Canadian exposure factors used in human health risk assessments

Fact sheet series: Topics in risk assessment of substances under the *Canadian Environmental Protection Act, 1999* (CEPA)

Exposure of the general population to chemical substances may occur through inhalation (breathing), ingestion (eating), and/or dermal absorption (through the skin). Sources of exposure include ambient and indoor air, water, food, soil, dust and through the use of products available to consumers.

In order to estimate human exposure to a substance, scientists use standard default values for receptor (the receptor is the person) characteristics, such as body weight, body surface area, inhalation rates, ingestion of dust and soil, and drinking water consumption to ensure consistency of approach. Values that are used are representative of the Canadian general population. Exposure is estimated separately for different age groups because of physiological and psychological differences that may affect exposure.

The values for exposure factors used in assessment of human exposure to chemical substances identified as priorities under CEPA are provided in this document. These defaults were derived from recent Canadian data, when available, or from modelling or surrogate (substitute) data from the United States (U.S.).

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Age groups

Estimates of exposure of the Canadian general population to priority substances assessed under CEPA are calculated separately for defined stages of life or age groups. This is because physiological and psychological differences between age groups may affect exposure, such as differences in surface area of body parts or inhalation rates, as well as varying behaviour patterns. For example, pre-schooler

exposure to substances in soil may be higher than that of other age groups because of an increased contact with soil/indoor dust and mouthing behavior.

Age groups for which human exposure assessments are derived under CEPA

- 0 to 5 months
- 6 to 11 months
- 1 year
- 2 to 3 years
- 4 to 8 years
- 9 to 13 years
- 14 to 18 years
- ≥ 19 years

Body weights

For ages 2 years and above, the default body weights are median values from the 2004 Canadian Community Health Survey (CCHS) cycle 2.2, which is the most comprehensive survey of Canadian body weight data.

For ages younger than 2 years, body weight data were not collected in the 2004 CCHS cycle 2.2, and median body weights were derived from data collected as part of the U.S. National Health and Nutrition Examination Survey (NHANES) between the period of 1999 and 2010. NHANES is the largest source of nationally representative data in the U.S. (n > 40,000 respondents), and approximately half of the respondents were children. It is considered a reasonable source for deriving Canadian default body weights for children under the age of 2.

Body weight values used in assessments of human exposure conducted under CEPA

Age group	Default body weight (kg)
0 to 5 months	6.3
6 to 11 months	9.1
1 year	11
2 to 3 years	15

4 to 8 years	23
9 to 13 years	42
14 to 18 years	62
≥ 19 years	74

Body surface area

The default values for total body surface area are based on body weights and heights collected in CCHS cycle 2.2 of 2004.

For ages 2 years and above, the total body surface area values were estimated based on the body weight and height from CCHS cycle 2.2 (2004) and the equation described below (Health Canada, 1995).

Total body surface area (m^2) = 0.0235 x body weight (kg)$^{0.51456}$ x height (cm)$^{0.42246}$

For ages younger than 2 years, body weight and height were not available from CCHS cycle 2.2 and were based on the values provided in the 2011 U.S. Environmental Protection Agency (EPA) Exposure Factors Handbook (U.S. EPA, 2011).

Surface areas for specific body parts (such as head, trunk, arms, or hands) were derived based on percentages of the total body surface area, adopted from the U.S. EPA Exposure Factors Handbook 2011 (U.S. EPA, 2011).

Body surface areas used in assessments of human exposure conducted under CEPA

Age group	Total body surface area (cm^2)	Head (cm^2)	Trunk (cm^2)	Arms (cm^2)	Hands (cm^2)
0 to 5 months	3,500	640	1,250	480	190
6 to 11 months	4,500	820	1,610	620	240
1 year	5,300	870	1,880	690	300
2 to 3 years	6,500	550	2,670	940	310
4 to 8 years	8,900	610	3,580	1,250	430

9 to 13 years	13,400	700	5,310	1,900	610
14 to 18 years	17,200	740	6,980	2,490	770
≥ 19 years	18,700	1,170	6,890	2,550	910

Body surface areas used in assessments of human exposure conducted under CEPA

Age group	Legs (cm^2)	Feet (cm^2)
0 to 5 months	720	230
6 to 11 months	930	290
1 year	1,220	330
2 to 3 years	1,640	410
4 to 8 years	2,450	590
9 to 13 years	3,990	900
14 to 18 years	5,140	1,080
≥ 19 years	5,970	1,210

Inhalation rates

Inhalation rates used in assessments of human exposure conducted under CEPA are based on the long-term mean default inhalation rates recommended in the 2011 U.S. EPA Exposure Factors Handbook (U.S. EPA, 2011), adjusted for the age groups for which CEPA assessments are conducted.

Inhalation rates used in assessments of human exposure conducted under CEPA

Age group	Inhalation rate (m^3/day)
0 to 5 months	3.7
6 to 11 months	5.4

1 year	8.0
2 to 3 years	9.2
4 to 8 years	11.1
9 to 13 years	13.9
14 to 18 years	15.9
≥ 19 years	15.1

Soil and dust ingestion

Soil and dust ingestion exposure can occur through routine hand-to-mouth behaviours for younger age groups and through incidental hand-to-mouth contact or indirect exposures for older age groups (for example, from cigarettes or finger foods). The recommended values for soil and indoor dust ingestion rates were developed based on a mechanistic (a type of mathematical calculation) approach taking into consideration hand-to-mouth activity, presented in Wilson et al. (2013), and using Canadian receptor characteristics.

Intentional ingestion of large amounts of soil or clay, sometimes referred to as "geophagy", is not addressed in this section.

Soil and dust ingestion rates used in assessments of human exposure conducted under CEPA

Age group	Soil ingestion rate (mg/day)	Dust ingestion rate (mg/day)
0 to 5 months	n/a[1]	21.6
6 to 11 months	7.3	27.0
1 year	8.8	35.0
2 to 3 years	6.2	21.4
4 to 8 years	8.7	24.4
9 to 13 years	6.9	23.8
14 to 18 years	1.4	2.1
≥ 19 years	1.6	2.6

1 n/a = not applicable – No soil ingestion was assumed for infants (0 to 5 months) given typical caregiver behaviours (that is, all indoor and outdoor awake time for infants is assumed to be in contact with soft surfaces).

Drinking water intake

Drinking water intake values for use in assessments of substances conducted under CEPA are based on data collected in cycle 2.2 of the 2004 CCHS.

Drinking water is defined as water consumed from the tap, bottled or sparkling water, as well as water used at home either to reconstitute a beverage (such as coffee, tea and iced tea, juices, fruit drinks, alcoholic beverages) or added to food for final preparation (for example, soups).

For ages less than 1-year-old (infants 0 to 5 months and 6 to 11 months old), it is assumed that the drinking water volume is equivalent to the volume of intake of reconstituted (or ready-made) formula.

An overall mean intake value was derived for 0 to 5 months and 6 to 11 months-old infants, based on intake values collected from the recent literature. A total of 18 studies measuring formula intake values were collected. These studies were conducted from 2008 to 2017, and were from the U.S., Europe, Asia, and South America (no publicly available and relevant Canadian studies were identified). The intake of breast milk was also examined but was found to be consistently lower than formula intake.

Drinking water intakes used in assessments of human exposure conducted under CEPA.

Age group (years)	Drinking water intake (L/day)
0 to 5 months	0.83
6 to 11 months	0.76
1 year	0.36
2 to 3 years	0.43
4 to 8 years	0.53
9 to 13 years	0.74
14 to 18 years	1.09
≥ 19 years	1.53

References

Health Canada. 1995. Investigating human exposure to contaminants in the environment: a handbook for exposure calculations.

(U.S. EPA) U.S. Environmental Protection Agency. 2011. Exposure Factors Handbook 2011 Edition (Final). U.S. Environmental Protection Agency: Washington, DC. EPA/600/R-09/052F.

Wilson R, Jones-Otazo H, Petrovic S, Mitchell I, Bonvalot Y, Williams D, Richardson GM. 2013. Revisiting dust and soil ingestion rates based on hand-to-mouth transfer. Human and Ecological Risk Assessment 19(1): 158-188.