	2.2	2.8	2.6	2.8

[a] Includes races other than White and Black.

Source: Xu et al. (2010).

Time Outdoors (total) minutes/day			
Birth to <1 month	0	-	Children, Birth to < 12 months: EPA analysis of source data from Wiley et al., 1991. Average for boys and girls, whole population. See Table 16-14. Children, 1 to <21 years: EPA re-analysis of source data from EPA 1996, whole population. See Table 16-21. Adults, ≥ 18 years: EPA 1996. Sum of minutes spent outdoors away from the residence and minutes spent outdoors at the residence. Doers[b] only. See Table 16-22.
1 to <3 months	8	-	
3 to <6 months	26	-	
6 to <12 months	139*	-	
1 to <2 years	36	-	
2 to <3 years	76	-	
3 to <6 years	107	-	
6 to <11 years	132	-	
11 to <16 years	100	-	
16 to <21 years	102	-	
18 to <65 years	281	-	
≥ 65 years	298	-	
Time Indoors (at residence) minutes/day			
Birth to <1year	1,108	1,440	Children, Birth to <21 years: EPA re-analysis of source data from EPA 1996. Doers[b] only. See Table 16-15. Adults ≥ 18 years: EPA 1996. Doers[b] only. See Table 16-16
1 to <2 years	1,065	1,440	
2 to <3 years	979	1,296	
3 to <6 years	957	1,355	
6 to <11 years	893	1,275	
11 to <16 years	889	1,315	
16 to <21 years	833	1,288	
18 to < 65 years	948	1,428	
≥ 65 years	1,175	1,440	
Showering minutes/day			
Birth to <1year	15	-	EPA re-analysis of source data from EPA 1996. Doers only. See Table 16-28.
1 to <2 years	20	-	
2 to <3 years	22	44	
3 to <6 years	17	34	
6 to <11 years	18	41	
11 to <16 years	18	40	
16 to <21 years	20	45	
Age Group	Mean	95th Percentile	Source
Bathing minutes/day			
Birth to <1 year	19	30	EPA re-analysis of source data from EPA 1996. Doers[b] only. See Table 16-28.
1 to <2 years	23	32	
2 to <3 years	23	45	
3 to <6 years	24	60	
6 to <11 years	24	46	
11 to <16 years	25	43	
16 to <21 years	33	60	
Bathing/Showering minutes/day			
18 to <65 years	17	-	EPA 1996. Doers[b] only. See Table 16-29.
≥65 years	17	-	
Swimming minutes/month			
Birth to <1 year	96	-	Children, Birth to < 21 years: EPA re-analysis of source data from EPA 1996. Doers[b] only. See Table 16-35. Adults, ≥18 years: EPA 1996. Doers[b] only. See Table 16-37.
1 to < 2 years	105	-	
2 to <3 years	116	181	
3 to <6 years	137	181	
6 to <11 years	151	181	
11 to <16 years	139	181	
16 to <21 years	145	181	
18 to <65 years	45[c]	181	
≥65 years	40 [c]	181	

Playing on Sand/Gravel minutes/day			
Birth to <1 year	18	-	Children, <21 years: EPA re-analysis of source data from EPA 1996. Doers[b] only. See Table 16-38. Adults, ≥18 years: EPA 1996. Doers[b] only. See Table 16-39.
1 to < 2 years	43	121	
2 to <3 years	53	121	
3 to <6 years	60	121	
6 to <11 years	67	121	
11 to <16 years	67	121	
16 to <21 years	83	-	
18 to < 64 years	0[c]	121	
≥ 65 years	0 [c]	-	
Playing on Grass minutes/day			
Birth to <1 year	52	-	Children, <21 years: EPA re-analysis of source data from EPA 1996. Doers[b] only. See Table 16-38. Adults, ≥18 years: EPA 1996. Doers[b] only. See Tables 16-39.
1 to < 2 years	68	121	
2 to <3 years	62	121	
3 to <6 years	79	121	
6 to <11 years	73	121	
11 to <16 years	75	121	
16 to <21 years	60	-	
18 to <65 years	60[c]	121	
≥65 years	121[c]	-	
Age Group	Mean	95th Percentile	Source
Playing on Dirt minutes/day			
Birth to <1 year	33	-	Children, <21 years: EPA re-analysis of source data from EPA 1996. Doers[b] only. See Table 16-38. Adults, ≥18 years: EPA 1996. Doers[b] only. See Table 16-39.
1 to < 2 years	56	121	
2 to <3 years	47	121	
3 to <6 years	63	121	
6 to <11 years	63	121	
11 to <16 years	49	120	
16 to <21 years	30	-	
18 to <65 years	0[c]	120	
≥65 years	0[c]	-	

- Percentiles were not calculated for sample sizes less than 10 or in cases where the mean was calculated by summing the means from multiple locations or activities.

[a] Those activities are averaged over seasons.

[b] Doers are those respondents who engaged or participated in the activity

[c] Median value, mean not available in EPA 1996.

Note: All activities are reported in units of minutes/day, except swimming, which is reported in units of minutes/month. There are 1,440 minutes in a day. Time indoors and outdoors may not add up to 1,440 minutes due to activities that could not be classified as either indoors or outdoors.

[*] For children from birth to < 12 month, EPA reanalyzed the source data (Wiley et al.) This value is the average for boys and girls. See table 16-14.

Table A-5. Recommended Values for Population Mobility (from EPA 2011, Table 16-5)

	Mean	95th Percentile	Source
Residential Occupancy Period	12 yrs	33 yrs	Johnson and Capel, 1992. See Table 16-87.

Source: Exposure Factors Handbook: 2011(Final). October 2011. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. EPA/600/R-09/052A. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=236252#Download

APPENDIX B. Tables for time spent indoors/outdoors for children and adults

TABLE B-1. Default daily assumptions for children's time spent at home, school, childcare*

Exposure group	CTE time spent indoors, residential (hr/day)	RME time spent indoors, residential (hr/day)	Time spent indoors, school or childcare (hr/day)	Time spent outdoors, school or playground (hr/day)
< 1 month	24.0	24.0	N/A	Not reported
0 to <1 year	18.5	24.0	5.3	Not reported
1 to <2 years	17.8	24.0	4.8	0.60
2 to <6 years[a]	16.0	22.3	5.3	1.43[d]
6 to <11 years	14.9	21.2	6.6	1.47
11 to <16 years[b]	14.8	21.9	6.7	1.34[e]
16 to <19 years[c]	13.9	21.5	6.7	1.31[c]

**This table was converted to hours from original tables in min/day in the EFH (Ch 16., Table 16-18); note that RME would be equivalent to continuous, 24 hr/day exposure*

[a] CTE average: EFH (2011) notes 1-4 year olds spend an average of 288.5 min/day and that 5-11-year-olds spend an average of 396.3 min/day ***indoors*** at childcare/school; thus, the 2 to <6-year-old range is 288.5*0.75 (2 through 4-year-olds) + 396.3 * 0.25 (5-year-olds) = 216.38 + 99.08 = 315.5 min/day (5.3 hrs/day).
RME average: Table 16-1 presents the 95th percentile min/day spent indoors at the child's residence; to merge the 2 to <3 and 3 to <6 age ranges to conform to ATSDR's age ranges (2 to <6), the weighted average of the two age ranges were calculated as follows: 2 to <3 years (1296 min/day *0.25 [1/4 years in the range]) + (1355 min/day*0.75 [3/4 years in the range]) = 324 + 1016.25 = 1340.25 min/day or 22.3 hrs/day.
[b] Average; EFH (2011) notes 5-11-year-olds spend an average of 396.3 min/day and that 12-17-year-olds spend an average of 402.6 min/day ***indoors*** at childcare/school; thus, the 11 to <16-year-old range is 396.3*0.20 (11 year olds) + 402.6 * 0.80 (12-15-year-olds) = 79.3 + 322.1 = 401.4 min/day (6.7 hrs/day).
[c] EFH (2011) only estimates hours in school through age 17; we assume the 12-17-year age range for older school children.

[d]Average; EFH (2011) notes 1-4-year-olds spend an average of 85 min/day and 5-11-year-olds spend an average of 88 min/day ***outdoors*** at childcare/school; thus, the 3 to <6-year-old range is 85*0.666 (3 and 4 year olds) + 88 * 0.333 (5 year olds) = 56.6 + 29.3 = 85.9 (86) min/day.
[e]Average; EFH (2011) notes 5-11-year-olds spend an average of 88 min/day and that 12-17-year-olds spend an average of 78.7 min/day ***outdoors*** at childcare/school; thus, the 11 to <16-year-old range is 88*0.20 (11 year olds) + 78.7 * 0.80 (12-15-year-olds) = 17.6 + 62.96 = 80.6 min/day (1.4 hr/day).

Table B-2. Default daily assumptions for adults: mean time spent at home and outdoors

Exposure group	CTE time spent indoors at residence (hrs/day)	RME time spent indoors at residence (hrs/day)	Time spent outdoors (hrs/day)
18 to <64 years	15.80	23.8	2.27
65+ Years	19.58	24.0	2.35

Source: Exposure Factors Handbook (2011), Chapter 16, "Activity Patterns."