

6. Inhalation Rates

6.1 Introduction

Ambient and indoor air are potential sources of exposure to toxic substances. Adults and children can be exposed to contaminated air during a variety of activities in different environments. They may be exposed to contaminants in ambient air, and may also inhale chemicals from the indoor use of various consumer products. U.S. EPA (1992) defines exposure as the chemical concentration at the boundary of the body. In the case of inhalation, the situation is complicated; the anatomy and physiology of the respiratory system as well as the characteristics of the inhaled agent diminishes the pollutant concentration in inspired air (potential dose) such that the amount of a pollutant that actually enters the body through the lung (internal dose) is less than that measured at the boundary of the body. When constructing risk assessments that concern the inhalation route of exposure, one must be aware of any adjustments that have been employed in the estimation of the pollutant concentration to account for this reduction in potential dose. Assessors may not always need to select and use inhalation rates when evaluating exposure to air contaminants; for example, IRIS and Superfund risk values (i.e., Reference Concentrations (RfCs) and Unit Risks) already incorporate inhalation rates. However, Chapter 6 of the *Exposure Factors Handbook* provides recommended inhalation rates for both long-term and short-term exposure scenarios where these factors are needed. The data are summarized in this Highlights document.

6.2 Recommended Exposure Factors

The recommended inhalation rates for adults and children are based on three recent studies (Brochu et al., 2006; U.S. EPA, 2009; and Stifelman, 2007), as well as an additional study of children (Arcus-Arth and Blaisdell, 2007). Long-term inhalation is repeated exposure for more than 30 days, up to approximately 10% of the life span in humans (more than 30 days). Long-term inhalation rates for adults and children (including infants) are presented as daily rates (m^3/day). Short-term exposure is repeated exposure for more than 24 hours, up to 30 days. Short-term inhalation rates are reported for adults and children (including infants) performing various activities in m^3/minute .

The *Exposure Factors Handbook* provides recommendations for both long- and short-term exposure inhalation rates. Values for short- versus long-term are necessary because the length of exposure influences the type and severity of any effects associated with the exposure.

Table 6-1 presents the long-term mean and 95th percentile data, by age group, for males and females combined. Table 6-2 presents the short-term data by activity level. The short-term values represent averages of the activity level data from the one key study from which short-term inhalation rate data were available (U.S. EPA, 2009). The overall confidence rating in the inhalation rates is medium.



Long-term exposure is repeated exposure for more than 30 days for adults and children (including infants).

Short-term exposure is repeated exposure for more than 24 hours, up to 30 days, for adults and children (including infants) performing various activities.



Table 6-1. Recommended Long-Term Exposure (More Than 30 Days) Values for Inhalation (Males and Females Combined)

Age Group ^a	Mean m ³ /day	Sources Used for Means	95 th Percentile ^{f,g} m ³ /day	Sources Used for 95 th Percentiles
Birth to <1 month	3.6	a	7.1	a
1 to <3 months	3.5	a, b	5.8	a, b
3 to <6 months	4.1	a, b	6.1	a, b
6 to <12 months	5.4	a, b	8.0	a, b
Birth to <1 year	5.4	a, b, c, d	9.2	a, b, c
1 to <2 years	8.0	a, b, c, d	12.8	a, b, c
2 to <3 years	8.9	a, b, c, d	13.7	a, b, c
3 to <6 years	10.1	a, b, c, d	13.8	a, b, c
6 to <11 years	12.0	a, b, c, d	16.6	a, b, c
11 to <16 years	15.2	a, b, c, d	21.9	a, b, c
16 to <21 years	16.3	a, b, c, d	24.6	a, b, c
21 to <31 years	15.7	b, c, d	21.3	b, c
31 to <41 years	16.0	b, c, d	21.4	b, c
41 to <51 years	16.0	b, c, d	21.2	b, c
51 to <61 years	15.7	b, c, d	21.3	b, c
61 to <71 years	14.2	b, c, d	18.1	b, c
71 to <81 years	12.9	b, c	16.6	b, c
81 years and older	12.2	b, c	15.7	b, c

^a Arcus-Arth and Blaisdell, 2007.

^b Brochu et al., 2006.

^c U.S. EPA, 2009.

^d Stifelman, 2007.

^e When age groupings in the original reference did not match the U.S. EPA's age groupings used for the Handbook, means from all age groupings in the original reference that overlapped U.S. EPA's age groupings by more than 1 year were averaged, weighted by the number of observations contributed from each age group. Similar calculations were performed for the 95th percentiles. See Table 6-25 of the *Exposure Factors Handbook* for concordance with U.S. EPA's age groupings.

^f Some 95th percentile values may be unrealistically high and not representative of the average person.

^g For multiple percentiles, see Tables 6-4, 6-6 to 6-8, 6-10, 6-14, and 6-15 in the *Exposure Factors Handbook*; none available for Stifelman, 2007.

Table 6-2. Recommended Short-Term Exposure (Less Than 30 Days) Values for Inhalation (Males and Females Combined)

Activity Level	Age Group years	Mean m ³ /minute	95 th Percentile ^a m ³ /minute
Sleep or Nap	Birth to <1 year	3.0×10 ⁻³	4.6×10 ⁻³
	1 to <2 years	4.5×10 ⁻³	6.4×10 ⁻³
	2 to <3 years	4.6×10 ⁻³	6.4×10 ⁻³
	3 to <6 years	4.3×10 ⁻³	5.8×10 ⁻³
	6 to <11 years	4.5×10 ⁻³	6.3×10 ⁻³
	11 to <16 years	5.0×10 ⁻³	7.4×10 ⁻³
	16 to <21 years	4.9×10 ⁻³	7.1×10 ⁻³
	21 to <31	4.3×10 ⁻³	6.5×10 ⁻³
	31 to <41	4.6×10 ⁻³	6.6×10 ⁻³
	41 to <51	5.0×10 ⁻³	7.1×10 ⁻³
	51 to <61	5.2×10 ⁻³	7.5×10 ⁻³
	61 to <71	5.2×10 ⁻³	7.2×10 ⁻³
	71 to <81	5.3×10 ⁻³	7.2×10 ⁻³
	81 years and older	5.2×10 ⁻³	7.0×10 ⁻³
Sedentary/Passive	Birth to <1 year	3.1×10 ⁻³	4.7×10 ⁻³
	1 to <2 years	4.7×10 ⁻³	6.5×10 ⁻³
	2 to <3 years	4.8×10 ⁻³	6.5×10 ⁻³
	3 to <6 years	4.5×10 ⁻³	5.8×10 ⁻³
	6 to <11 years	4.8×10 ⁻³	6.4×10 ⁻³
	11 to <16 years	5.4×10 ⁻³	7.5×10 ⁻³
	16 to <21 years	5.3×10 ⁻³	7.2×10 ⁻³
	21 to <31 years	4.2×10 ⁻³	6.5×10 ⁻³
	31 to <41 years	4.3×10 ⁻³	6.6×10 ⁻³
	41 to <51 years	4.8×10 ⁻³	7.0×10 ⁻³
	51 to <61 years	5.0×10 ⁻³	7.3×10 ⁻³
	61 to <71 years	4.9×10 ⁻³	7.3×10 ⁻³
	71 to <81 years	5.0×10 ⁻³	7.2×10 ⁻³
	81 years and older	4.9×10 ⁻³	7.0×10 ⁻³
Light Intensity	Birth to <1 year	7.6×10 ⁻³	1.1×10 ⁻²
	1 to <2 years	1.2×10 ⁻²	1.6×10 ⁻²
	2 to <3 years	1.2×10 ⁻²	1.6×10 ⁻²
	3 to <6 years	1.1×10 ⁻²	1.4×10 ⁻²
	6 to <11 years	1.1×10 ⁻²	1.5×10 ⁻²
	11 to <16 years	1.3×10 ⁻²	1.7×10 ⁻²
	16 to <21 years	1.2×10 ⁻²	1.6×10 ⁻²
	21 to <31 years	1.2×10 ⁻²	1.6×10 ⁻²
	31 to <41 years	1.2×10 ⁻²	1.6×10 ⁻²
	41 to <51 years	1.3×10 ⁻²	1.6×10 ⁻²
	51 to <61 years	1.3×10 ⁻²	1.7×10 ⁻²
	61 to <71 years	1.2×10 ⁻²	1.6×10 ⁻²
	71 to <81 years	1.2×10 ⁻²	1.5×10 ⁻²
	81 years and older	1.2×10 ⁻²	1.5×10 ⁻²

Table 6-2. Recommended Short-Term Exposure (Less Than 30 Days) Values for Inhalation (Males and Females Combined) (continued)

Activity Level	Age Group years	Mean m ³ /minute	95 th Percentile ^a m ³ /minute
Moderate Intensity	Birth to <1 year	1.4×10 ⁻²	2.2×10 ⁻²
	1 to <2 years	2.1×10 ⁻²	2.9×10 ⁻²
	2 to <3 years	2.1×10 ⁻²	2.9×10 ⁻²
	3 to <6 years	2.1×10 ⁻²	2.7×10 ⁻²
	6 to <11 years	2.2×10 ⁻²	2.9×10 ⁻²
	11 to <16 years	2.5×10 ⁻²	3.4×10 ⁻²
	16 to <21 years	2.6×10 ⁻²	3.7×10 ⁻²
	21 to <31 years	2.6×10 ⁻²	3.8×10 ⁻²
	31 to <41 years	2.7×10 ⁻²	3.7×10 ⁻²
	41 to <51 years	2.8×10 ⁻²	3.9×10 ⁻²
	51 to <61 years	2.9×10 ⁻²	4.0×10 ⁻²
	61 to <71 years	2.6×10 ⁻²	3.4×10 ⁻²
	71 to <81 years	2.5×10 ⁻²	3.2×10 ⁻²
	81 years and older	2.5×10 ⁻²	3.1×10 ⁻²
High Intensity	Birth to <1 year	2.6×10 ⁻²	4.1×10 ⁻²
	1 to <2 years	3.8×10 ⁻²	5.2×10 ⁻²
	2 to <3 years	3.9×10 ⁻²	5.3×10 ⁻²
	3 to <6 years	3.7×10 ⁻²	4.8×10 ⁻²
	6 to <11 years	4.2×10 ⁻²	5.9×10 ⁻²
	11 to <16 years	4.9×10 ⁻²	7.0×10 ⁻²
	16 to <21 years	4.9×10 ⁻²	7.3×10 ⁻²
	21 to <31 years	5.0×10 ⁻²	7.6×10 ⁻²
	31 to <41 years	4.9×10 ⁻²	7.2×10 ⁻²
	41 to <51 years	5.2×10 ⁻²	7.6×10 ⁻²
	51 to <61 years	5.3×10 ⁻²	7.8×10 ⁻²
	61 to <71 years	4.7×10 ⁻²	6.6×10 ⁻²
	71 to <81 years	4.7×10 ⁻²	6.5×10 ⁻²
	81 years and older	4.8×10 ⁻²	6.8×10 ⁻²

^a For multiple percentiles, see Tables 6-17 and 6-19 in the *Exposure Factors Handbook*.

Source: U.S. EPA, 2009.

For more information about the key studies used to derive the recommended inhalation rate values, refer to **Chapter 6 of the *Exposure Factors Handbook*** at <http://www.epa.gov/ncea/efh/pdfs/efh-chapter06.pdf>. These studies are discussed in Section 6.3 and information on other relevant studies is provided in Section 6.4.