Methods for Lifetime Excess Cancer Risk Estimates

Environmental exposures

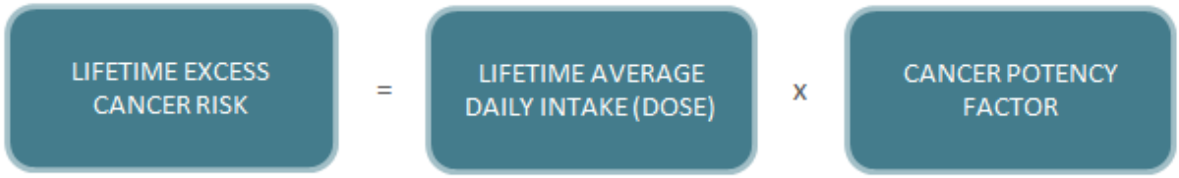
Table of Contents

**Note: Asbestos and radon lifetime excess cancer risk estimates use unique methodology; for more information on these calculations, please visit the corresponding substance profile on our website.*

1. Methods Overview

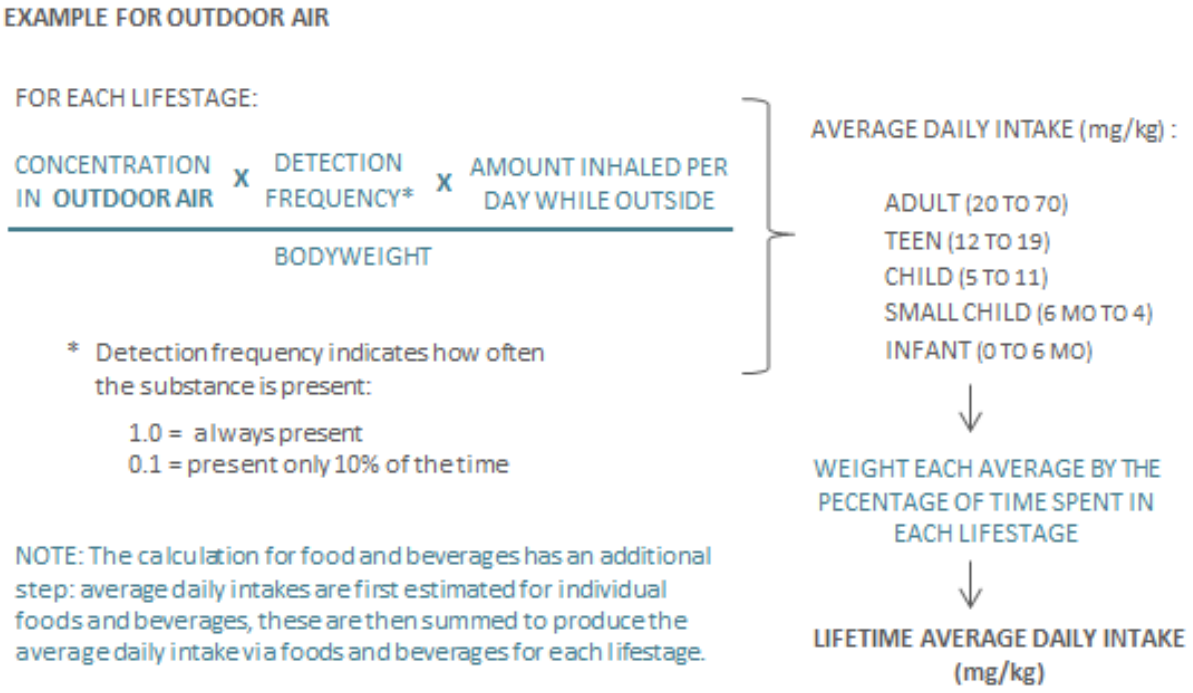
Combining data on measured concentrations of known or suspected carcinogens in outdoor air, indoor air, dust, drinking water, and foods and beverages with standard body weights, inhalation and ingestion rates allows us to calculate lifetime average daily intake.

Assuming that the lifetime average daily intake is the same for 70 years, multiplying the estimated intake by a cancer potency factor produces an estimate of the lifetime excess cancer risk.



2. Calculating Lifetime Average Daily Intake

Lifetime average daily intake is calculated for each exposure pathway (outdoor air, indoor air, indoor dust, drinking water, and food and beverages). First, the average daily intake is calculated for each of five lifestages (adult, teen, child, small child, and infant) and these are then weighted by the amount of time spent in each lifestage to produce the lifetime average daily intake for the exposure pathway.



3. Standard Assumptions

We assume these characteristics remain constant for each lifestage. This is rarely true for any single individual, but using a standard set of assumptions allows us to provide a relative ranking for known and suspected carcinogens across different exposure routes.

CHARACTERISTIC (age)	Adult (20 to 70)	Teen (12 to 19)	Child (5 to 11)	Small Child (6 months to 4)	Infant (0 to 6 months)
Bodyweight (kg)	70	57	27	13	6
Breathing (m^3 per day)	23	21	12	5	2
Drinking water (litres per day)	1.5	1.3	0.9	0.8	0.75
Ingestion of dust (milligrams per day)	0.02	0.02	0.035	0.05	0.035
Time outdoor (percent of day)	6.25	6.25	8.2	8.2	8.2
Time indoor (percent of day)	93.75	93.75	91.8	91.8	91.8

Bodyweights and ingestion rates for air, drinking water and dust*: Investigating Human Exposure to Contaminants in the Environment: A Handbook for Exposure Calculations. Health Canada. 1995.

*assumed to be the same as ingestion rates for soil

Time spent indoor and outdoor: Federal Contaminated Site Risk Assessment in Canada Part VI: Guidance on Human Health Detailed Quantitative Radiological Risk Assessment ($DQRA_{RAD}$). Health Canada. 2010.

i. Annual Consumption by Major Food Group

TOTAL BY FOOD GROUP	Units	Adult (20 to 70)	Teen (12 to 19)	Child (5 to 11)	Small Child (6 months to 4)	Infant (0 to 6 months)
Meats and oils	Kg/Year	62.66	49.75	24.80	11.90	5.54
Seafood	Kg/Year	5.26	3.72	2.82	1.12	0.18
Fruit	Kg/Year	69.56	57.32	59.90	34.34	5.58
Vegetables	Kg/Year	93.94	81.44	56.10	33.14	16.33
Dairy and eggs	Kg/Year	134.68	230.69	235.43	250.97	200.71
Grains, nuts and breads	Kg/Year	159.53	140.93	131.95	75.86	32.53
Beverages	L/Year	464.92	182.18	105.01	66.83	8.39

ii. Annual Consumption of Meats and Oils

MEATS AND OILS	Units	Adult (20 to 70)	Teen (12 to 19)	Child (5 to 11)	Small Child (6 months to 4)	Infant (0 to 6 months)
Beef	Kg/Year	12.64	9.99	4.93	2.40	1.14
Chicken	Kg/Year	3.89	3.07	1.52	0.74	0.35
Mutton and lamb	Kg/Year	0.28	0.44	0.66	0.01	0.00
Offal	Kg/Year	0.68	0.54	0.27	0.13	0.06
Oils and fats	Kg/Year	18.61	14.70	7.26	3.54	1.67
Pork	Kg/Year	9.69	7.66	3.78	1.84	0.87
Salad oils	Kg/Year	7.82	6.18	3.05	1.49	0.70
Shortening and shortening oils	Kg/Year	5.53	4.37	2.16	1.05	0.50
Stewing hen	Kg/Year	0.51	0.40	0.20	0.10	0.05
Turkey	Kg/Year	2.22	1.75	0.87	0.42	0.20
Veal	Kg/Year	0.79	0.65	0.12	0.18	0.00

- Adult consumption taken from Statistics Canada food report. Adult consumption is reduced proportionally to body weight decrease for other age groups.
- Consumption for each age group taken from the Nutrition Canada Survey, 1970.

iii. Annual Consumption of Seafood

SEAFOOD	Units	Adult (20 to 70)	Teen (12 to 19)	Child (5 to 11)	Small Child (6 months to 4)	Infant (0 to 6 months)
Fish fresh and frozen sea fish	Kg/Year	2.51	1.83	1.76	0.55	0.18
Fish freshwater	Kg/Year	0.31	0.39	0.39	0.41	0.00
Fish processed sea fish	Kg/Year	2.44	1.51	0.67	0.16	0.00

- Adult consumption taken from Statistics Canada food report. Adult consumption is reduced proportionally to body weight decrease for other age groups.
- Consumption for each age group taken from the Nutrition Canada Survey, 1970.

iv. Annual Consumption of Fruit

FRUIT (includes sugar and honey)	Units	Adult (20 to 70)	Teen (12 to 19)	Child (5 to 11)	Small Child (6 months to 4)	Infant (0 to 6 months)
Apple pie filling	Kg/Year	0.08	0.06	0.03	0.02	0.01
Apple sauce	Kg/Year	2.18	1.15	3.22	1.42	0.53
Apples canned	Kg/Year	0.34	0.27	0.13	0.06	0.03
Apples dried	Kg/Year	0.05	0.04	0.02	0.01	0.00
Apples fresh	Kg/Year	7.49	12.36	15.10	9.78	0.42
Apples frozen	Kg/Year	0.04	0.03	0.02	0.01	0.00
Apricots canned	Kg/Year	0.04	0.03	0.02	0.01	0.00
Apricots fresh	Kg/Year	0.07	0.06	0.03	0.01	0.01
Bananas fresh	Kg/Year	4.68	4.08	7.82	4.74	1.19
Berries other fresh	Kg/Year	0.26	0.21	0.10	0.05	0.02
Blueberries canned	Kg/Year	0.01	0.01	0.00	0.00	0.00
Blueberries fresh	Kg/Year	0.73	0.55	0.37	0.24	0.24
Blueberries frozen	Kg/Year	0.47	0.37	0.18	0.09	0.04
Cherries fresh	Kg/Year	0.60	0.32	0.42	0.33	0.00
Cherries frozen	Kg/Year	0.18	0.14	0.07	0.03	0.02
Citrus other fresh	Kg/Year	12.14	8.14	9.02	4.19	0.00
Coconut fresh	Kg/Year	0.26	0.21	0.10	0.05	0.02
Cranberries fresh	Kg/Year	0.63	0.50	0.25	0.12	0.06
Dates fresh	Kg/Year	0.95	0.75	0.37	0.18	0.09
Figs fresh	Kg/Year	0.34	0.27	0.13	0.06	0.03
Fruit dried	Kg/Year	1.35	1.07	0.53	0.26	0.12
Grapefruit fresh	Kg/Year	0.50	0.40	0.20	0.10	0.05
Grapes fresh	Kg/Year	1.07	0.97	0.55	0.30	0.00
Guava and mangoes fresh	Kg/Year	0.58	0.46	0.23	0.11	0.05
Kiwi fresh	Kg/Year	0.33	0.26	0.13	0.06	0.03
Lemons fresh	Kg/Year	0.46	0.36	0.18	0.09	0.04
Limes fresh	Kg/Year	0.27	0.21	0.11	0.05	0.02
Mandarins fresh	Kg/Year	1.62	1.28	0.63	0.31	0.15
Melons musk and cantaloupe fresh	Kg/Year	1.09	0.86	0.43	0.21	0.10
Melons other fresh	Kg/Year	3.48	1.39	2.70	0.43	0.00
Melons watermelons fresh	Kg/Year	2.07	1.64	0.81	0.39	0.19
Melons winter melons fresh	Kg/Year	0.64	0.51	0.25	0.12	0.06
Nectarines fresh	Kg/Year	0.38	0.30	0.15	0.07	0.03
Oranges fresh	Kg/Year	4.90	3.87	1.91	0.93	0.44
Papayas fresh	Kg/Year	0.16	0.13	0.06	0.03	0.01
Peaches canned	Kg/Year	0.82	0.65	0.32	0.16	0.07
Peaches fresh	Kg/Year	3.71	2.39	3.75	4.47	0.18
Pears canned	Kg/Year	0.27	0.21	0.11	0.05	0.02
Pears fresh	Kg/Year	0.57	0.45	0.22	0.11	0.05
Pineapples canned	Kg/Year	0.72	0.57	0.28	0.14	0.06
Pineapples fresh	Kg/Year	0.81	0.61	0.61	0.26	0.00
Plums total fresh	Kg/Year	0.53	0.42	0.21	0.10	0.05
Quinces fresh	Kg/Year	0.00	0.00	0.00	0.00	0.00
Raspberries frozen	Kg/Year	0.34	0.27	0.13	0.06	0.03

v. Annual Consumption of Vegetables

VEGETABLES	Units	Adult (20 to 70)	Teen (12 to 19)	Child (5 to 11)	Small Child (6 months to 4)	Infant (0 to 6 months)
Artichokes fresh	Kg/Year	0.01	0.01	0.00	0.00	0.00
Asparagus canned	Kg/Year	0.26	0.21	0.10	0.05	0.02
Asparagus fresh	Kg/Year	0.22	0.17	0.09	0.04	0.02
Avocados fresh	Kg/Year	0.34	0.27	0.13	0.06	0.03
Beans baked and canned	Kg/Year	1.09	0.86	0.43	0.21	0.10
Beans dry	Kg/Year	2.03	1.60	0.79	0.39	0.18
Beans green and wax canned	Kg/Year	0.95	0.75	0.37	0.18	0.09
Beans green and wax fresh	Kg/Year	2.49	1.64	1.56	0.97	0.12
Beans green and wax frozen	Kg/Year	0.25	0.20	0.10	0.05	0.02
Beets canned	Kg/Year	0.13	0.10	0.05	0.02	0.01
Beets fresh	Kg/Year	0.66	0.37	0.46	0.16	0.00
Broccoli fresh	Kg/Year	0.80	0.07	0.49	0.12	0.32
Broccoli frozen	Kg/Year	0.53	0.42	0.21	0.10	0.05
Brussels sprouts fresh	Kg/Year	0.09	0.07	0.04	0.02	0.01
Brussels sprouts frozen	Kg/Year	0.06	0.05	0.02	0.01	0.01
Cabbage Chinese fresh	Kg/Year	0.42	0.33	0.16	0.08	0.04
Cabbage fresh	Kg/Year	3.74	2.27	1.84	0.98	0.00
Carrots canned	Kg/Year	0.13	0.10	0.05	0.02	0.01
Carrots fresh	Kg/Year	5.18	4.04	3.77	2.97	0.51
Carrots frozen	Kg/Year	0.95	0.75	0.37	0.18	0.09
Cauliflower fresh	Kg/Year	0.53	0.41	0.04	0.09	0.00
Cauliflower frozen	Kg/Year	0.10	0.08	0.04	0.02	0.01
Celery fresh	Kg/Year	3.04	1.26	0.89	0.58	0.01
Corn canned	Kg/Year	0.97	0.77	0.38	0.18	0.09
Corn flour and meal	Kg/Year	0.96	0.76	0.37	0.18	0.09
Corn fresh	Kg/Year	2.98	4.39	6.42	3.61	0.20
Corn frozen	Kg/Year	0.75	0.59	0.29	0.14	0.07
Cucumbers fresh	Kg/Year	4.15	4.11	3.02	1.27	0.00
Eggplant fresh	Kg/Year	0.23	0.18	0.09	0.04	0.02
Garlic fresh	Kg/Year	0.21	0.17	0.08	0.04	0.02
Kohlrabi fresh	Kg/Year	0.11	0.09	0.04	0.02	0.01
Leeks fresh	Kg/Year	0.13	0.10	0.05	0.02	0.01
Lettuce fresh	Kg/Year	4.64	3.00	1.64	0.87	0.00
Lima beans frozen	Kg/Year	0.01	0.01	0.00	0.00	0.00

vi. Annual Consumption of Dairy and Eggs

DAIRY AND EGGS	Units	Adult (20 to 70)	Teen (12 to 19)	Child (5 to 11)	Small Child (6 months to 4)	Infant (0 to 6 months)
Butter	Kg/Year	4.97	6.08	4.72	2.58	0.27
Cheese cheddar	Kg/Year	2.78	2.20	1.08	0.53	0.25
Cheese cottage	Kg/Year	1.95	0.64	0.49	0.63	0.00
Cheese processed	Kg/Year	1.39	2.35	1.80	1.31	0.02
Cheese variety	Kg/Year	5.37	2.07	1.16	0.93	0.04
Cream cereal 10%	L/Year	3.72	0.97	1.03	0.59	0.00
Cream sour	L/Year	0.98	0.77	0.38	0.19	0.09
Cream table 18%	L/Year	2.10	1.66	0.82	0.40	0.19
Cream whipping 32% or 35%	L/Year	0.82	0.65	0.32	0.16	0.07
Eggs	Kg/Year	5.84	9.41	9.34	5.60	0.50
Ice cream	L/Year	1.19	0.94	0.46	0.23	0.11
Ice milk	L/Year	1.19	0.94	0.46	0.23	0.11
Margarine	Kg/Year	2.27	3.04	2.24	0.97	0.01
Milk buttermilk	L/Year	0.30	0.24	0.12	0.06	0.03
Milk chocolate drink	L/Year	3.88	3.07	1.51	0.74	0.35
Milk concentrated skim	L/Year	0.25	0.20	0.10	0.05	0.02
Milk concentrated whole	L/Year	4.18	2.58	2.39	4.39	21.82
Milk other whole milk products	Kg/Year	0.73	0.58	0.28	0.14	0.07
Milk partly skimmed 2%	L/Year	27.06	71.08	67.75	70.99	68.84
Milk skim	L/Year	11.25	26.48	20.28	21.78	7.74
Milk standard	L/Year	50.46	93.31	117.95	137.93	100.07
Milk sweetened concentrated skim	L/Year	0.07	0.06	0.03	0.01	0.01
Milkshake	L/Year	0.16	0.13	0.06	0.03	0.01
Powder buttermilk	Kg/Year	0.07	0.06	0.03	0.01	0.01
Powder skim milk	Kg/Year	0.77	0.61	0.30	0.15	0.07
Powder whey	Kg/Year	0.24	0.19	0.09	0.05	0.02
Sherbet	L/Year	0.12	0.09	0.05	0.02	0.01
Yogurt	L/Year	0.56	0.32	0.18	0.28	0.00

- Adult consumption taken from Statistics Canada food report. Adult consumption is reduced proportionally to body weight decrease for other age groups.
- Consumption for each age group taken from the Nutrition Canada Survey, 1970.

vii. Annual Consumption of Grains, Nuts, and Breads

GRAINS, NUTS AND BREADS	Units	Adult (20 to 70)	Teen (12 to 19)	Child (5 to 11)	Small Child (6 months to 4)	Infant (0 to 6 months)
Cereal products	Kg/Year	90.16	118.63	109.50	61.32	19.35
Oatmeal and rolled oats	Kg/Year	6.00	4.47	7.28	7.61	12.09
Peanuts	Kg/Year	1.28	2.41	2.22	1.09	0.06
Pot and pearl barley	Kg/Year	0.05	0.04	0.02	0.01	0.00
Pulses and nuts	Kg/Year	7.99	6.31	3.12	1.52	0.72
Rice	Kg/Year	5.53	5.31	5.10	2.46	0.00
Rye flour	Kg/Year	0.19	0.15	0.07	0.04	0.02
Tree nuts	Kg/Year	1.21	0.96	0.47	0.23	0.11
Wheat flour	Kg/Year	46.16	1.89	3.79	1.41	0.10

- Adult consumption taken from Statistics Canada food report. Adult consumption is reduced proportionally to body weight decrease for other age groups.
- Consumption for each age group taken from the Nutrition Canada Survey, 1970.

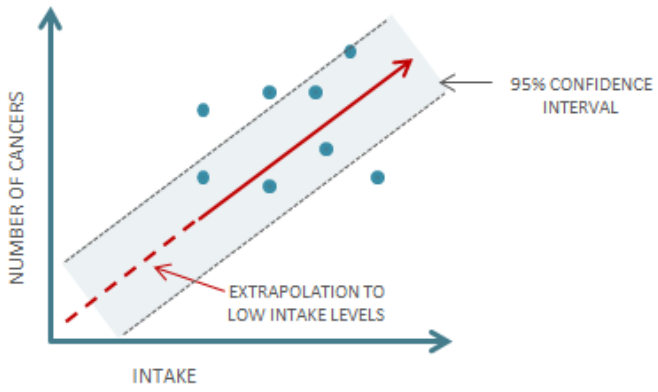
viii. Annual Consumption of Beverages

BEVERAGES	Units	Adult (20 to 70)	Teen (12 to 19)	Child (5 to 11)	Small Child (6 months to 4)	Infant (0 to 6 months)
Ale, beer, stout and porter	L/Year	77.90	7.83	--	--	--
Coffee	L/Year	126.94	30.64	4.38	2.37	0.00
Distilled spirits	L/Year	7.06	--	--	--	--
Juice apple	L/Year	4.85	3.52	9.73	16.14	5.47
Juice grape	L/Year	0.78	1.83	0.92	1.92	0.00
Juice tomato	L/Year	3.66	2.06	1.65	1.93	0.00
Juice grapefruit	L/Year	0.60	0.47	0.23	0.11	0.05
Juice lemon	L/Year	0.52	0.41	0.20	0.10	0.05
Juice orange	L/Year	11.48	9.07	4.48	2.18	1.03
Juice pineapple	L/Year	0.76	0.60	0.30	0.14	0.07
Juice vegetable	L/Year	1.13	0.89	0.44	0.21	0.10
Soft drinks	L/Year	84.89	87.86	70.65	36.62	0.87
Tea	L/Year	129.26	29.80	8.10	3.09	0.00
Water bottled	L/Year	--	--	--	--	--
Wines	L/Year	13.89	0.67	--	--	--
Cocoa	Kg/Year	1.20	0.95	0.47	0.23	0.11

- Adult consumption taken from Statistics Canada food report. Adult consumption is reduced proportionally to body weight decrease for other age groups.
- Consumption for each age group taken from the Nutrition Canada Survey, 1970.

4. Cancer Potency Factors

There is a lot of uncertainty in predicting excess cancer risk in humans, but by using standard cancer potency factors, we can make relative comparisons between substances and exposure routes.

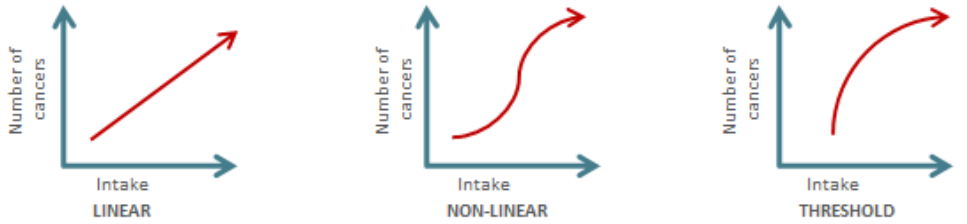


When the number of cancers increases in direct proportion to the intake (dose), it is possible to predict the number of cancers expected for any given intake, using the slope of the line that is the best fit for the data. Cancer potency factors are also called oral or inhalation slope factors.

Cancer potency factors are often developed using data that reflect relatively high intake levels. When intake levels are low, the best fit line must be extrapolated below the point of any observed data.

The cancer potency factors used by Health Canada, US EPA and California OEHHA assume a linear relationship and reflect the slope of the upper bound of the 95% confidence interval.

The real relationship between intake and the number of cancers may not always be linear. This adds uncertainty to the extrapolation of the cancer potency factor to intakes lower than those observed in the existing studies.



5. Lifetime Excess Cancer Risk

Potential lifetime excess cancer risk is a useful means to summarize population risks and allow comparisons between pollutants and exposure routes. It indicates how many *additional* cases of cancer would be expected in a population of one million people exposed to a given pollutant concentration and intake level for an entire 70 year lifetime.

LIFETIME EXCESS CANCER RISK		
10,000 per million people	=	One extra cancer per 100 people
1,000 per million people	=	One extra cancer per 1,000 people
100 per million people	=	One extra cancer per 10,000 people
10 per million people	=	One extra cancer per 100,000 people
1 per million people	=	One extra cancer per 1,000,000 people
0.1 per million people	=	One extra cancer per 10,000,000 people
0.01 per million people	=	One extra cancer per 100,000,000 people
0.001 per million people	=	One extra cancer per 1,000,000,000 people
0.0001 per million people	=	One extra cancer per 10,000,000,000 people

i. Limitations

This approach does not estimate the actual risk for any one individual, as individual risk is influenced by a range of genetic and lifestyle factors. For environmental concentrations, levels may change at any one place over time due to changes in industrial activity, new technology, or regulation. For any one person these levels may change as they move from place to place or change their eating habits.

ii. Interpretation

For non-threshold substances with a linear dose response, any level of exposure above zero may pose some probability of risk. Agencies and jurisdictions may have different guidelines regarding risk levels that are deemed as acceptable, tolerable, or negligible (*de minimus*). Generally, lifetime excess cancer risks between 1 in 1,000,000 (10^{-6}) and 1 in 100,000 (10^{-5}) due to non-occupational exposure are treated as essentially negligible, depending on the situation and circumstances of exposure.

iii. Guidelines

Many agencies and provinces use an increased chance of 1 per 1,000,000 (10^{-6}) for developing cancer due to lifetime of exposure to as substance as a guideline for when to manage environmental contamination. The US EPA and Health Canada use the following guidelines:

Agency	Lifetime Excess Cancer Risk	Guideline
US EPA[1]	< 1 in 1,000,000 (10^{-6})	Negligible
	> 1 in 10,000 (10^{-4})	Remediation may be desirable
	1 in 1,000,000 to 1 in 10,000 (10^{-6} to 10^{-4})	Acceptable, assessed on a case-by-case basis
Health Canada[2]	≤ 1 in 100,000 (10^{-5})	Negligible (for assessing and managing federal contaminated sites)

CAREX Canada's screening level approach uses 1 in 1,000,000 (10^{-6}) in any single pathway as a guideline to indicate when an estimated risk warrants further investigation, such as assessing the need to reduce individual exposures. This risk exceeds a level that agencies generally recognize as greater than "essentially negligible". Data sources and data quality should be taken into consideration when interpreting the risk estimates.

Sources:

- US EPA (2014). Region 8 HH: Risk Characterization. [Online].
- Health Canada 2010. Part 1: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0. Federal Contaminated Site Risk Assessment in Canada.