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HUMAN EXPOSURE TO HARMFUL SUBSTANCES

CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

Canada

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CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

HUMAN EXPOSURE TO HARMFUL SUBSTANCES

October 2023

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Human exposure to harmful substances

Chemical substances are present in air, soil, water, products and food. Humans are exposed to chemicals in many ways, including inhalation, ingestion and skin contact. For some of these substances exposure, even in small amounts, can be hazardous to both humans and wildlife. Mercury and its compounds, lead, inorganic cadmium compounds and bisphenol A (BPA) are listed as toxic substances under the *Canadian Environmental Protection Act, 1999*. These indicators present the average concentrations of mercury, lead, cadmium and BPA in the Canadian population.

Summary

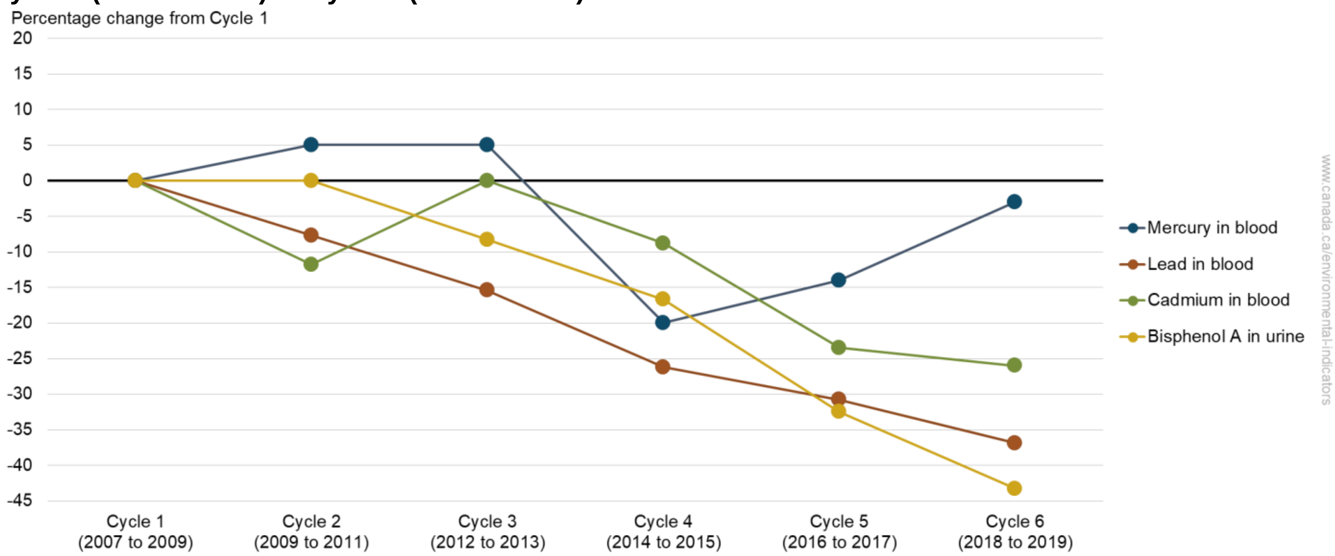
Key results

The Canadian Health Measures Survey has conducted over a decade of national biomonitoring between 2007 and 2019, with data collected in two-year cycles or collection periods.

Biomonitoring data collected between Cycle 1 (2007 to 2009) and Cycle 6 (2018 to 2019) showed that the average concentrations in the Canadian population of:

- bisphenol A (BPA), lead and cadmium generally decreased
- mercury remained relatively unchanged

Figure 1. Changes in the average concentrations of selected substances in the Canadian population, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)



Data for Figure 1

Note: The chart presents the percentage change in the average (geometric mean) concentrations of selected substances in the Canadian population relative to Cycle 1 (2007 to 2009). The concentrations of lead and cadmium in blood and bisphenol A in urine are from participants aged 6 to 79 years, mercury in blood are from participants aged 20-79 years. These averages do not include children under the age of 6 years, as they were not included in the Cycle 1 survey. For mercury, averages do not include data from the age group 6-19, due to poor detection of mercury in some younger age groups affecting the ability to calculate geometric means for the total population (i.e. more than 40% of samples were below the limit of detection when including children aged 6-19 years).
Source: Health Canada (2021b) Mercury in Canadians. Health Canada (2021c) Lead in Canadians. Health Canada (2021d) Cadmium in Canadians. Health Canada (2021e) Bisphenol A (BPA) in Canadians.

Between Cycle 1 (2007-2009) and Cycle 6 (2018-2019):

- average concentrations of mercury in blood remained relatively unchanged in the Canadian population[1]
- average concentrations of lead in blood showed a declining trend[2] with a decrease of 37%
    - average blood lead concentrations declined by 83% since 1978 to 1979[3]
- average concentrations of cadmium in blood showed a declining trend with a decrease of 26%
- average concentrations of BPA in urine showed a declining trend with a decrease of 43%

Mercury

Mercury is widespread in the environment. It is a naturally occurring metal that can be emitted by natural processes (like forest fires, melting permafrost, volcanic activity and soil and rock erosion) and is also released by many industrial processes, such as chemical manufacturing operations, metal mining and coal combustion. It can travel long distances in the atmosphere and settles everywhere in Canada, including sensitive areas such as the Canadian Arctic and the Great Lakes.

Mercury emissions are both a national and a global concern and can have significant negative impacts on human health and the environment. Mercury is toxic to humans and persists in the environment and accumulates in food chains over time. It therefore poses a particular risk to populations, like the northern and Indigenous communities, who rely heavily on the consumption of predatory fish, such as freshwater trout or Arctic char, and traditional food items, including marine mammals.

Mercury exists in 3 forms: elemental mercury, inorganic mercury compounds and organic mercury compounds, such as methylmercury. Humans are exposed to methylmercury primarily through consumption of contaminated fish and seafood. Marine mammals or fish that are long-lived and feed on other fish can accumulate high levels of methylmercury. To a much lesser extent, the general population is also exposed to inorganic mercury from improper disposal of products containing mercury such as switches, batteries, thermometers and fluorescent lamps and from the use of dental amalgam.

The human health effects depend on various factors, such as the form and amount of mercury encountered, the length of exposure, and the age of the person exposed. Oral exposure to organic mercury compounds, such as methylmercury, can cause neurological damage and developmental neurotoxicity. Exposure of a fetus or young child to organic mercury can affect the development of the nervous system, including fine-motor function, attention, verbal learning and memory. High exposure to inorganic mercury can cause damage to the gastrointestinal tract and kidneys. Exposure to elemental mercury inhaled as mercury vapour may cause adverse neurological, respiratory and kidney effects.

Mercury is listed on the Toxic substances list (Schedule 1) of the *Canadian Environmental Protection Act, 1999*. It is also subject to numerous federal risk management initiatives directed towards consumer products, cosmetics, drinking water, food, therapeutic products and environmental media, including water and air.

Key results

Over the 6 cycles (2007 to 2019) of the Canadian Health Measures Survey, the average concentrations of mercury (measured as total mercury comprising of both organic and inorganic mercury) in the blood of the Canadian population aged 20 to 79:

- remained relatively unchanged[1]
- were similar in females and males

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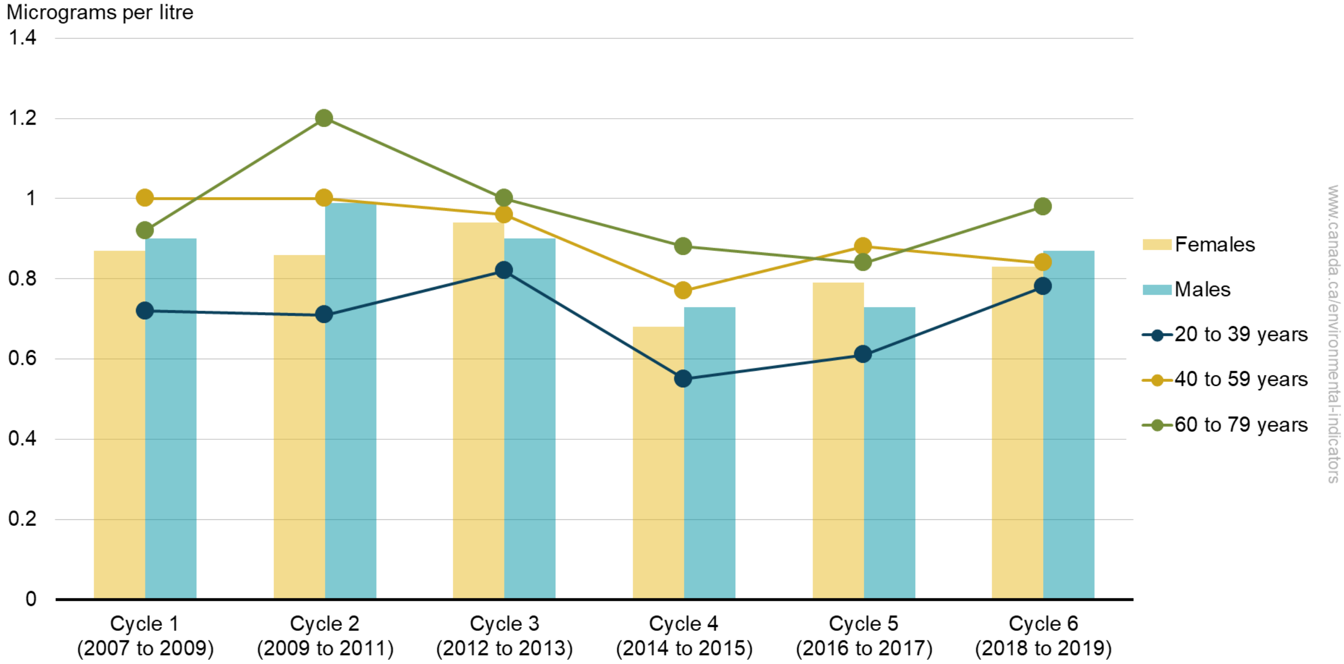
[1] A statistical analysis of the biomonitoring data from Cycle 1 to Cycle 6 for mercury did not show a trend. A percentage increase between Cycle 1 and Cycle 6 was calculated only when there was a statistically meaningful trend. For more information on this analysis, refer to the Data sources and methods.

[2] The declining trends for lead, cadmium and BPA are based on a statistical analysis of the biomonitoring data from Cycle 1 to Cycle 6. For more information on this analysis, refer to the Data sources and methods.

[3] The geometric mean was 47.9 micrograms per litre among people aged 6 to 79 years in 1978 to 1979 (Bushnik et al. 2010).

Figure 2. Average concentration of mercury in blood in the Canadian population, aged 20 to 79, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)



[Data for Figure 2]

Note: Average refers to geometric mean. Averages based on ages 3-19 are not presented as they are not consistently available for all cycles (i.e. geometric means could not be calculated for certain child age groups as either data were not available (3-5 years, cycle 1) or more than 40% of the samples were below the limit of detection for certain child age groups (6-11, and 12-19 years, cycles 3 and 4). Due to poor detection in younger age groups preventing the calculation of geometric means for the total population by sex, averages for males and females are also presented for ages 20-79 years only. Mercury is shown as total mercury (organic and inorganic).
Source: Health Canada (2021b) Mercury in Canadians.

Concentrations of mercury in blood remained relatively unchanged in the Canadian population between Cycle 1 (2007-2009) and Cycle 6 (2018-2019).

Adults aged 40 to 59 years and 60 to 79 years have consistently presented higher average concentrations of mercury than those aged 20-39 years due to mercury accumulation in the body.

Average concentrations of mercury in the blood of the Canadian population were similar between females and males.

Lead

Lead is a naturally occurring element found in rock, water and soil that can be released during natural processes, such as weathering, rock and soil erosion and volcanic activity. It is used in the refining and manufacturing of products such as lead acid car batteries, lead shot and fishing weights, sheet lead, solder, some brass and bronze products, pipes, paints and some ceramic glazes. Lead can be deposited on land or water surfaces and then build up in soils, sediments, humans and wildlife.

Exposure to lead, even in small amounts, can be hazardous to both humans and wildlife. Exposure to trace amounts of lead occurs through soil, household dust, consumer products, food, drinking water and air because of its natural abundance in the environment and its widespread use for much of the 20th century. In humans, exposure to very high levels of lead may result in vomiting, diarrhea, convulsions, coma and death. Chronic exposure to relatively low levels of lead may affect the central and peripheral nervous systems, blood pressure, and renal function and may result in reproductive problems and developmental neurotoxicity.

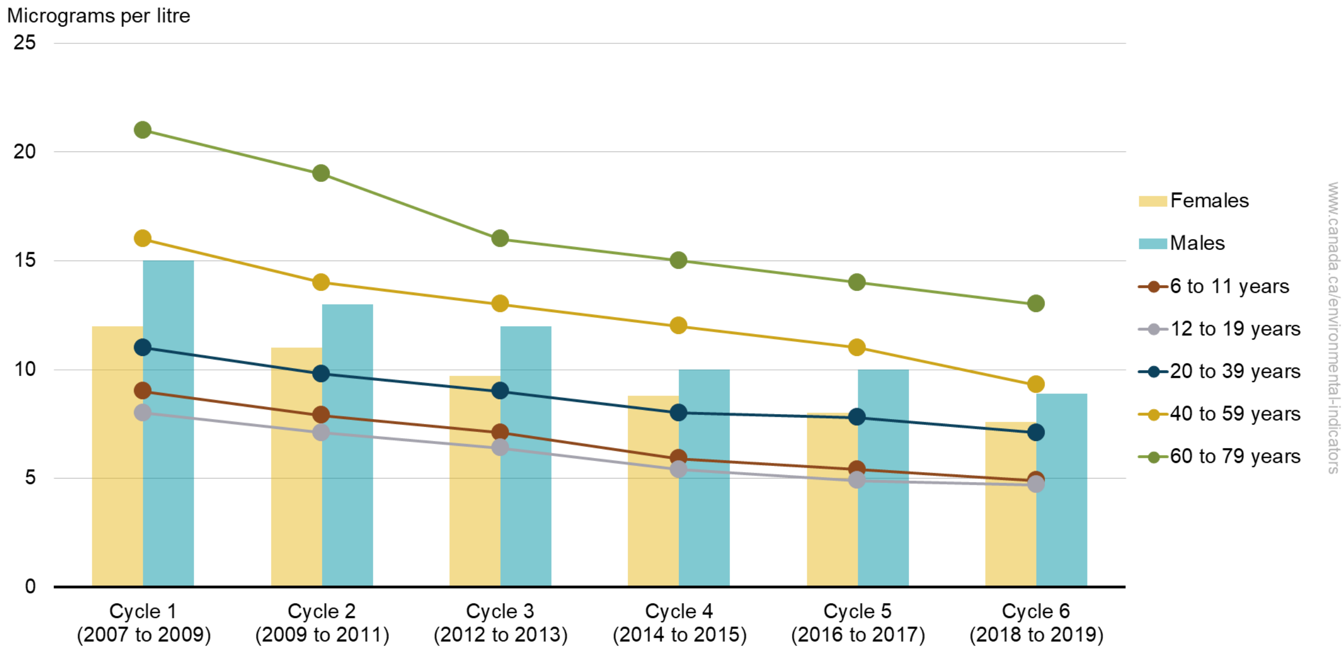
Lead is listed on the Toxic substances list (Schedule 1) of the *Canadian Environmental Protection Act, 1999*. It is also subject to numerous federal risk management initiatives directed towards consumer products, cosmetics, drinking water, food, natural health products, therapeutic products, tobacco and environmental media, including household dust, soil, and air.

Key results

Over the 6 cycles (2007 to 2019) of the Canadian Health Measures Survey, the average concentrations of lead in the blood of the Canadian population, aged 6 to 79:

- showed a declining trend,[4] with a decrease of 37% between Cycle 1 and Cycle 6
- were lower in children than in adults
- were highest in adults aged 60 to 79 years
- were higher in males than in females

Figure 3. Average concentration of lead in blood in the Canadian population, aged 6 to 79, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)



Data for Figure 3

Note: Average refers to geometric mean. Averages based on ages 3-5 are not presented as children aged 3-5 years were not included in cycle 1.
Source: Health Canada (2021c) Lead in Canadians.

Adults aged 60 to 79 years consistently presented the highest concentrations of lead due to accumulation in teeth and bones over time. Children could be more vulnerable to exposure because of their hand-to-mouth behaviour, which increases their exposure to lead from dust and soil.

On average, males have greater concentrations of lead in their blood than females. This may be due in part to males having a higher volume of red blood cells, to which lead binds in the body.

Lead exposure in Canada has decreased by approximately 83% over the past 45 years.[5] This decrease is largely attributed to the phase-out of leaded gasoline, restrictions on the use of lead in consumer paints and other coatings on children's products, and elimination of lead solder in food cans.

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[4] The declining trend for lead was based on a statistical analysis of the biomonitoring data from Cycle 1 to Cycle 6. For more information on this analysis, refer to the Data sources and methods.

[5] Bushnik et al. (2010) Lead and bisphenol A concentrations in the Canadian population. Health Report (3):7-18.

Cadmium

Cadmium is a naturally occurring metal found in the Earth's crust that can be released into the environment as a result of natural processes, including forest fires, volcanic emissions, and weathering of soil and bedrock. It is used in batteries and in electroplating to protect other metals from corrosion. It may be released directly into the environment from human activities such as non-ferrous smelting and refining, and fuel consumption for electricity generation or heating. Inhalation of cigarette smoke is a major source of cadmium exposure in people who smoke. People who do not smoke are exposed to cadmium through food, breathing in second-hand smoke, and, for some, occupational exposure. Other minor sources of exposure include drinking water, soil or dust, as well as inhalation and releases from consumer products.

Exposure to cadmium can be hazardous to both humans and wildlife since it accumulates in the food chain over time. In humans, exposure to cadmium has been associated with gastrointestinal irritation and harmful effects to the kidneys and lungs. Cadmium and its compounds have been classified by Environment and Climate Change Canada and Health Canada as a probable carcinogen in humans when inhaled.

Inorganic cadmium compounds are listed on the Toxic substances list (Schedule 1) of the *Canadian Environmental Protection Act, 1999*. It is also subject to a number of federal risk management initiatives directed towards consumer products, cosmetics, drinking water, food and environmental media, including water and air.

Key results

Over the 6 cycles (2007 to 2019) of the Canadian Health Measures Survey, the average concentrations of cadmium in the blood of the Canadian population aged 6 to 79:[6]

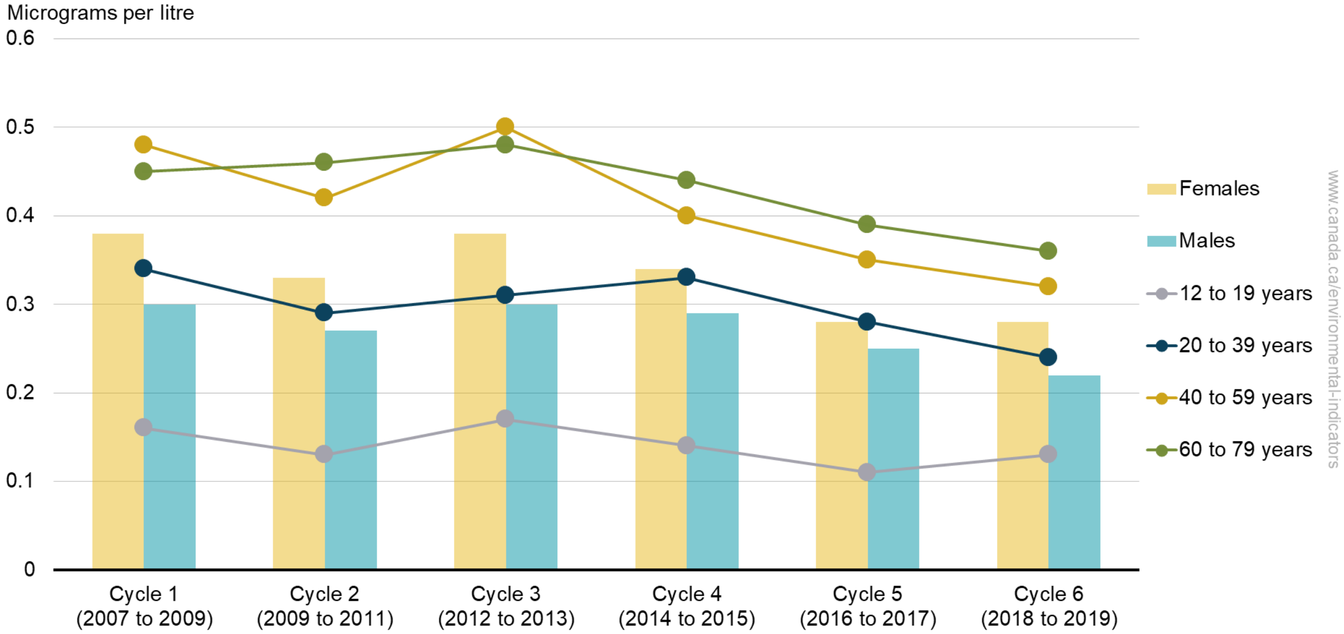
- showed a declining trend[7] in the total population, with a decrease of 26% between Cycle 1 and Cycle 6
- were highest in adults aged 40 to 59 years and 60 to 79 years[8]
- were higher in females than in males

[6] Averages for the age groups 3 to 5 years are not presented as the data were not collected in cycle 1 and therefore not consistently available for all cycles.

[7] The declining trend for cadmium was based on a statistical analysis of the biomonitoring data from Cycle 1 to Cycle 6. For more information on this analysis, refer to the Data sources and methods.

[8] Averages for the age group 6 to 11 years are not presented as more than 40% of the samples were below the limit of detection for the age group in cycles 5 and 6 preventing the generation of geometric means.

Figure 4. Average concentration of cadmium in blood in the Canadian population, aged 6 to 79, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)



Data for Figure 4

Note: Average refers to geometric mean. Averages for the age groups 3 to 5 and 6 to 11 years are not presented as the data were not available for 3-5 years in cycle 1 and more than 40% of the samples were below the limit of detection for the age group 6-11 years in cycles 5 and 6 preventing the generation of geometric means. Averages by sex (males and females) cover population aged 6-79 years.
Source: Health Canada (2021d) Cadmium in Canadians.

Adults aged 40 to 59 years and 60 to 79 years consistently had the highest average concentrations of cadmium. Cadmium has a biological half-life (the time it takes to reduce the concentration by half) of about 10 to 12 years in the kidney and accumulates with age.

Females on average have greater concentrations of cadmium in their blood than males. This is due in part to the average rate of gastrointestinal absorption of dietary cadmium. The gastrointestinal absorption rate in females is estimated to be 10% or higher, while in males it is estimated to be 5%.

Bisphenol A

Bisphenol A (BPA) is a synthetic chemical found in food packaging and repeat-use plastic containers; it migrates from the packaging into food and drinks. Exposure can also occur from epoxy resins, thermal paper coatings (such as receipts and airline tickets), air, drinking water, soil, dust and the use of consumer products. The Government of Canada has concluded that current dietary exposure to BPA through food packaging is not expected to pose a health risk to the general population, including newborns and infants.

BPA can have negative impacts on human health and the environment and is known as a hormone disruptor and can adversely affect the liver, the kidneys and reproduction, including fertility and development, in humans and wildlife. Although dietary exposure to BPA through food packaging is not expected to pose a health risk to the Canadian population, a precautionary approach has been taken to limit exposure of infants and newborns to BPA from food packaging. As part of these efforts, BPA has been prohibited in baby bottles sold in Canada since 2010.

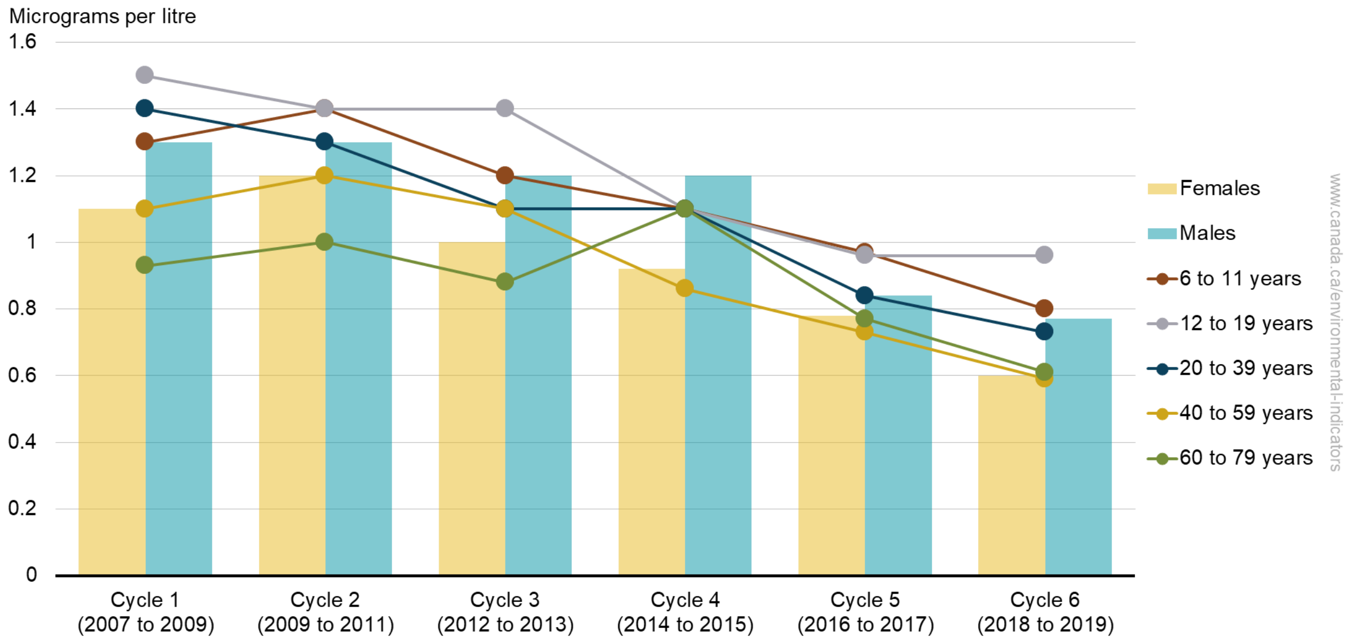
BPA is listed on the Toxic substances list (Schedule 1) of the *Canadian Environmental Protection Act, 1999* and is subject to federal risk management initiatives directed towards cosmetics, foods and industrial effluents.

Key results

Over the 6 cycles (2007 to 2019) of the Canadian Health Measures Survey, the average concentrations of BPA in the urine of the Canadian population aged 6 to 79[9]:

- showed a declining trend[10] in the total population, with a decrease of 43% between Cycle 1 and Cycle 6
- were higher in children than in adults
- were similar between females and males

Figure 5. Average concentration of bisphenol A in urine in the Canadian population, aged 6 to 79, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)



Data for Figure 5

Note: Average refers to geometric mean. Averages based on ages 3-5 are not presented as children aged 3-5 years were not included in cycle 1.
Source: Health Canada (2021e) Bisphenol A (BPA) in Canadians.

The average concentration of BPA was lower in adults aged 40 to 59 years and 60 to 79 years and higher in the younger age groups.

About the indicators

What the indicators measure

These indicators present the concentrations of 4 substances (mercury, lead, cadmium and bisphenol A) in the Canadian population for the 6 survey cycles from 2007 to 2019 based on data collected as part of the Canadian Health Measures Survey. These substances were chosen from the Canadian Health Measures Survey because they complement other indicators from the Canadian Environmental Sustainability Indicators program. For each substance, the concentration in blood or urine is provided by age group and by sex when data are available.

[9] Averages for the age groups 3 to 5 years are not presented as the data were not collected in cycle 1 and therefore not consistently available for all cycles.

[10] The declining trend for BPA was based on a statistical analysis of the biomonitoring data from Cycle 1 to Cycle 6. For more information on this analysis, refer to the Data sources and methods.

Why these indicators are important

Chemical substances are everywhere, including in the air, soil, water, products and food, and can enter the body through ingestion, inhalation and skin contact. Mercury and its compounds, lead, inorganic cadmium compounds and bisphenol A are on the Toxic substances list under Schedule 1 of the *Canadian Environmental Protection Act, 1999*. This means that these substances are "entering or may enter the environment in a quantity or concentration or under conditions that (a) have or may have an immediate or long-term harmful effect on the environment or its biological diversity; (b) constitute or may constitute a danger to the environment on which life depends; or (c) constitute or may constitute a danger in Canada to human life or health."

The Government of Canada uses a variety of methods, tools and models to assess human exposure to environmental chemicals and their potential health effects. Human exposure to chemicals can be estimated indirectly by measuring chemicals in the environment, food or products, or directly by biomonitoring. The Canadian Health Measures Survey measures environmental chemicals and/or their metabolites in blood and urine of participants. These indicators provide a snapshot of the survey results.

Through biomonitoring, the government can identify priorities, develop or revise risk management strategies, and track progress on policies put in place to reduce or control these substances.

Related initiatives

These indicators support the measurement of progress towards the following 2022 to 2026 Federal Sustainable Development Strategy Goal 12: Reduce waste and transition to zero-emission vehicles.

In addition, the indicators contribute to the Sustainable Development Goals of the 2030 Agenda for Sustainable Development. They are linked to Goal 12, Responsible consumption and production and Target 12.4, "By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment."

Related indicators

The Air pollutant emissions indicators track emissions from human activities of 6 key air pollutants: sulphur oxides (SO_X), nitrogen oxides (NO_X), volatile organic compounds (VOCs), ammonia (NH_3), carbon monoxide (CO) and fine particulate matter ($PM_{2.5}$). Black carbon, which is a component of $PM_{2.5}$, is also reported. For each air pollutant, data are provided at the national, provincial/territorial and facility level and by major source.

The Emissions of harmful substances to air indicators track human-related emissions to air of 3 toxic substances, namely mercury, lead and cadmium, and their compounds. For each substance, data are provided at the national, provincial/territorial and facility level and by source. Global emissions to air are also provided for mercury.

The Releases of harmful substances to water indicators track human-related releases to water of 3 toxic substances, namely mercury, lead and cadmium, and their compounds. For each substance, data are provided at the national, provincial/territorial and facility level and by source.

Data sources and methods

Data sources

These indicators are based on data from Health Canada's reports on Human Biomonitoring of Environmental Chemicals in Canada. The reports provide results from the Canadian Health Measures Survey (the survey). The survey started in 2007 and data are collected in 2-year cycles.

More information

Statistics Canada, in partnership with Health Canada and the Public Health Agency of Canada, launched the survey to collect national-level data on important indicators of the Canadian population’s health status, including those pertaining to environmental chemical exposure. The survey is representative of approximately 96% of the Canadian population aged 6 to 79 years (Cycle 1) and 3 to 79 years (Cycle 2 to Cycle 6).

Table 1. Characteristics of the Canadian Health Measures Survey cycles

Cycle	Temporal coverage	Spatial coverage	Sample size	Age of participants in the sample
Cycle 1	March 2007 to February 2009	15 sites across Canada	5 604	6 to 79 years
Cycle 2	August 2009 to November 2011	18 sites across Canada	6 395	3 to 79 years
Cycle 3	January 2012 to December 2013	16 sites across Canada	5 785	3 to 79 years
Cycle 4	January 2014 to December 2015	16 sites across Canada	5 794	3 to 79 years
Cycle 5	January 2016 to December 2017	16 sites across Canada	5 786	3 to 79 years
Cycle 6	January 2018 to December 2019	16 sites across Canada	5 797	3 to 79 years

Source: Health Canada (2010) Report on Human Biomonitoring of Environmental Chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 1 (2007-2009). Health Canada (2013) Second Report on Human Biomonitoring of Environmental Chemicals. Results of the Canadian Health Measures Survey Cycle 2 (2009-2011). Health Canada (2015) Third Report on Human Biomonitoring of Environmental Chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 3 (2012-2013). Health Canada (2017) Fourth Report on Human Biomonitoring of Environmental Chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 4 (2014-2015). Health Canada (2019) Fifth Report on Human Biomonitoring of Environmental Chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 5 (2016-2017). Health Canada (2021a) Sixth Report on Human Biomonitoring of Environmental Chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 6 (2018-2019).

The collection sites (Table 2) were selected from within the 5 standard regional boundaries used by Statistics Canada (Atlantic, Quebec, Ontario, Prairies and British Columbia). The collection sites varied between each survey cycle. The survey design does not target specific exposure scenarios, meaning that participants are not selected or excluded on the basis of their potential for low or high exposures to environmental chemicals.

Table 2. Collection sites of the Canadian Health Measures Survey, Canada, 2007 to 2019

Cycle	Atlantic	Quebec	Ontario	Prairies	British Columbia
Cycle 1 (2007 to 2009)	Moncton, New Brunswick	Montérégie Montréal Québec City South Mauricie	Clarington Don Valley Kitchener-Waterloo North York Northumberland County St. Catherine's-Niagara	Edmonton, Alberta Red Deer, Alberta	Vancouver Williams Lake and Quesnel
Cycle 2 (2009 to 2011)	Colchester and Pictou Counties, Nova Scotia St. John's, Newfoundland and Labrador	Gaspésie Laval North Shore Montréal South Montérégie	Central and East Ottawa East Toronto Kingston Oakville South of Brantford Southwest Toronto	Calgary, Alberta Edmonton, Alberta Winnipeg, Manitoba	Central and East Kootney Coquitlam Richmond

Cycle	Atlantic	Quebec	Ontario	Prairies	British Columbia
Cycle 3 (2012 to 2013)	Kent County, New Brunswick Halifax, Nova Scotia	South-central Laurentians Southwest Montérégie East Montréal West Montréal	Brampton Brantford-Brant County Orillia Oshawa-Whitby North Toronto Windsor	Southwest Calgary, Alberta Lethbridge, Alberta	Victoria-Saanich Vancouver
Cycle 4 (2014 to 2015)	Shelburne-Argyle, Nova Scotia South Fredericton, New Brunswick	Saguenay Sainte-Hyacinthe West Laval West Montréal	Kitchener-Waterloo Leeds-Grenville North Toronto Thunder Bay West Hamilton West Toronto	Central and East Edmonton, Alberta East Regina, Saskatchewan	Kelowna Terrace-Kitimat
Cycle 5 (2016 to 2017)	Montague, Prince Edward Island Saint John, New Brunswick	Montréal Centre Rimouski Sherbrooke West Longueuil/ Boucherville	Brampton Cambridge Petawawa/Pembroke Peterborough Pickering/Ajax Toronto West	Calgary South, Alberta Humboldt, Saskatchewan	Coquitlam Trail
Cycle 6 (2018 to 2019)	Deer Lake/Pasadena, Newfoundland and Labrador Lower Sackville/Bedford, Nova Scotia	Baie-Comeau Montreal Centre Quebec Centre	London West Mississauga Northwest Ottawa Centre Owen Sound Richmond Hill Toronto Centre	Canmore/Banff, Alberta Edmonton West/St. Albert, Alberta Winnipeg Southwest, Manitoba	Nanaimo North and West Vancouver

Source: Health Canada (2010) Report on Human Biomonitoring of Environmental Chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 1 (2007-2009). Health Canada (2013) Second Report on Human Biomonitoring of Environmental Chemicals. Results of the Canadian Health Measures Survey Cycle 2 (2009-2011). Health Canada (2015) Third Report on Human Biomonitoring of Environmental Chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 3 (2012-2013). Health Canada (2017) Fourth Report on Human Biomonitoring of Environmental Chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 4 (2014-2015). Health Canada (2019) Fifth Report on Human Biomonitoring of Environmental Chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 5 (2016-2017). Health Canada (2021a) Sixth Report on Human Biomonitoring of Environmental Chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 6 (2018-2019).

Methods

Selected environmental chemicals were measured in the blood and/or urine of survey participants. For the national summary, the geometric mean of all results was calculated for each substance. The geometric mean was also calculated for results within the different age and sex groupings. A trend analysis was done to support statements regarding change over time.

More information

The geometric mean (or average) was used because it is less influenced by extreme values and provides a better estimate of central tendency compared to the arithmetic mean. It uses the product of a set of values, whereas an arithmetic mean uses the sum. The geometric mean is defined as the *n*th root of the product of *n* numbers.

For the laboratory methods used, there is a limit of detection. This is the lowest concentration of the substance that can be detected with 99% confidence. Results that fell below the limit of detection were assigned a value equal to half the limit of detection. If more than 40% of results were below the limit of detection, the geometric mean was not calculated.

There are some variations between cycles in analytical methods and limits of detection. For consistency and to ensure meaningful trend analyses across all cycles, chemical concentrations below the highest, most conservative, limit of detection (LODc) were replaced with values equal to the LODc, divided by 2.

Table 3. Limit of detection of the Canadian Health Measures Survey by chemical substance

Substance	Limit of detection Cycle 1 (micrograms per litre)	Limit of detection Cycle 2 (micrograms per litre)	Limit of detection Cycle 3 (micrograms per litre)	Limit of detection Cycle 4 (micrograms per litre)	Limit of detection Cycle 5 (micrograms per litre)	Limit of detection Cycle 6 (micrograms per litre)
Mercury	0.1	0.1	0.42	0.42	0.2	0.2
Lead	0.2	1.0	1.6	1.6	1.7	1.7
Cadmium	0.04	0.04	0.08	0.08	0.097	0.097
Bisphenol A	0.2	0.2	0.23	0.23	0.32	0.31

Source: Health Canada (2023) Canadian Biomonitoring Dashboard.

The following tables provide a summary of the data characteristics for the selected substances by survey cycle.

The sample size and detection frequency (Health Canada, 2023) are for the total population in which the chemical was measured. However, the geometric mean along with its 95% confidence interval are based on population aged 20-79 years for mercury, and 6-79 years for lead, cadmium and bisphenol A. The age ranges were chosen to enable calculation and consistent presentation of average concentrations for all cycles and to be able calculate time trends (Health Canada, 2021 b, c, d, e). Mercury is shown as total mercury (organic and inorganic). Bisphenol A (BPA) was not measured in all survey participants in Cycles 2, 4, 5 and 6. In this case, the sample size differs and is less than the total sample size for the survey.

Table 4. Characteristics of the selected substances from Cycle 1 (2007 to 2009) of the Canadian Health Measures Survey

Substance	Sample size	Detection frequency	Geometric mean (micrograms per litre)	95% confidence interval (micrograms per litre)
Mercury	5 319	n/a	0.88	0.71 to 1.1
Lead	5 319	n/a	13.0	12 to 14
Cadmium	5 319	n/a	0.34	0.31 to 0.37
Bisphenol A	5 476	n/a	1.2	1.1 to 1.3

Note: n/a = not available.

Table 5. Characteristics of the selected substances from Cycle 2 (2009 to 2011) of the Canadian Health Measures Survey

Substance	Sample size	Detection frequency	Geometric mean (micrograms per litre)	95% confidence interval (micrograms per litre)
Mercury	6 070	88.6	0.92	0.74 to 1.2
Lead	6 070	100	12	11 to 13
Cadmium	6 070	97.1	0.30	0.28 to 0.33

Bisphenol A	2 560	93.8	1.2	1.1 to 1.3

Note: Bisphenol A was measured for only a subset of the survey participants in Cycle 2.

Table 6. Characteristics of the selected substances from Cycle 3 (2012 to 2013) of the Canadian Health Measures Survey

Substance	Sample size	Detection frequency	Geometric mean (micrograms per litre)	95% confidence interval (micrograms per litre)
Mercury	5 538	71.2	0.92	0.74 to 1.1
Lead	5 538	99.8	11	10 to 12
Cadmium	5 538	94.4	0.34	0.31 to 0.37
Bisphenol A	5 670	91.7	1.1	1.0 to 1.2

Table 7. Characteristics of the selected substances from Cycle 4 (2014 to 2015) of the Canadian Health Measures Survey

Substance	Sample size	Detection frequency	Geometric mean (micrograms per litre)	95% confidence interval (micrograms per litre)
Mercury	5 498	61.5	0.70	0.60 to 0.82
Lead	5 498	99.9	9.6	9.1 to 10
Cadmium	5 497	94.9	0.31	0.30 to 0.33
Bisphenol A	2 560	91.9	1.0	0.94 to 1.1

Note: n/a = not available. Bisphenol A was measured for only a subset of the survey participants in Cycle 4.

Table 8. Characteristics of the selected substances from Cycle 5 (2016 to 2017) of the Canadian Health Measures Survey

Substance	Sample size	Detection frequency	Geometric mean (micrograms per litre)	95% confidence interval (micrograms per litre)
Mercury	4 488	81.3	0.76	0.65 to 0.89
Lead	4 517	99.7	9.0	8.4 to 9.7
Cadmium	4 517	84.8	0.26	0.24 to 0.29
Bisphenol A	2 647	81.5	0.81	0.70 to 0.93

Note: Bisphenol A was measured for only a subset of the survey participants in Cycle 5.

Table 9. Characteristics of the selected substances from Cycle 6 (2018 to 2019) of the Canadian Health Measures Survey

Substance	Sample size	Detection frequency	Geometric mean (micrograms per litre)	95% confidence interval (micrograms per litre)
Mercury	4 596	86.1	0.85	0.73 to 1.0
Lead	4 596	99.6	8.2	7.8 to 8.7
Cadmium	4 596	87.7	0.25	0.23 to 0.27
Bisphenol A	2 533	79.3	0.68	0.59 to 0.78

Note: Bisphenol A was measured for only a subset of the survey participants in Cycle 6.

Further information on survey methodology can be obtained directly from the surveys.

Trend analysis

The trend analysis was conducted using the R platform using the R survey package incorporating the survey sample weights (taking into account the unequal probability of selection into the survey as well as non-response) as described in Pollock et al (2021). All data considered in this analysis were log normally distributed; therefore, the results are based on the natural log transformation of the data. Data for each chemical were re-screened at the maximum detection limit across all cycles by applying half the highest analytical limit of detection. Chemical trends over time were evaluated using analysis of variance models that included the natural log-transformed chemical concentrations (continuous) as the dependent variable and cycle (categorical) as the predictor variable.

Recent changes

The current iteration of the indicator no longer presents concentrations for children under the age of 6. For Cycle 1, data were not available for children under the age of 6 years, as they were not included in the survey. Therefore, in order to have direct comparisons between all the cycles, averages (geometric means) do not include data for children aged 3 to 5 years.

Caveats and limitations

The Canadian Health Measures Survey (the survey) is designed to provide national-level estimates, or regional level estimates when data from multiple cycles are combined, but it does not permit further breakdown of data by collection site. In addition, the survey design does not target specific exposure scenarios and consequently does not select or exclude participants based on their potential for low or high exposures to environmental chemicals.

More information

People living on reserves or in other Indigenous settlements in the provinces, residents of institutions, full-time members of the Canadian Forces, people living in certain remote areas, and people living in areas with a low population density were excluded from the survey.

Concentrations of total mercury, lead, and cadmium in blood and total bisphenol A in urine differ between cycles, owing in part to changes in the limit of detection. These changes were accounted for in the statistical testing of trends across cycles. Chemicals may be present and detectable in a person without causing an adverse health effect. Detection of a chemical indicates that exposure has occurred. However, biomonitoring alone cannot predict the health effects, if any, that may result from exposure. Factors such as age, health status, dosage, duration, frequency and timing of exposure and toxicity of the chemical must be considered in order to predict whether adverse health effects may occur.

Biomonitoring cannot tell us the source or route of exposure. The amount of chemical measured in a person's blood or urine is representative of the total amount present in the body at a given time from all sources (air, water, soil, food and consumer products) and all routes of exposure (ingestion, inhalation, skin contact).

Resources

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Related information

Human Biomonitoring of Environmental Chemicals

Bisphenol A (BPA)

Lead

Mercury

Annex

Annex A. Data tables for the figures presented in this document

Table A.1. Data for relatively unchanged
Figure 1. Changes in the average concentrations of selected substances in the Canadian population, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)

Survey period	Mercury in blood (percentage change from Cycle 1)	Lead in blood (percentage change from Cycle 1)	Cadmium in blood (percentage change from Cycle 1)	Bisphenol A in urine (percentage change from Cycle 1)
Cycle 1 2007 to 2009	n/a	n/a	n/a	n/a
Cycle 2 2009 to 2011	5	-8	-12	0
Cycle 3 2012 to 2013	5	-15	0	-8
Cycle 4 2014 to 2015	-20	-26	-9	-17
Cycle 5 2016 to 2017	-14	-31	-24	-33
Cycle 6 2018 to 2019	-3	-37	-26	-43

Note: n/a = not available. The table presents the percentage change in the average (geometric mean) concentrations of selected substances in the Canadian population relative to Cycle 1 (2007 to 2009). The concentrations are presented in table A.2 below.
Source: Health Canada (2021b) Mercury in Canadians. Health Canada (2021c) Lead in Canadians. Health Canada (2021d) Cadmium in Canadians. Health Canada (2021e) Bisphenol A (BPA) in Canadians.

Table A.2. Data for Figure 1. Average concentrations of selected substances in the Canadian population, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)

Survey period	Mercury in blood (micrograms per litre)	Lead in blood (micrograms per litre)	Cadmium in blood (micrograms per litre)	Bisphenol A in urine (micrograms per litre)
Cycle 1 2007 to 2009	0.88	13.0	0.34	1.2
Cycle 2 2009 to 2011	0.92	12.0	0.30	1.2
Cycle 3 2012 to 2013	0.92	11.0	0.34	1.1
Cycle 4 2014 to 2015	0.70	9.6	0.31	1.0
Cycle 5 2016 to 2017	0.76	9.0	0.26	0.81
Cycle 6 2018 to 2019	0.85	8.2	0.25	0.68

Note: n/a = not available. The table presents changes in the average (geometric mean) concentrations of selected substances in the Canadian population. The concentrations of lead and cadmium in blood and bisphenol A in urine are from participants aged 6 to 79 years, and mercury in blood are from participants aged 20-79 years. These averages do not include children under the age of 6 years, as they were not included in the Cycle 1 survey. For mercury, averages do not include data from the age group 6-19, due to poor detection of mercury in children affecting the ability to calculate geometric means for the total population (i.e. more than 40% of samples were below the limit of detection when including children aged 6-19 years).
Source: Health Canada (2021b) Mercury in Canadians. Health Canada (2021c) Lead in Canadians. Health Canada (2021d) Cadmium in Canadians. Health Canada (2021e) Bisphenol A (BPA) in Canadians.

Table A.3. Figure 2. Average concentration of mercury in blood in the Canadian population, aged 20 to 79, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)

Survey period	20 to 39 years (micrograms per litre)	40 to 59 years (micrograms per litre)	60 to 79 years (micrograms per litre)	Females (micrograms per litre)	Males (micrograms per litre)
Cycle 1 2007 to 2009	0.72	1.00	0.92	0.87	0.90
Cycle 2 2009 to 2011	0.71	1.00	1.20	0.86	0.99
Cycle 3 2012 to 2013	0.82	0.96	1.00	0.94	0.90
Cycle 4 2014 to 2015	0.55	0.77	0.88	0.68	0.73
Cycle 5 2016 to 2017	0.61	0.88	0.84	0.79	0.73
Cycle 6 2018 to 2019	0.78	0.84	0.98	0.83	0.87

Note: Average refers to geometric mean. Averages based on ages 3-19 are not presented as they are not consistently available for all cycles (i.e. geometric means could not be calculated for certain child age groups as either data were not available (3-5 years, cycle 1) or more than 40% of the samples were below the limit of detection for certain child age groups (6-11, and 12-19 years, cycles 3 and 4). Due to poor detection in younger age groups preventing the calculation of geometric means for the total population by sex, averages for males and females are also presented for ages 20-79 years only. Mercury is shown as total mercury (organic and inorganic).
Source: Health Canada (2021b) Mercury in Canadians.

Table A.4. Over the 6 cycles (2007 to 2019) of the Canadian Health Measures Survey, the average concentrations of lead in the blood of the Canadian population, aged 6 to 79:

- showed a declining trend, with a decrease of 37% between Cycle 1 and Cycle 6
- were lower in children than in adults
- were highest in adults aged 60 to 79 years
- were higher in males than in females

Figure 3. Average concentration of lead in blood in the Canadian population, aged 6 to 79, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)

Survey period	6 to 11 years (micrograms per litre)	12 to 19 years (micrograms per litre)	20 to 39 years (micrograms per litre)	40 to 59 years (micrograms per litre)	60 to 79 years (micrograms per litre)	Females (micrograms per litre)	Males (micrograms per litre)
Cycle 1 2007 to 2009	9.0	8.0	11.0	16.0	21.0	12.0	15.0
Cycle 2 2009 to 2011	7.9	7.1	9.8	14.0	19.0	11.0	13.0
Cycle 3 2012 to 2013	7.1	6.4	9.0	13.0	16.0	9.7	12.0
Cycle 4 2014 to 2015	5.9	5.4	8.0	12.0	15.0	8.8	10.0
Cycle 5 2016 to 2017	5.4	4.9	7.8	11.0	14.0	8.0	10.0
Cycle 6 2018 to 2019	4.9	4.7	7.1	9.3	13.0	7.6	8.9

Note: Average refers to geometric mean. Averages based on ages 3-5 are not presented as children aged 3-5 years were not included in cycle 1.
Source: Health Canada (2021c) Lead in Canadians.

Table A.5. Over the 6 cycles (2007 to 2019) of the Canadian Health Measures Survey, the average concentrations of cadmium in the blood of the Canadian population aged 6 to 79:

- showed a declining trend in the total population, with a decrease of 26% between Cycle 1 and Cycle 6
- were highest in adults aged 40 to 59 years and 60 to 79 years
- were higher in females than in males

Figure 4. Average concentration of cadmium in blood in the Canadian population, aged 6 to 79, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)

Survey period	12 to 19 years (micrograms per litre)	20 to 39 years (micrograms per litre)	40 to 59 years (micrograms per litre)	60 to 79 years (micrograms per litre)	Females (micrograms per litre)	Males (micrograms per litre)
Cycle 1 2007 to 2009	0.16	0.34	0.48	0.45	0.38	0.30
Cycle 2 2009 to 2011	0.13	0.29	0.42	0.46	0.33	0.27
Cycle 3 2012 to 2013	0.17	0.31	0.50	0.48	0.38	0.30
Cycle 4 2014 to 2015	0.14	0.33	0.40	0.44	0.34	0.29
Cycle 5 2016 to 2017	0.11	0.28	0.35	0.39	0.28	0.25
Cycle 6 2018 to 2019	0.13	0.24	0.32	0.36	0.28	0.22

Note: Average refers to geometric mean. Averages for the age groups 3 to 5 and 6 to 11 years are not presented as the data were not available for 3-5 years in cycle 1 and more than 40% of the samples were below the limit of detection for the age group 6-11 years in cycles 5 and 6 preventing the generation of geometric means. Averages by sex (males and females) cover population aged 6-79 years.
Source: Health Canada (2021d) Cadmium in Canadians.

Table A.6. Over the 6 cycles (2007 to 2019) of the Canadian Health Measures Survey, the average concentrations of BPA in the urine of the Canadian population aged 6 to 79:

- showed a declining trend in the total population, with a decrease of 43% between Cycle 1 and Cycle 6
- were higher in children than in adults
- were similar between females and males

Figure 5. Average concentration of bisphenol A in urine in the Canadian population, aged 6 to 79, Cycle 1 (2007 to 2009) to Cycle 6 (2018 to 2019)

Survey period	6 to 11 years (micrograms per litre)	12 to 19 years (micrograms per litre)	20 to 39 years (micrograms per litre)	40 to 59 years (micrograms per litre)	60 to 79 years (micrograms per litre)	Females (micrograms per litre)	Males (micrograms per litre)
Cycle 1 2007 to 2009	1.3	1.5	1.4	1.1	0.93	1.1	1.3
Cycle 2 2009 to 2011	1.4	1.4	1.3	1.2	1.0	1.2	1.3
Cycle 3 2012 to 2013	1.2	1.4	1.1	1.1	0.88	1.0	1.2
Cycle 4 2014 to 2015	1.1	1.1	1.1	0.86	1.1	0.92	1.2
Cycle 5 2016 to 2017	0.97	0.96	0.84	0.73	0.77	0.78	0.84
Cycle 6 2018 to 2019	0.80	0.96	0.73	0.59	0.61	0.60	0.77

Note: Average refers to geometric mean. Averages based on ages 3-5 are not presented as children aged 3-5 years were not included in cycle 1.
Source: Health Canada (2021e) Bisphenol A (BPA) in Canadians.

Additional information can be obtained at:

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