Benzo[a]pyrene

Environmental estimates (circa 2011): Supplemental data

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1. Data for lifetime excess cancer risk estimates

Overview

The summary data used to calculate lifetime excess cancer risk and the results for benzo[a]pyrene are provided in the tables below. For more detailed information on supporting data and sources, see below for each exposure pathway.

i. Environmental Concentrations

Exposure pathway	Units	Average	Maximum	Notes
Outdoor air	µg/m³	0.00011	0.00056	
Indoor air	µg/m³	0.0002	0.0026	
Dust	µg/g	2.91	38.8	
Drinking water	µg/L	Insufficient data		
Foods and beverages		See detailed data	Not estimated	

ii. Calculated Lifetime Daily Intake

Exposure pathway	Average intake (mg/kg bodyweight per day)	Maximum intake (mg/kg bodyweight per day)
Outdoor air	0.000000003	0.000000013
Indoor air	0.000000065	0.00000084
Dust	0.0000019	0.000025
Drinking water	Insufficient data	
Foods and beverages	0.000000027	Not estimated

iii. Cancer Potency Factors

Exposure route	Health Canada	US EPA	CA OEHHA
Inhalation	0.13	--	3.9
Ingestion	2.3	7.3	12.0

Sources for Cancer Potency Factors:

- Health Canada, 2010. Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment. Version 2.0.
- Health Canada, 2010. Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors. Version 2.0.
- United States Environmental Protection Agency Integrated Risk Information System.
- California Office of Environmental Health Hazard Assessment, 2009. Air Toxics Hot Spots Risk Assessment Guidelines Part II: Technical Support Document for Cancer Potency Factors, Appendix A. (Updated 2011)

iv. Lifetime Excess Cancer Risk (per million people)

	Average[1]			Maximum[2]
Exposure pathway	Health Canada	US EPA	CA OEHHA[3]	
Outdoor air	0.00033	--	0.0099	0.051
Indoor air	0.00845	--	0.25	3.29
Dust	4.396	13.95	22.93	305.8
Drinking water		Insufficient data		
Foods and beverages	0.06187	0.19637	0.32281	Not estimated

[1]Lifetime excess cancer risk based on average intake x cancer potency factor from each agency
[2]Lifetime excess cancer risk based on maximum intake x highest cancer potency factor
[3]California Office of Environmental Health Hazard Assessment

Supporting data by exposure pathway

i. Outdoor air

Outdoor air concentrations are from the National Air Pollution Surveillance monitoring network operated by Environment Canada, for the year 2010.

Source	Stations (n)	Min	Max	Mean	DF
NAPS 2010 (µg/m³)	17	0.000011	0.00056	0.00011	1.0

DF = Detection frequency

We assume benzo[a]pyrene is present at these levels in all outdoor air, although concentrations may vary from one location to another.

ii. Indoor air

Indoor air concentrations are based on data published in peer-reviewed literature since 2000. A ranking system was used to select data most representative of Canadian conditions circa 2011:

1. Canadian data collected in 2000 or more recently, sample duration of 24 hours or longer;
2. US studies of similar currency and sample duration;
3. Studies from northern European countries of similar currency and sample duration;
4. Canadian, US or European studies with data collected prior to 2000 and similar sample duration; and
5. Studies with sample duration of less than 24 hours regardless of country or collection date, or studies from countries not comparable to Canada.

Rank: 1 Author: Weichenthal (2013) Location: Manitoba, First Nations Reserve

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
20			March 2011	µg/m³	1 week			0.00018	0.00019		
20								0.00022	0.00020		

*DF = Detection frequency
**DL = Detection limit

Rank: 2 Author: Jung (2010) Location: New York City

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
203			2005 - 2010	µg/m³	14 days	0.00002	0.0033	0.00019	0.00010		
98							0.00449	0.00015	0.00006		

Notes: Values listed in the following order: heating season (Oct-Apr), non-heating season (May-Sept)
*DF = Detection frequency
**DL = Detection limit

Rank: 2 Author: Li (2005) Location: Chicago

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
10	~0.95		2000 - 2001	µg/m³	48h x 14 months	0.000001	0.0013		0.00011		10th 0.000008 25th 0.00005 75th 0.00025 90th 0.0003

Notes: non-smoking homes, (sampled once a month for 14 months) total n = 115
*DF = Detection frequency
**DL = Detection limit

Rank: 3	Author:	Gustafson (2008)					Location:	Hagfors, Sweden			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
13	100	0.00005	Feb-March 2003	µg/m³	24hr	0.00009	0.0022	0.00063	0.00052		
10	100					0.00009	0.00048	0.00016	0.00012		

Notes: Values listed in the following order: wood burning, non-wood burning homes.
*DF = Detection frequency
**DL = Detection limit

Rank: 3	Author:	Halsall (2008)					Location:	Lancaster UK			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
7	0.14	0.00001 to 0.0015	Summer 2003	µg/m³	6 to 24 hours	<dl	0.00057	0.00012	0.000025		

Notes: 3 locations
*DF = Detection frequency
**DL = Detection limit

Rank: 4	Author:	Naumova (2002)					Location:	RIOPA – Los Angeles, Houston, Elizabeth NJ			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
19	1.0		1999-2000	µg/m³	48h	0.000018	0.00057			0.000078	
21	assumed					0.0000027	0.0011			0.00002	
15						0.0000055	0.00023			0.000055	

Notes: Values listed in the following order: Los Angeles, Houston, Elizabeth NJ.
*DF = Detection frequency
**DL = Detection limit

Rank: 4	Author:	Sanderson (2004)					Location:	Beauharnois, PQ			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
3	0.84	0.00001		µg/m³	24h			0.000093			
12								0.000177		0.000064	

Notes: near aluminum smelter, Values listed in the following order: homes with oil heating, with no oil heating
*DF = Detection frequency
**DL = Detection limit

Sources for indoor air data:

- Gustafson P, Östman C, Sällsten G. 2008. Indoor levels of polycyclic aromatic hydrocarbons in homes with or without wood burning for heating. Environ Sci Technol 42: 5074-5080.
- Halsall CJ, Maher BA, Karloukovski VV, Shah P, Watkins SJ. 2008. A novel approach to investigating indoor/outdoor pollution links: Combined magnetic and PAH measurements. Atmospheric Environment 42: 8902-8909.
- Jung K, Patel MM, Kinney PL, Chillrud SN, Whyatt R, Hoepner L, et al. 2010. 1. Effects of Season and Indoor Heating on Indoor and Outdoor Residential Levels of Airborne Polycyclic Aromatic Hydrocarbons, Absorbance and Particulate Matter 2.5 in an Inner City Cohort of Young Children. Journal of Allergy and Clinical Immunology 125: AB81.

- Li A, Schoonover TM, Zou QM, Norlock F, Conroy LM, Scheff PA, et al. 2005. Polycyclic aromatic hydrocarbons in residential air of ten Chicago area homes: Concentrations and influencing factors. Atmospheric Environment 39: 3491-3501.
- Naumova YY, Eisenreich SJ, Turpin BJ, Weisel CP, Morandi MT, Colome SD, et al. 2002. Polycyclic aromatic hydrocarbons in the indoor and outdoor air of three cities in the US. Environmental Science & Technology 36: 2552-2559.
- Sanderson EG, Farant JP. 2004. Indoor and outdoor polycyclic aromatic hydrocarbons in residences surrounding a Soderberg aluminum smelter in Canada. Environ Sci Technol 38: 5350-5356.
- Weichenthal S, Mallach G, Kulka R, Black A, Wheeler, A, You H, St-Jean M, Kwiatkowski, Sharp D. 2013. A randomized double blink crossover study of indoor air infilatration and acute changes in cardiorespiratory health in a First Nations community. Indoor Air 23: 175-184.

iii. Dust

Indoor dust concentrations are based on data published in peer-reviewed literature since 2000. A ranking system was used to select data most representative of Canadian conditions circa 2011:

1. Canadian data collected in 2000 or more recently, sample duration of 24 hours or longer;
2. US studies of similar currency and sample duration;
3. Studies from northern European countries of similar currency and sample duration;
4. Canadian, US or European studies with data collected prior to 2000 and similar sample duration; and
5. Studies with sample duration of less than 24 hours regardless of country or collection date, or studies from countries not comparable to Canada.

Rank: 1	Author:	Maertens (2008)					Location:	Ottawa, Canada			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
51	1.0	0.051	2002 - 2003	µg/g		0.04	38.8	2.91	0.8	1.0	

Notes: Analyzed using GC/MS
*DF = Detection frequency
**DL = Detection limit

Rank: 2	Author:	Whitehead (2011)					Location:	California, USA			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
583	0.984	0.002	2001-2007	µg/g		<DL	1.948		0.040	1.0	

Notes: Analyzed using GC/MS
*DF = Detection frequency
**DL = Detection limit

Rank: 2	Author:	Hoh (2012)					Location:	San Diego County, CA, USA			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
43	0.907		2005-2007	µg/g		<DL	0.129		0.0408		25th 0.0240 75th 0.0687
89	0.876					<DL	0.282		0.0478		25th 0.0197 75th 0.0877

Notes: Analyzed using GC/MS
*DF = Detection frequency
**DL = Detection limit

Sources for dust data:

- Hoh E, Hunt RN, Quintana PJE, Zakarian JM, Chatfield DA, Wittry BC, Rodriguez E, Matt GE. 2012. Environmental tobacco smoke as a source of polycyclic aromatic hydrocarbons in settled house dust. Environ Sci Technol 46: 4174-4183.
- Maertens RM, Yang XF, Zhu JP, Gagne RW, Douglas GR, White PA. 2008. Mutagenic and carcinogenic hazards of settled house dust I: Polycyclic aromatic hydrocarbon content and excess lifetime cancer risk from preschool exposure. Environmental Science & Technology 42: 1747-1753.
- Whitehead T, Metayer C, Gunier RB, Ward MH, Nishioka MG, Buffler P, Rappaport SM. 2011. Determinants of polycyclic aromatic hydrocarbon levels in house dust. J Expo Sci Environ Epidemiol 21(2): 123-132.

iv. Drinking water

No recent data or studies were identified.

v. Food and Beverages

Food consumption data are from the Statistics Canada Food Survey (2006) - Food available, adjusted for losses tables, and from the Nutrition Canada Survey (1970-1972).

Food concentration data are primarily from the US-FDA Total Diet Study (2003-2004), with additional data on metals and several PAHs from the Canadian Food Inspection Agency (CFIA) - National Chemical Residue Monitoring Program: 2009-2010 Annual Report and the US-FDA (TDS Statistics on Element Results - 2008).

In order to better represent actual intake, we incorporated data for cooked and/or processed foods, as in some cases, this can either add to or diminish the amount measured in raw food.

Concentration data were obtained for 26% of total meat consumed.

Food or Beverage	Concentration (µg/g)	DF
Beef	0.00036	0.07700
Chicken	0.00104	0.07700
Mutton and lamb	0.00042	0.14300
Offal		
Oils and fats		
Pork		
Salad oils		
Shortening and shortening oils		
Stewing hen		
Turkey		
Veal		
Fish fresh and frozen seafish		
Fish freshwater		
Fish processed seafish		
Apple pie filling		
Apple sauce		
Apples canned		
Apples dried		
Apples fresh		
Apples frozen		
Apricots canned		
Apricots fresh		
Bananas fresh		
Berries other fresh		
Blueberries canned		
Blueberries fresh		
Blueberries frozen		
Cherries fresh		
Cherries frozen		
Citrus other fresh		
Coconut fresh		
Cranberries fresh		
Dates fresh		
Figs fresh		
Fruit dried		
Grapefruit fresh		
Grapes fresh		
Guava and mangoes fresh		
Kiwi fresh		
Lemons fresh		
Limes fresh		
Mandarins fresh		
Melons musk, cantaloupe fresh		
Melons other fresh		
Melons watermelons fresh		
Melons, winter melons fresh		
Nectarines fresh		
Oranges fresh		
Papayas fresh		
Peaches canned		

Food or Beverage	Concentration (µg/g)	DF
Peaches fresh		
Pears canned		
Pears fresh		
Pineapples canned		
Pineapples fresh		
Plums total fresh		
Quinces fresh		
Raspberries frozen		
Strawberries canned		
Strawberries fresh		
Strawberries frozen		
Sugar maple		
Sugar refined		
Honey		
Artichokes fresh		
Asparagus canned		
Asparagus fresh		
Avocados fresh		
Beans baked and canned		
Beans dry		
Beans green and wax canned		
Beans green and wax fresh		
Beans green and wax frozen		
Beets canned		
Beets fresh		
Broccoli fresh		
Broccoli frozen		
Brussels sprouts fresh		
Brussels sprouts frozen		
Cabbage Chinese fresh		
Cabbage fresh		
Carrots canned		
Carrots fresh		
Carrots frozen		
Cauliflower fresh		
Cauliflower frozen		
Celery fresh		
Corn canned		
Corn flour and meal		
Corn fresh		
Corn frozen		
Cucumbers fresh		
Eggplant fresh		
Garlic fresh		
Kohlrabi fresh		
Leeks fresh		
Lettuce fresh		
Lima beans frozen		
Manioc fresh		
Mushrooms canned		

Food or Beverage	Concentration (µg/g)	DF	Food or Beverage	Concentration (µg/g)	DF
Mushrooms fresh			Milk buttermilk		
Okra fresh			Milk chocolate drink		
Olives fresh			Milk concentrated skim		
Onions and shallots fresh			Milk concentrated whole		
Parsley fresh			Milk other whole milk products		
Parsnips fresh			Milk partly skimmed 2%		
Peas canned			Milk skim		
Peas dry			Milk standard		
Peas fresh			Milk sweetened concentrated skim		
Peas frozen			Milkshake		
Peppers fresh			Powder buttermilk		
Potatoes chips			Powder skim milk		
Potatoes frozen			Powder whey		
Potatoes other processed			Sherbet		
Potatoes sweet fresh			Yogurt		
Potatoes white fresh			Cereal products		
Potatoes white fresh and processed			Oatmeal and rolled oats		
Pumpkins and squash fresh			Peanuts		
Radishes fresh			Pot and pearl barley		
Rappini fresh			Pulses and nuts		
Rutabagas and turnip fresh			Rice		
Spinach fresh			Rye flour		
Spinach frozen			Tree nuts		
Tomatoes canned			Wheat flour		
Tomatoes fresh			Ale, beer, stout and porter		
Tomatoes pulp, paste and puree			Beverages alcoholic		
Vegetables other edible root fresh			Coffee		
Vegetables other leguminous fresh			Distilled spirits		
Vegetables unspecified canned			Juice apple		
Vegetables unspecified fresh			Juice grape		
Vegetables unspecified frozen			Juice tomato		
Butter			Juice fruit		
Cheese cheddar			Juice grapefruit		
Cheese cottage			Juice lemon		
Cheese processed			Juice orange		
Cheese variety			Juice pineapple		
Cream cereal 10%			Juice vegetable		
Cream sour			Soft drinks		
Cream table 18%			Tea		
Cream whipping 32% or 35%			Water bottled		
Eggs			Wines		
Ice cream			Cocoa		
Ice milk					
Margarine					

2. Data quality for lifetime excess cancer risk estimates

Only publicly available data were used to calculate these indicators. Data that are not publicly available may produce different results.

No systematic method for measuring data quality was possible, so we provide the following assessments of how well the data used may represent the actual Canadian average levels. Quality is rated higher when there are data from a number of Canadian monitors, or from Canadian studies that show results similar to other comparable studies. Quality is rated lower when data from few monitors or studies were available, and lowest when estimates are based on non-Canadian data. Others may rate data quality differently.

Exposure Pathway	Data Quality	Notes
Outdoor air	Low	• Benzo[a]pyrene is regularly measured in outdoor air at 17 monitoring stations across Canada using accepted protocols.
Indoor air	Low	• One recent Canadian study identified on a First Nations Reserve in Manitoba. Agrees well with a recent study conducted in New York City, USA, as well as a smaller study in Chicago.
Indoor dust	Low	• Measured levels from one recent Canadian study (Ottawa, ON) are considerably higher than 2 recent studies conducted in California, USA using the same analytical methods.
Drinking water	Gap	• Only 1 distribution sample was analyzed for benzo[a]pyrene in Ontario in 2009. No recent data or studies identified.
Foods and beverages	Very Low	• Very limited data from CFIA (National Chemical Residue Monitoring Program: 2009-2010 Annual Report) for benzo[a]pyrene in foods and beverages were identified.

3. Data for mapping concentrations

The maps use geographic coordinates at the census block level to represent residential locations. Concentration estimates are mapped at the health region level, which are created with aggregated census block data.

We used a model to predict annual average concentrations of benzo[a]pyrene in outdoor air at residential locations for 2011. These are predicted using levels measured from the National Air Pollution Surveillance (NAPS) monitors and estimated concentrations from known emitters. For more information on how these estimates were created, please see the Mapping Methods document on the Environmental Approach section of our website.

Estimates by health region

The table below shows predicted benzo[a]pyrene concentrations by province based on data at the health region level. The median concentration of benzo[a]pyrene measured in outdoor air in 2011 at the health region level was 0.00015 µg/m^3, while the mean concentration was 0.00018 µg/m^3. Concentrations of benzo[a]pyrene can be higher or lower than average in many locations.

i. Provincial averages of predicted benzo[a]pyrene concentrations (µg/m^3) in outdoor air in 2011 based on health regions

Province	Median	Mean
BC	0.00020	0.00020
AB	0.00010	0.00011
SK	0.00009	0.00010
MB	0.00009	0.00009
ON	0.00019	0.00023
QC	0.00017	0.00021
NB	0.00015	0.00015
PE	0.00014	0.00014
NS	0.00019	0.00020
NL	0.00008	0.00009
YK	0.00014	0.00014
NT	0.00009	0.00009
NU	0.00014	0.00014
Canada	**0.00015**	**0.00018**

Estimates by census block

The table below shows provincial populations by concentration levels (either annual average or number of times above/below the national average) based on the census block data and the associated potential lifetime excess risk given different cancer potency factors.

i. Provincial population distribution by estimated average concentration (µg/m³) of benzo[a]pyrene in outdoor air in 2011 based on NAPS data at the census block

Estimated annual average concentration (µg/m³)	Less than 0.000037	0.000037 to 0.000044	0.000044 to 0.000055	0.000055 to 0.000073	0.000073 to 0.00011	0.00011 to 0.00017	0.00017 to 0.00022	0.00022 to 0.00028	0.00028 to 0.00033	More than 0.00033
Compared to national average (0.00011µg/m³)*	> 3x lower	2.5 to 3x lower	2 to 2.5x lower	1.5 to 2x lower	1 to 1.5x lower	1 to 1.5x higher	1.5 to 2x higher	2 to 2.5x higher	2.5 to 3x higher	> 3.0x higher
	← Below Average					→ Above Average				
BC	--	--	435,943 (9.9%)	28,403 (0.6%)	27,763 (0.6%)	2,456,137 (55.8%)	378,623 (8.6%)	394,808 (9.0%)	367,091 (8.3%)	311,289 (7.1%)
AB	--	--	2,205,063 (60.5%)	205,125 (5.6%)	384,711 (10.6%)	687,111 (18.8%)	74,116 (2.0%)	35,068 (1.0%)	25,773 (0.7%)	28,290 (0.8%)
SK	--	--	32,399 (31.5%)	21,231 (2.1%)	16,595 (1.6%)	425,431 (41.2%)	54,435 (5.3%)	40,040 (3.9%)	44,875 (4.3%)	105,375 (10.2%)
MB	--	--	821,067 (68.0%)	86,894 (7.2%)	123,379 (10.2%)	136,662 (11.3%)	18,066 (1.5%)	6,764 (0.6%)	7,320 (0.6%)	8,116 (0.7%)
ON	938,382 (7.3%)	29,855 (0.2%)	2,032,560 (15.8%)	339,816 (2.6%)	411,332 (3.2%)	5,019,611 (39.1%)	852,495 (6.6%)	1,073,893 (8.4%)	541,573 (4.2%)	1,612,304 (12.5%)
QC	--	--	1,004,131 (12.7%)	62,242 (0.8%)	1,630,838 (20.6%)	2,042,678 (25.8%)	1,508,969 (19.1%)	608,291 (7.7%)	328,175 (4.2%)	717,677 (9.1%)
NB	89,973 (12.0%)	1,259 (0.2%)	233,217 (31.0%)	9,807 (138%)	14,665 (2.0%)	266,216 (35.4%)	25,216 (3.4%)	19,402 (2.6%)	23,443 (3.1%)	67,973 (9.0%)
NS	--	--	266,849 (29.0%)	11,066 (1.2%)	14,250 (1.5%)	448,188 (48.6%)	48,913 (53.1%)	35,495 (3.9%)	36,312 (3.9%)	60,654 (6.6%)
PE	--	--	49,274 (35.1%)	1,354 (1.0%)	2,587 (1.8%)	66,409 (44.1%)	5,128 (36.6%)	3,560 (2.5%)	3,426 (2.4%)	8,466 (6.0%)
NL	--	--	198,090 (38.5%)	7,335 (1.4%)	42,236 (8.2%)	181,545 (35.3%)	37,842 (7.4%)	19,157 (3.7%)	16,338 (3.2%)	11,993 (2.3%)
NU	--	--	31,906 (100.0%)	--	--	--	--	--	--	--
NT	--	--	20,107 (48.5%)	298 (0.7%)	568 (1.4%)	17,240 (41.6%)	1,267 (0.3%)	685 (1.6%)	1,297 (3.1%)	0 (<0.1%)
YT	--	--	6,888 (20.3%)	176 (0.5%)	258 (0.8%)	18,445 (54.4%)	2,302 (6.8%)	1,574 (4.6%)	3,193 (9.4%)	1,061 (3.1%)
CANADA	1,028,355	31,114	7,630,494	773,747	2,669,182	11,765,673	3,007,372	2,238,737	1,398,816	2,933,198
% of pop.	(3.1%)	(0.1%)	(22.8%)	(2.3%)	(8.0%)	(35.1%)	(9.0%)	(6.7%)	(4.2%)	(8.8%)

ASSOCIATED LIFETIME EXCESS CANCER RISK (per million people):
RED = POTENTIAL LIFETIME EXCESS RISK IS GREATER THAN 1 PER MILLION PEOPLE

Health Canada CPF: 0.13	<0.00011	0.00011 to < 0.00013	0.00013 to < 0.00017	0.00017 to < 0.00022	0.00022 to < 0.00033	0.00033 to < 0.0005	0.0005 to < 0.0006	0.0006 to < 0.0008	0.0008 to < 0.001	> 0.001
California OEHHA CPF: 3.9	< 0.0033	0.0033 to < 0.004	0.004 to < 0.005	0.005 to < 0.007	0.007 to < 0.01	0.01 to < 0.015	0.015 to < 0.02	0.02 to < 0.025	0.025 to < 0.03	> 0.03
US EPA CPF: No CPF										

* measured at National Air Pollution Surveillance (NAPS) monitors in 2011
CPF: Cancer Potency Factor