Lindane

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 Lindane 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	0.000153	0.00262	
Indoor air	µg/m³	--	0.11	Level measured at 1 sample site only.
Dust	µg/g	--	1.04	
Drinking water	µg/L	--	0.001	
Food 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	0.0000000035	0.000000061
Indoor air	--	0.000036
Dust	--	0.00000068
Drinking water	--	0.000000026
Food and beverages	0.000000116	Not estimated

iii. Cancer Potency Factors

Exposure route	Health Canada	US EPA	CA OEHHA
Inhalation	--	--	1.1
Ingestion	--	--	1.1

Sources for Cancer Potency Factors:

- Health Canada, 2007 (draft). Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment. Version 2.0.*
- Health Canada, 2007 (draft). Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs). Version 2.0. *
  *Cited by Persistent Organic Pollutants Toolkit website.
- 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.

iv. Lifetime Excess Cancer Risk (per million people)

	Average[1]			Maximum[2]
Exposure pathway	Health Canada	US EPA	CA OEHHA[3]	
Outdoor air	--	--	0.0039	0.067
Indoor air	--	--	--	39.31
Dust	--	--	--	0.75
Drinking water	--	--	--	0.029
Food and beverages	--	--	0.1272	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 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: Aulagnier (2008) Location: Canada, Québec

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
12	0-13%	$5.0x10^{-6}$	2004 (summer)	µg/m³	7-day; Monthly	<DL	0.002623	0.002592	<DL		

*DF = Detection frequency
**DL = Detection limit

Rank: 1 Author: Daly (2007) Location: Canada, (BC and AB)

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
16			2003-2004	µg/m³	Annual		0.000008		0.0000033		

*DF = Detection frequency
**DL = Detection limit

Rank: 1 Author: Environment Canada (2009) Location: Canada, Ontario

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
12	33%	$1.0x10^{-6}$	2004-2005	µg/m³	3 months		0.000498				

*DF = Detection frequency
**DL = Detection limit

Rank: 1 Author: Gouin (2008) Location: Canada, Ontario

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
16		$1.0x10^{-7}$	2003-2004	µg/m³	monthly			0.0000262			

*DF = Detection frequency
**DL = Detection limit

Rank: 1 Author: Harner (2004) Location: Canada, Ontario

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
7			July-Oct 2000	µg/m³	120 days			0.0000322			

*DF = Detection frequency
**DL = Detection limit

Rank: 1 Author: Hayward (2010) Location: Canada, Ontario

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
1			2006-2007	µg/m³	2 weeks	0.00000138	0.0000251	0.0000087			95th 0.000012

*DF = Detection frequency
**DL = Detection limit

Rank: 1 Author: Hung (2010) Location: Canada, Alert

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
6			2000-2005	µg/m³	Continuous annual		0.000019	0.00000327			

*DF = Detection frequency
**DL = Detection limit

Rank: 1 Author: Yao (2006) Location: Canada (BC, SK, ON, QC, PEI)

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
8			May-Aug 2003	µg/m³	7-days		0.00048	0.000069			

*DF = Detection frequency
**DL = Detection limit

Rank: 1 Author: Yao (2008) Location: Canada (BC, SK, ON, QC, PEI)

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
15		$2.0x10^{-7}$	May-Aug 2004/2005	µg/m³	7-days		0.00092	0.00100			

*DF = Detection frequency
**DL = Detection limit

Rank: 2 Author: Kumar (2001) Location: Canada, AB

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
68	35-71%	$5.0x10^{-5}$	1999-2000	µg/m³	24-hr		0.00292				

*DF = Detection frequency
**DL = Detection limit

Sources for outdoor air:

- Aulagnier F, Poissant L, Brunet D, Beauvais C, Pilote M, Deblois C, Dassylva N. 2008. Pesticides measured in air and precipitation in the Yamaska Basin (Québec) : occurrence and concentrations in 2004. Sci Total Environ 294(2-3): 338-348.
- Daly GL, Lei YD, Teixeira C, Muir DCG, Wania F. 2007. Pesticides in Western Canadian mountain air and soil. Environmental Science and Technology 41: 6020-6025.
- Environment Canada. 2009. Presence and levels of priority pesticides in selected Canadian aquatic ecosystems. Prepared for Water Science and Technology Directorate, Environment Canada
- Gouin T, Shoeib M, Harner T. 2008. Atmospheric concentrations of current-use pesticides across south-central Ontario using monthly-resolbed passive air samplers. Atmospheric Environment 42: 8096-8104.
- Harner T, Shoeib M, Diamond M, Stern G, Rosenberg B. 2004. Using passive air samplers to assess urban-rural trends for persistent organic pollutants. 1. Polychlorinated Biphenyls and Organochlorine Pesticides. Environmental Science and Technology 38: 4474-4483.
- Hayward SJ, Gouin T, Wania F. 2010. Levels and seasonal variability of pesticides in the rural atmosphere of Southern Ontario. Journal of Agricultural Food and Chemistry 58: 1077-1084.
- Hung H, Kallenborn R, Breivik K, Su Y, Brorström-Lundén E, Olafsdottir K, Thorlacius JM Leppänen S, Bossi R, Skov H, Manø S, Patton GW, Stern G, Sverko E, Fellin P. 2010. Atmospheric monitoring of organic pollutants in the Arctic under the Arctic Monitoring and Assessment Programme (AMAP): 1993-2006. Science of the Total Environment 408: 2854-2873.
- Kumar Y. 2001. Pesticides in ambient air in Alberta. ISBN 0-7785-1889-4. Report prepared for the Air Research Users Group, Alberta Environment, Edmonton, Alberta.
- Yao Y, Tuduri L, Harner T, Blanchard P, Waite D, Poissant L, Murphy C, Belzer W, Aulagnier F, Li Y, Sverko E. 2006. Spatial and temporal distribution of pesticide air concentrations in Canadian agricultural regions. Atmospheric Environment 40: 4339-4351.
- Yao Y, Harner T, Blanchard P, Tuduri L, Waite D, Poissant L, Murphy C, Belzer W, Aulagnier F, Sverko E. 2008. Pesticides in the atmosphere accross Canadian agricultural regions. Enivon Sci Technol 42: 5931-5937.

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: 2	Author:	Rudel (2003)					Location:	USA, Cape Cod, MA			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
90	1	0.002	1999-2001	µg/m³	24-hr		0.11				

*DF = Detection frequency
**DL = Detection limit

Sources for indoor air data:

- Rudel RA, Camann DE, Spenger JD, Korn LR, Brody JG. 2003. Phthalates, alkyphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting compounds in indoor air and dust. Environmental Science and Technology 37(20): 4543-4553.

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: 2	Author:	Rudel (2003)					Location:	USA, Cape Cod, MA			
Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
119	2	0.4	1999-2001	µg/g			1.04				

*DF = Detection frequency
**DL = Detection limit

Sources for dust:

- Rudel RA, Camann DE, Spenger JD, Korn LR, Brody JG. 2003. Phthalates, alkyphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting compounds in indoor air and dust. Environmental Science and Technology 37(20): 4543-4553.

iv. Drinking water

Drinking water data are from the Ontario Drinking Water Surveillance Program (DWSP) for 2006. 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 2006	(µg/L)	0.001

Sample Type	Parameter	Mean	SD	Min	25th	50th	75th	Max	N
Distribution		0.001	0.0	0.001	0.001	0.001	0.001	0.001	1
Treated Water		0.001	0.0	0.001	0.001	0.001	0.001	0.001	76

DL = Detection limit
SD = Standard Deviation

Rank: 1 Author: Byrtus (2004) Location: Canada, Alberta

Samples (n)	DF*	DL**	Sample Date	Units	Sample Duration	Min	Max	Mean (AM)	Med	Geomean (GM)	Percentile
238	0.8		2000	µg/L			0.026				
196	0.5		2001				0.004				
212			2002								
111			2003								

*DF = Detection frequency
**DL = Detection limit

Sources for drinking water:

- Byrtus G, Pongar K, Browning C, Burland R, McGuinness E, Humphries D. 2004. A summary of pesticide residue data from the Alberta Treated Water Survey, 1995-2003. Alberta Environment, Environmental Assurance Service. Edmonton. 57 pp.

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 37% of total meat consumed, 48% of total seafood consumed, 3% of total vegetables consumed, 13% of total dairy and eggs consumed, and 1% of total grains consumed.

Food or Beverage	Concentration (µg/g)	DF
Beef	0.00050	0.02273
Chicken		
Mutton and lamb		
Offal		
Oils and fats	0.00200	0.02273
Pork	0.00200	0.02273
Salad oils		
Shortening and shortening oils		
Stewing hen		
Turkey		
Veal	0.00002	0.05000
Fish fresh and frozen seafish	0.00008	0.29167
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		
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
Mushrooms fresh	0.01000	0.02273
Okra fresh		
Olives fresh	0.00003	0.06818
Onions and shallots fresh		
Parsley fresh		
Parsnips fresh		
Peas canned		
Peas dry		
Peas fresh		
Peas frozen		
Peppers fresh		
Potatoes chips		
Potatoes frozen		
Potatoes other processed		
Potatoes sweet fresh		
Potatoes white fresh		
Potatoes white fresh and processed		
Pumpkins and squash fresh	0.00060	0.02273
Radishes fresh		
Rappini fresh		
Rutabagas and turnip fresh		
Spinach fresh	0.00060	0.02273
Spinach frozen		
Tomatoes canned		
Tomatoes fresh		
Tomatoes pulp, paste and puree		
Vegetables other edible root fresh		
Vegetables other leguminous fresh		
Vegetables unspecified canned		
Vegetables unspecified fresh		
Vegetables unspecified frozen		
Butter	0.00019	0.31818
Cheese cheddar		
Cheese cottage		
Cheese processed	0.00020	0.02273
Cheese variety	0.00200	0.04545
Cream cereal 10%		
Cream sour	0.00030	0.02273
Cream table 18%		
Cream whipping 32% or 35%		
Eggs		
Ice cream		
Ice milk		
Margarine		

Food or Beverage	Concentration (µg/g)	DF
Milk buttermilk		
Milk chocolate drink		
Milk concentrated skim		
Milk concentrated whole	0.00080	0.02500
Milk other whole milk products		
Milk partly skimmed 2%		
Milk skim		
Milk standard		
Milk sweetened concentrated skim		
Milkshake		
Powder buttermilk		
Powder skim milk		
Powder whey		
Sherbet		
Yogurt		
Cereal products		
Oatmeal and rolled oats		
Peanuts	0.00400	0.02273
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		
Juice grape		
Juice tomato		
Juice fruit		
Juice grapefruit		
Juice lemon		
Juice orange		
Juice pineapple		
Juice vegetable		
Soft drinks		
Tea		
Water bottled		
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	Moderate	• Ten recent Canadian studies identified (BC, AB, SK, ON, PQ, PEI, NV) with similar low average levels. Mean and maximum concentrations in agricultural areas are a magnitude higher than predominately non-agricultural areas.
Indoor air	Very Low	• No Canadian studies identified. Data from a US study (Cape Cod, MA) reported a maximum of 0.11 µg/m³ at 1 of 90 sample sites. This value is used to calculate maximum risk, but quality of this estimate is very low.
Indoor dust	Very Low	• No recent Canadian data or studies identified using appropriately accurate analytical methods. Data from a US study (Cape Cod, MA) report lindane detected in 40% of samples (n=119).
Drinking water	Very Low	• Lindane was not measured in the Ontario Drinking Water Surveillance Program in 2009. In 2006, it was not detected in any samples of treated water (n=76) or water in the distribution system (n=1). The detection limit was 0.001 µg/L. One study from Alberta measured a maximum level of 0.0026 µg/L.
Food and beverages	Very Low	• No Canadian data on concentrations of lindane in foods and beverages were identified. Data from the US-FDA (TDS-2003-2004) were used for this estimate.