Benzene

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 benzene 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	0.84	12.09	
Indoor air	µg/m³	2.0	87	
Drinking water	µg/L	0.05	0.15	
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	0.000019	0.00028
Indoor air	0.00065	0.0283
Drinking water	0.0000013	0.0000039
Foods and beverages	0.000023	Not estimated

iii. Cancer Potency Factors

Exposure route	Health Canada	US EPA	CA OEHHA
Inhalation	0.0145	0.0273	0.1
Ingestion	0.0834	0.055	--

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	0.28	0.531	1.94	27.97
Indoor air	9.42	17.738	64.97	2826.37
Drinking water	0.108	0.0714	--	0.325
Foods and beverages	1.91	1.26	--	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)	53	0.13	12.09	0.84	1.0

DF = Detection frequency

We assume benzene 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:	Wheeler (2013)					Location:	Canada National			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
3857	0.73	0.70	2009-2011	µg/m³	7 days			1.95	0.90	1.07	25th 0.51 75th 2.07 90th 4.25 95th 7.42

*DF = Detection frequency
**DL = Detection limit

Rank: 1	Author:	Health Canada (2012)					Location:	Halifax, NS			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
331	1.0	0.024	2009 summer	µg/m³	24hr	0.0148	85.17	2.435	0.520	0.751	25th 0.328 75th 1.408 90th 4.980 95th 9.020
312	1.0		winter			0.307	89.69	3.219	0.830	1.174	25th 0.599 75th 1.795 90th 3.357 95th 8.173

*DF = Detection frequency
**DL = Detection limit

Rank: 1	Author:	Health Canada (2010)					Location:	Regina, SK			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
105	1.0	0.044	2007 Summer	µg/m³	24hr	0.180	32.325	2.723	0.997	1.275	25th 0.540 75th 2.265 90th 6.485 95th 13.313
101	1.0				5 day	0.285	37.330	3.419	1.205	1.581	25th 0.680 75th 2.890 90th 10.365 95th 14.330
105	1.0		winter		24hr	0.533	17.873	2.062	1.150	1.438	25th 0.823 75th 1.967 90th 3.617 95th 5.513
89	1.0				5 day	0.487	13.127	1.931	1.167	1.388	25th 0.790 75th 2.120 90th 3.890 95th 6.277

*DF = Detection frequency
**DL = Detection limit

Rank: 1	Author:	Héroux (2010)					Location:	Canada, Regina			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
105			2007	µg/m³	1 week	0.18	32.33	2.72		1.25	
105						0.53	17.87	2.06		1.44	
91						0.18	32.33	2.66		1.19	
84						0.53	17.87	0.85		1.31	

Notes: Values listed in the following order: Summer, Winter, Non-smoking Summer, Non-smoking winter
*DF = Detection frequency
**DL = Detection limit

Rank: 1	Author:	Héroux (2008)					Location:	Canada, Quebec			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
96	0.94	0.2	2005	µg/m³	7 days	0.1	22.37		1.18	1.22	

*DF = Detection frequency
**DL = Detection limit

Rank: 1	Author:	Health Canada (2010)					Location:	Windsor, ON			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
217	1.0	0.100	2005 summer	µg/m³	24hr	0.525	16.485	3.076	1.475	1.958	25th 1.025 75th 2.870 90th 8.705 95th 11.070
232	1.0		winter			0.596	513.936	2.094	1.541	1.682	25th 1.068 75th 2.360 90th 3.752 95th 5.260
211	1.0	0.038	2006 summer		24hr	0.450	50.107	3.765	1.353	1.824	25th 1.000 75th 2.343 90th 10.497 95th 21.010
224	1.0		winter			0.497	0.497	1.594	1.190	1.324	25th 0.975 75th 1.517 90th 2.937 95th 3.646

*DF = Detection frequency
**DL = Detection limit

Rank: 1	Author:	Stocco (2008)					Location:	Canada, Windsor			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
48	1.0	0.014	2005	µg/m³	5 days					1.95	
48	1.0									1.68	

Notes: Non-smoking homes, values listed for summer and winter respectively
*DF = Detection frequency
**DL = Detection limit

Rank: 1	Author:	WBEA (2008)					Location:	Canada, Alberta			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
35	0.95	0.42	2006	µg/m³	4 weeks				1.9		95th 18.9
24									2.5		95th 15.0

Notes: Values listed in the following order: Fort MacKay, Fort McMurray
*DF = Detection frequency
**DL = Detection limit

Rank: 2	Author:	Adgate (2004)					Location:	USA, Minnesota			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
113	1.0		2000	µg/m³	48 hrs				2.2		10th 0.8 90th 6.2
	0.99								2.1		10th 0.6 90th 7.2

Notes: Values presented in the following order: Winter, Spring
*DF = Detection frequency
**DL = Detection limit

Rank: 2	Author:	Batterman (2007)					Location:	USA, Michigan			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
15	1.0	0.024	April – July, 2005	µg/m³	4 days		7.6	2			

Notes: Single family dwelling with attached garages
*DF = Detection frequency
**DL = Detection limit

Rank: 2 Author: Jia (2008) Location: USA, Michigan (Ann Arbor, Ypsilanti, Dearborn)

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
252	1.0		2004/ 2005	µg/m³	3-4 days		47.35	2.84	1.17	252	
46								3.15	0.94	46	
50								2.77	1.06	50	
30								4.06	1.05	30	
29								1.98	1.15	29	
45								2.05	1.25	45	
52								3.09	1.83	52	

Notes: Values listed in the following order: ALL, Suburban Summer 2004, Suburban Winter 2005, Urban Summer 2004, Urban Winter 2005, Industrial Spring 2005, Industrial Fall 2004
*DF = Detection frequency
**DL = Detection limit

Rank: 2 Author: Johnson (2010) Location: USA, Michigan

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
41	1.0	0.4	2006 (winter)	µg/m³	7day or 24/48 hr	0.8	37.6	3			25th 1.1 50th 1.5 75th 2.7 95th 5.8

*DF = Detection frequency
**DL = Detection limit

Rank: 2 Author: Payne-Sturges (2004) Location: USA, Baltimore

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
33			2000 – 2001	µg/m³	3 day			3.7	2.45		10th 1.03 90th 8.34

*DF = Detection frequency
**DL = Detection limit

Rank: 2 Author: Weisel (2008) Location: USA, New Jersey

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
100	0.76	1.6 or 0.64	2003 - 2006	µg/m³	24 hr	Less than DL <0.64	42	4.07			25th <1.6 50th 1.80 75th 3.28 90th 10.0 95th 13.1

*DF = Detection frequency
**DL = Detection limit

Rank: 3 **Author:** Gustafson (2007) **Location:** Sweden, Hagfors

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
24		0.03,	Feb 10-	µg/m³	24hr,						
14		0.04	Mar 12		7day			3.9	2.6		
14			2003					5.7	3.0		
10								2.0	1.7		
10								2.5	1.5		

Notes: Values listed in the following order: All, Wood burning 24-hr, Wood burning 7 day, Non-wood burning 24-hr, Non-wood burning 7 day
*DF = Detection frequency
**DL = Detection limit

Rank: 3 **Author:** Schlink (2010) **Location:** Germany, Leipzig

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
601			2004-2005	µg/m³	4 weeks		22	2.03			46th 1.02 50th 1.55 54th 2.18 95th 4.77 98th 10.00

*DF = Detection frequency
**DL = Detection limit

Rank: 4 **Author:** Hippelein (2004) **Location:** Germany

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
63		1	2000 – 2001	µg/m³	2 L sample		13	2.9	2.4	2.1	90th 5.4

*DF = Detection frequency
**DL = Detection limit

Rank: 4 **Author:** Kim (2001) **Location:** England, Birmingham

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
128		0.26	1999 - 2000	µg/m³	8 hrs	3.4	63.7	13.9	9.2		
32						4.2	63.7	16.3	11.4		
32						3.1	51.7	11.5	6.6		
2								3.5			
2								12.6			
2								6.1			
2								9.2			

Notes: Values listed in the following order: All, Smoking (6), Non-smoking (6), Before Solvent Cleaning, After Solvent Cleaning, Before Painting, After Painting
*DF = Detection frequency
**DL = Detection limit

Rank: 4 **Author:** Ohura (2006) **Location:** Japan, Shimizu

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
25			2000 2001	µg/m³	24 hr					0.99	10th 0.59 90th 1.48
21										2.69	10th 0.89 90th 5.84

Notes: Values listed in the following order: Industrial city, Summer 2000, Winter 2001
*DF = Detection frequency
**DL = Detection limit

Rank: 4 **Author:** Schlink (2004) **Location:** Germany

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
2103			1994-2001	µg/m³	4 weeks		3.3	3.2	2.3		95th 8.6 98th 12.0

Notes: (Leipzig, München, Köln)
*DF = Detection frequency
**DL = Detection limit

Rank: 5 **Author:** Esplugues (2010) **Location:** Spain, Valencia

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
352	0.64	1.04	2006-2007	µg/m³	15 days	0.52	88.7	2.7		1.4	25th 0.5 50th 1.5 75th 2.4

Notes: March 2006 – February 2007, Living rooms
*DF = Detection frequency
**DL = Detection limit

Rank: 5 **Author:** Fondelli (2008) **Location:** Italy, Florence

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
11		0.01	2001-2002	µg/m³	4 day	3.3 1.7 2.9 1.6	9.6 6.0 8.7 6.2	5.9 3.3 5.1 2.7	5.7 3.1 4.7 2.5		

Notes: Dec. 10-13, 2001 (winter) June 3-6, 2002 (spring),
Values listed in the following order: Rooms close to street (W) Rooms close to street (S) Rooms farther from street (W) Rooms farther from street (S)
*DF = Detection frequency
**DL = Detection limit

Rank: 5 **Author:** Gallego (2010) **Location:** Spain, Barcelona (Urban) Catalan (Rural)

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
48		0.5	2000	µg/m³	21 days	0.5	36.0	4.3			5th 1.1 50th 3.69 95th 8.5
13			2001			0.2	70.6	5.8			5th 0.5 50th 2.2 95th 19.5

Notes: Values listed in the following order: samples taken in 2000-, samples taken in 2001
*DF = Detection frequency
**DL = Detection limit

Rank: 5 **Author:** Hinwood (2006) **Location:** W Australia, Perth

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
27		<.01	2000	ppb	12 hrs		2.7 2.2 0.7 0.3 0.2 bdl				

Notes: Values listed in the following order: Open Fireplace Heating, Pot-bellied Stove Heating, With Garage, Indoor (daytime,) New Furnishings, Gas Heater
*DF = Detection frequency
**DL = Detection limit

Rank: 5 **Author:** Kinney (2002) **Location:** New York City, Los Angeles

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
36 41			1999	µg/m³	48 hrs			0.00597 0.00175			

Notes: Values listed in the following order: Winter, Summer
*DF = Detection frequency
**DL = Detection limit

Rank: 5 **Author:** Massolo (2009) **Location:** Argentine, La Plata

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
		.01-.05	2000-2002	µg/m³	4 weeks						
26							59.54	19.07	18.0		
24							12.74	3.58	3.20		
23							13.17	4.69	3.14		
14							10.5	3.69	3.10		

Notes: Values listed in the following order: Industry, Urban, Semi-Rural, Residential
*DF = Detection frequency
**DL = Detection limit

Rank: 5	Author:	Raw (2004)					Location:	England			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
796		0.1	1997 - 1999	µg/m³	4 weeks	< 0.1	93.5			3	10th 1.0 50th 3.3 75th 5.8 95th 14.6

Notes: National Survey
*DF = Detection frequency
**DL = Detection limit

Rank: 5	Author:	Sax (2006)					Location:	New York City, Los Angeles			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
79	0.83		1999-2000	µg/m³	48 hr		20.7	3.64	2.75		
75	1.0						11.4	3.87	3.30		

Notes: Values listed in the following order: New York City, Los Angeles.
*DF = Detection frequency
**DL = Detection limit

Rank: 5	Author:	Sexton (2004)					Location:	USA, Minnesota			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
292	1.0		1999	µg/m³	2 day			5.8	1.9		10th 0.8 90th 15.3

Notes: ALL: Spring, Summer, Fall Non-Smoking
*DF = Detection frequency
**DL = Detection limit

Rank: 5	Author:	Zhu (2005)					Location:	Canada, Ottawa			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
75	0.97	0.05	2002-2003	µg/m³	100 min	0.025	20.99	2.85			50th 2.15 75th 3.43 90th 5.21

Notes: Nov.2002 – March 2003
*DF = Detection frequency
**DL = Detection limit

Sources for indoor air data:

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- Kinney PL, Chillrud SN, Ramstrom S, Ross J, Spengler JD. 2002. Exposures to multiple air toxics in New York City. Environmental Health Perspectives 110: 539-546.
- Massolo L, Rehwagen M, Porta A, Ronco A, Herbarth O, Mueller A. 2010. Indoor-outdoor distribution and risk assessment of volatile organic compounds in the atmosphere of industrial and urban areas. Environmental Toxicology 25(4): 339-349.
- Ohura T, Amagai T, Senga Y, Fusaya M. 2006. Organic air pollutants inside and outside residences in Shimizu, Japan: Levels, sources and risks. Science of the Total Environment 366: 485-499.
- Payne-Sturges DC, Burke TA, Breyesse P, Diener-West M, Campbell S. 2004. Personal exposure meets risk assessment: a comparison of measured and modeled exposures and risks in an urban community. Environmental Health Perspectives 112: 589-598.
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iii. Dust

Benzene is not expected to be present in indoor dust in significant amounts.

iv. Drinking water

Drinking water data are from the Ontario Drinking Water Surveillance Program (DWSP) for 2011. A review of published reports was also conducted in order to compare how well the Ontario data represented other regions in Canada.

Source	Units	DL							
Ontario DWSP 2011	(µg/L)	0.05							
Sample Type	Parameter	Mean	SD	Min	25th	50th	75th	Max	N
Distribution		0.05	0.005	0.05	0.05	0.05	0.05	0.15	342

DL = Detection limit
SD = Standard Deviation

Rank: 1 Author: Health Canada (2009) Location: Canada

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
1000	0.05		1998 -	µg/L		0.01	4.92	0.28			96th 1.0
1000	0.05		2003			0.01	0.23	0.01			--
30		0.0005	1995 -			< 0.2	< 1.0	0.25			
34		to 1.0	2005			0.1		0.71			
12						0.1	1.0	0.46			
		1.0	1995 - 2005				<1.0				
2277		0.05	2002 - 2008			< 0.05	0.2				
2388	0.01	0.03 to 2.0	2001 - 2005			0.03	3.6	0.35			
104		0.5 to 1.0	2001 - 2005				<0.5 or 1.0				

Notes: Data presented in the following order: Alberta municipal treated surface water; Alberta municipal treated ground water; Saskatchewan municipal treated surface water; Saskatchewan municipal treated ground water; Saskatchewan municipal treated surface and ground water mix; Newfoundland raw, or municipal treated surface or ground water; Ontario municipal drinking water systems using surface or ground water; Quebec municipal treated drinking water; Nova Scotia municipal treated surface or groundwater
*DF = Detection frequency
**DL = Detection limit

Sources for drinking water:

- Health Canada. 2009. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document - Benzene. Ottawa, Ontario, Canada: Water Quality and Health Bureau, Healthy Environments and Consumer Safety Branch, Health Canada.'

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 75% of total meat consumed, 46% of total seafood consumed, 41% of total fruit consumed, 20% of total vegetables consumed, 52% of total dairy and eggs consumed, 57% of total grains consumed, and 26% of total beverages consumed.

Food or Beverage	Concentration (µg/g)	DF
Beef	0.01550	0.56820
Chicken	0.03600	0.02270
Mutton and lamb		
Offal		
Oils and fats	0.00250	0.75000
Pork	0.00177	0.04550
Salad oils		
Shortening and shortening oils		
Stewing hen		
Turkey	0.03400	0.02270
Veal		
Fish fresh and frozen seafish		
Fish freshwater		
Fish processed seafish	0.00875	1.00000
Apple pie filling		
Apple sauce		
Apples canned		
Apples dried		
Apples fresh	0.00245	0.27273
Apples frozen		
Apricots canned		
Apricots fresh		
Bananas fresh	0.03368	0.59091
Berries other fresh		
Blueberries canned		
Blueberries fresh		
Blueberries frozen		
Cherries fresh	0.01600	0.02941
Cherries frozen		
Citrus other fresh		
Coconut fresh		
Cranberries fresh		
Dates fresh		
Figs fresh		
Fruit dried	0.00461	0.22727
Grapefruit fresh		
Grapes fresh	0.01000	0.02273
Guava and mangoes fresh		
Kiwi fresh		
Lemons fresh		
Limes fresh		
Mandarins fresh		
Melons musk, cantaloupe fresh	0.01300	0.02273
Melons other fresh		
Melons watermelons fresh		
Melons, winter melons fresh		
Nectarines fresh		
Oranges fresh	0.00134	0.13636
Papayas fresh		
Peaches canned		

Food or Beverage	Concentration (µg/g)	DF
Peaches fresh	0.02700	0.02273
Pears canned		
Pears fresh	0.01800	0.02273
Pineapples canned		
Pineapples fresh		
Plums total fresh	0.01300	0.02564
Quinces fresh		
Raspberries frozen		
Strawberries canned		
Strawberries fresh	0.00105	0.13954
Strawberries frozen		
Sugar maple		
Sugar refined		
Honey		
Artichokes fresh		
Asparagus canned		
Asparagus fresh		
Avocados fresh	0.00823	0.52273
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	0.01300	0.02273
Eggplant fresh		
Garlic fresh		
Kohlrabi fresh		
Leeks fresh		
Lettuce fresh		
Lima beans frozen		
Manioc fresh		
Mushrooms canned		

Food or Beverage	Concentration (µg/g)	DF
Mushrooms fresh		
Okra fresh		
Olives fresh		
Onions and shallots fresh		
Parsley fresh		
Parsnips fresh		
Peas canned		
Peas dry		
Peas fresh		
Peas frozen		
Peppers fresh		
Potatoes chips	0.00216	0.34091
Potatoes frozen		
Potatoes other processed		
Potatoes sweet fresh		
Potatoes white fresh	0.01400	0.02273
Potatoes white fresh and processed		
Pumpkins and squash fresh	0.01400	0.02273
Radishes fresh	0.02300	0.02500
Rappini fresh		
Rutabagas and turnip fresh		
Spinach fresh		
Spinach frozen		
Tomatoes canned		
Tomatoes fresh	0.00389	0.29546
Tomatoes pulp, paste and puree		
Vegetables other edible root fresh		
Vegetables other leguminous fresh		
Vegetables unspecified canned		
Vegetables unspecified fresh		
Vegetables unspecified frozen		
Butter	0.00320	0.36364
Cheese cheddar	0.00250	0.20455
Cheese cottage		
Cheese processed	0.00073	0.15909
Cheese variety	0.00218	0.29546
Cream cereal 10%		
Cream sour	0.00157	0.18182
Cream table 18%		
Cream whipping 32% or 35%		
Eggs		
Ice cream	0.00118	0.18182
Ice milk		
Margarine	0.00027	0.09091

Food or Beverage	Concentration (µg/g)	DF
Milk buttermilk		
Milk chocolate drink		
Milk concentrated skim		
Milk concentrated whole		
Milk other whole milk products		
Milk partly skimmed 2%		
Milk skim		
Milk standard	0.00027	0.09091
Milk sweetened concentrated skim		
Milkshake		
Powder buttermilk		
Powder skim milk		
Powder whey		
Sherbet		
Yogurt		
Cereal products	0.00027	0.02273
Oatmeal and rolled oats		
Peanuts	0.00252	0.36364
Pot and pearl barley		
Pulses and nuts		
Rice		
Rye flour		
Tree nuts		
Wheat flour		
Ale, beer, stout and porter		
Beverages alcoholic		
Coffee		
Distilled spirits		
Juice apple	0.0160	0.02273
Juice grape		
Juice tomato		
Juice fruit	0.00525	0.50000
Juice grapefruit	0.01900	0.02273
Juice lemon		
Juice orange	0.00170	0.22727
Juice pineapple		
Juice vegetable		
Soft drinks	0.00536	0.25000
Tea		
Water bottled	0.00275	0.50000
Wines		
Cocoa		

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	High	• Benzene is regularly measured in outdoor air at 53 monitoring stations across Canada using accepted protocols.
Indoor air	High	• The 2009-2011 Canadian Health Measures Survey provides a nationally representative sample of benzene in indoor air across Canada. The mean level reported is lower than those of three other Canadian studies identified (Halifax NS, Regina SK, and Windsor ON).
Drinking water	Moderate	• Trace amounts of benzene were detected in 2 of 342 samples from the Ontario Drinking Water Surveillance Program in 2011, given a detection limit of 0.05 µg/L. A national review of drinking water data by Health Canada reported infrequent detection of higher levels. • Potential lifetime excess cancer risk could be much higher if source water is contaminated from leaking fuel storage tanks.
Foods and beverages	Very Low	• No Canadian data on concentration of benzene in foods and beverages were identified. Data from the US-FDA (TDS-2003-2004) were used for this estimate. • The potential lifetime excess cancer risk is above 1 per million due to older data showing benzene in some soft drinks containing benzoate. Many soft drinks no longer contain benzoate.

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 benzene 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 benzene concentrations by province based on data at the health region level. The median concentration of benzene measured in outdoor air in 2011 at the health region level was 0.608 µg/m^3, while the mean concentration was 0.742 µg/m^3. Concentrations of benzene can be higher or lower than average in many locations.

i. Provincial averages of predicted benzene concentrations (µg/m^3) in outdoor air in 2011 based on health regions

Province	Median	Mean
BC	0.630	0.864
AB	0.574	0.838
SK	0.423	0.476
MB	0.481	0.673
ON	0.714	0.826
QC	0.678	0.800
NB	0.493	0.571
PE	0.583	0.583
NS	0.603	0.705
NL	0.681	0.697
YK	0.412	0.412
NT	0.477	0.477
NU	0.560	0.560
Canada	**0.608**	**0.742**

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 benzene in outdoor air in 2011 based on NAPS data at the census block

Estimated annual average concentration (µg/m³)	Less than 0.28	0.28 to 0.34	0.34 to 0.42	0.42 to 0.56	0.56 to 0.84	0.84 to 1.26	1.26 to 1.68	1.68 to 2.10	2.10 to 2.52	More than 2.52
Compared to national average (0.84 µg/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	225,775 (5.1%)	392,834 (8.9%)	115,398 (2.6%)	808,588 (18.4%)	1,238,014 (28.1%)	920,991 (20.9%)	346,144 (7.9%)	50,856 (1.2%)	149,941 (3.4%)	151,516 (0.3%)
AB	--	458,044 (12.6%)	165,975 (4.6%)	70,101 (1.9%)	1,013,503 (27.8%)	1,184,894 (32.5%)	580,795 (15.9%)	120,381 (3.3%)	24,568 (0.7%)	26,996 (0.7%)
SK	2,577 (0.2%)	231,131 (22.4%)	98,342 (9.5%)	60,151 (5.8%)	114,210 (11.1%)	356,865 (34.5%)	151,358 (14.6%)	14,565 (1.4%)	1,997 (0.2%)	2,185 (0.2%)
MB	--	230,030 (19.0%)	66,560 (5.5%)	258,640 (21.4%)	493,903 (40.9%)	117,745 (9.7%)	37,518 (3.1%)	2,639 (0.2%)	741 (0.1%)	492 (<0.1%)
ON	238,584 (1.9%)	1,060,711 (8.2%)	614,640 (4.8%)	2,676,711 (20.8%)	3,837,757 (29.9%)	3,280,694 (25.5%)	890,817 (6.9%)	174,597 (1.4%)	46,619 (0.4%)	30,691 (0.2%)
QC	375,566 (4.8%)	904,378 (11.4%)	488,257 (6.2%)	807,073 (10.2%)	1,738,659 (22.0%)	1,904,902 (24.1%)	1,235,596 (15.6%)	218,977 (2.8%)	141,499 (1.8%)	88,094 (1.1%)
NB	14,348 (1.9%)	225,190 (30.0%)	31,476 (4.2%)	13,473 (1.8%)	3,142 (0.4%)	293,932 (39.1%)	103,739 (13.8%)	27,800 (3.7%)	21,537 (2.9%)	16,534 (2.2%)
NS	24,597 (2.7%)	267,564 (29.0%)	42,468 (4.6%)	10,969 (1.2%)	368,968 (40.0%)	166,878 (18.1%)	35,979 (3.9%)	2,920 (0.3%)	481 (<0.1%)	903 (0.1%)
PE	--	51,742 (36.9%)	5,221 (3.7%)	1,441 (1.0%)	668 (0.5%)	50,908 (36.3%)	28,728 (20.5%)	705 (0.5%)	416 (0.3%)	375 (0.3%)
NL	--	162,864 (31.7%)	46,301 (9.0%)	135,806 (26.4%)	108,649 (21.1%)	39,928 (7.8%)	19,380 (3.8%)	576 (0.1%)	671 (0.1%)	361 (<0.1%)
NU	0 (<0.1%)	11,495 (3.6%)	12,779 (40.1%)	4,728 (14.8%)	2,820 (8.8%)	74 (0.2%)	10 (<0.1%)	--	--	--
NT	--	12,056 (29.1%)	5,243 (12.6%)	2,564 (6.2%)	2,099 (5.1%)	9,580 (23.1%)	8,141 (19.6%)	1,779 (4.3%)	0 (<0.1%)	0 (<0.1%)
YT	--	6,162 (18.1%)	1,223 (3.6%)	439 (1.3%)	20 (0.1%)	14,383 (42.4%)	9,583 (28.3%)	1920 (5.7%)	122 (0.4%)	45 (0.1%)
CANADA	881,447	4,014,201	1,693,883	4,850,684	8,922,412	8,341,774	3,477,788	617,715	388,592	318,192
% of pop.	(2.6%)	(12.0%)	(5.1%)	(14.5%)	(26.7%)	(24.9%)	(10..3%)	(1.8%)	(1.2%)	(1.0%)

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

Health Canada CPF: 0.0145	< 0.09	0.09 to < 0.11	0.11 to < 0.14	0.14 to < 0.19	0.19 to < 0.28	0.28 to < 0.42	0.42 to < 0.56	0.56 to < 0.7	0.7 to < 0.84	> 0.84
California OEHHA CPF: 0.1	< 0.65	0.65 to < 0.78	0.78 to < 0.97	0.97 to < 1.29	1.29 to < 1.94	1.94 to < 2.91	2.91 to < 3.88	3.88 to < 4.85	4.85 to < 5.82	> 5.82
US EPA CPF: 0.0273	< 0.18	0.18 to < 0.21	0.21 to < 0.27	0.27 to < 0.35	0.35 to < 0.53	0.53 to < 0.80	0.80 to < 1.06	1.06 to < 1.33	1.33 to < 1.59	> 1.59

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