



SIXTH REPORT
ON **HUMAN**
BIOMONITORING
OF **ENVIRONMENTAL**
CHEMICALS
IN **CANADA**

Results of the Canadian
Health Measures
Survey Cycle 6 (2018–2019)

December 2021



Health
Canada

Santé
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INTRODUCTION

1

These data tables present national data on concentrations of environmental chemicals in Canadians. The data were collected as part of an ongoing national direct health measures survey called the Canadian Health Measures Survey (CHMS). Statistics Canada, in partnership with Health Canada and the Public Health Agency of Canada, launched the CHMS in 2007 to collect health and wellness data and biological specimens from a nationally representative sample of Canadians. Biological specimens were analyzed for indicators of health status, chronic and infectious diseases, nutritional status and environmental chemicals.

The CHMS biomonitoring component measures many environmental chemicals and/or their metabolites in the blood and urine of survey participants. An environmental chemical can be defined as a chemical substance, either human-made or natural, that is present in the environment and to which humans may be exposed through media such as air, water, food, soil, dust or consumer products.

Data from previous cycles have been published in 5 Health Canada reports. The most recent report, the *Fifth Report on Human Biomonitoring of Environmental Chemicals in Canada*, was published in November 2019 (HC, 2019). Data from environmental chemicals measured in pooled serum collected from Canadians between 2007 and 2017 were published by Health Canada in December 2020 (HC, 2020). During the first 5 cycles, data were collected for approximately 200 environmental chemicals in individual samples and 90 environmental chemicals in pooled serum samples.

Data for cycle 6 were collected between January 2018 and December 2019 from approximately 5,700 Canadians aged 3–79 at 16 sites across Canada. Cycle 6 included 79 environmental chemicals, all of which have been measured in previous cycles.

A summary of the environmental chemicals measured in the blood and/or urine of individual respondents in the first 6 cycles of the CHMS is presented in Table 1.1.

Table 1.1

Summary of chemical groups measured in blood and/or urine of individual respondents in the Canadian Health Measures Survey between 2007 and 2019

Chemical group	Cycle 1 (2007–2009)	Cycle 2 (2009–2011)	Cycle 3 (2012–2013)	Cycle 4 (2014–2015)	Cycle 5 (2016–2017)	Cycle 6 (2018–2019)
Flame retardants	Yes	—	—	—	—	—
Organochlorines	Yes	—	—	—	—	—
Polychlorinated biphenyls	Yes	—	—	—	—	—
Chlorophenols	Yes	Yes	—	—	—	—
Per- and polyfluoroalkyl substances	Yes	Yes	—	—	Yes	Yes
Plasticizers	Yes	Yes	—	—	Yes	Yes
Polycyclic aromatic hydrocarbons	—	Yes	Yes	Yes	—	—
Acrylamide	—	—	Yes	Yes	Yes	Yes
Volatile organic compounds	—	—	Yes	Yes	Yes	—
Metals and trace elements	Yes	Yes	Yes	Yes	Yes	Yes
Self-care and consumer product chemicals	Yes	Yes	Yes	Yes	Yes	Yes
Nicotine	Yes	Yes	Yes	Yes	Yes	Yes
Pesticides	Yes	Yes	Yes	Yes	Yes	Yes

The COVID-19 outbreak delayed the collection of data for cycle 7 of the CHMS. Collection is now anticipated to begin in 2022. Planning for future cycles is underway.

This report describes the general CHMS survey design and implementation, with emphasis on the biomonitoring component. These sections are followed by descriptive summaries for each chemical, outlining the chemical's identity, common uses, occurrence in the environment, potential sources of exposure in the human population, toxicokinetics and health effects, and Canadian regulatory status. For more information on trends in chemical concentrations measured as part of the CHMS, as well as comparisons with other biomonitoring initiatives, please refer to chemical-specific biomonitoring fact sheets available on the [Human Biomonitoring Resources](#) web page.

Throughout this report, data tables specific to each chemical are provided below the relevant text. The tables are broken down by age group and sex, and contain descriptive statistics on the distribution of blood and/or urine concentrations in the Canadian population. Data from all cycles are presented together in tables for ease of comparison. For chemicals measured only in previous cycles and/or in pooled serum, data can be found in previous reports (HC, 2010; 2013; 2015; 2017; 2019; 2020). Downloadable tables are available in comma-separated values (CSV) format through the [Government of Canada's Open data portal](#).

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OBJECTIVES 2

The primary purpose of the biomonitoring component of the Canadian Health Measures Survey (CHMS) is to provide human biomonitoring data to scientists and health and environment officials to help them assess Canadians' exposure to environmental chemicals and develop policies to reduce exposure to toxic chemicals for the protection of their health.

Some specific uses of the CHMS biomonitoring data include:

- establishing baseline concentrations of chemicals in Canadians that allow for comparisons with subpopulations in Canada and with populations in other countries
- establishing baseline concentrations of chemicals to track trends in Canadians over time
- providing information for setting priorities and taking action to reduce Canadians' exposure to environmental chemicals and protect their health
- assessing the effectiveness of health and environmental risk management actions intended to reduce exposures and health risks from specific chemicals
- supporting research on the potential links between exposure to certain chemicals and specific health effects
- contributing to international monitoring programs, such as the Stockholm Convention on Persistent Organic Pollutants

SURVEY DESIGN

3

The Canadian Health Measures Survey (CHMS) was designed as a cross-sectional survey to address important data gaps and limitations in existing health information in Canada. Its principal objective is to collect national-level baseline data on important indicators of Canadians' health status, including those pertaining to exposures to environmental chemicals. This information is important in understanding exposure risk factors, detecting emerging trends in risk factors and exposures, and advancing health surveillance and research in Canada. Detailed descriptions of the CHMS rationale, survey design, sampling strategy and mobile examination centre (MEC) operations and logistics for cycle 6 have been published (Mather, 2020; StatCan, 2021).

3.1 TARGET POPULATION

Cycle 6 of the CHMS targets the population aged 3–79 living in one of the 10 provinces. The following groups were excluded from the survey: persons living in the 3 territories; persons living on reserves and other Indigenous settlements in the provinces; full-time members of the Canadian Forces; the institutionalized population; and residents of certain remote regions. Altogether, these exclusions represent approximately 3% of the target population.

Although the CHMS is not able to provide representative data for the entire Canadian population, a number of surveys and research projects are carried out in partnership with Health Canada that directly target some of these population gaps.

The First Nations Biomonitoring Initiative (FNBI) is a survey carried out by the Assembly of First Nations (AFN) and Health Canada that seeks to establish baseline biomonitoring data for First Nations people living on-reserve south of the 60° parallel (AFN, 2013). Between 2009 and 2011, the FNBI measured the levels of 97 environmental chemicals in blood and urine samples collected from 503 participants living in 13 First Nations communities across Canada. The [complete report](#) has been published by the AFN.

In addition, numerous biomonitoring studies have been undertaken in Canada's North through the Northern Contaminants Program (NCP). The NCP, which is managed by federal government departments, provincial and territorial agencies, and Indigenous organizations, was established in 1991 to respond to concerns about human exposure to contaminants in the traditional diets of Northern Indigenous peoples. The NCP provides funding for numerous individual studies undertaken in various regions of the North, including the Northwest Territories, Nunavut and Nunavik (Québec's North). More detailed information and results from these studies have been summarized in the [Canadian Arctic Contaminants Assessment Reports](#) and numerous scientific articles.

3.2 SAMPLE SIZE AND ALLOCATION

To meet the objective of producing reliable estimates at the national level by age group and sex, cycle 6 of the CHMS required a minimum sample of at least 5,700 participants over a 2-year period. The participants were distributed among age groups (3–5, 6–11, 12–19, 20–39, 40–59 and 60–79 years) and sex (except for 3–5 years), for a total of 11 groups. For the 3–5-year age group, the survey was not designed to provide estimates for the individual sexes.

3.3 SAMPLING STRATEGY

To meet the requirements of the CHMS, a multistage sampling strategy was used.

3.3.1 Sampling of collection sites

The CHMS required participants to report to a MEC and be able to travel to it within a reasonable period of time. For cycle 6, Census geography was used to create 425 collection sites across the country. A geographic area with a population of at least 10,000 and a maximum participant travel distance of 50 km in urban areas and 75 km in rural areas was required for the location of collection sites. Areas not meeting these criteria were excluded.

Including a larger number of collection sites with few respondents would have optimized the precision of the estimates. However, the logistical and cost constraints associated with the use of MECs restricted the number of collection sites to 16. The 16 collection sites were selected from within the 5 standard regional boundaries used by Statistics Canada (the Atlantic provinces, Québec, Ontario, the Prairies and British Columbia) and were allocated to these regions in proportion to population size. Although not every province in Canada had a collection site, the CHMS sites were chosen to represent the Canadian population in all 10 provinces, including larger and smaller population densities. The collection sites selected for cycle 6 of the CHMS are listed in Table 3.3.1.1.

Table 3.3.1.1

Canadian Health Measures Survey cycle 6 (2018–2019) collection sites

Atlantic	Québec	Ontario	Prairies	British Columbia
<ul style="list-style-type: none"> Deer Lake/Pasadena, NL Lower Sackville/Bedford, NS 	<ul style="list-style-type: none"> Baie-Comeau Montréal Centre Québec Centre 	<ul style="list-style-type: none"> London West Mississauga Northwest Ottawa Centre Owen Sound Richmond Hill Toronto Centre 	<ul style="list-style-type: none"> Canmore/Banff, AB Edmonton West/St. Albert, AB Winnipeg Southwest, MB 	<ul style="list-style-type: none"> Nanaimo North and West Vancouver

3.3.2 Dwelling and participant sampling

Within each site, the most recent version of Statistics Canada's Household Survey Frame and more current information from other administrative sources were used to select dwellings and identify the birth dates of household members. Dwellings with known household composition at the time of the sample selection were stratified by age of household residents at the time of the survey, with the 6 age-group strata corresponding to the CHMS cycle 6 age groups (3–5, 6–11, 12–19, 20–39, 40–59 and 60–79 years). Within each site, a simple random sample of dwellings was selected in each stratum. Each selected dwelling was then contacted and asked to provide a list of current household members; this list was used to select the survey participants. One or 2 people were selected, depending on the household composition.

3.4 SELECTION OF ENVIRONMENTAL CHEMICALS

A series of formal and informal consultations were carried out to determine the set of environmental chemicals measured in cycle 6 of the CHMS. The consultations included stakeholders with expertise or interest in human biomonitoring of environmental chemicals. Key participants were various internal Health Canada branches and programs as well as a number of external groups, including other federal departments, provincial/territorial health and environment departments, industry groups, environment and health non-governmental organizations and academics.

The following criteria were used as general guides for identifying and selecting the environmental chemicals to include in the CHMS:

- seriousness of known or suspected health effects related to the substance
- need for public health actions related to the substance
- level of public concern about exposures and possible health effects related to the substance
- evidence of exposure of the Canadian population to the substance
- feasibility of collecting biological specimens in a national survey and associated burden on survey participants
- availability and efficiency of laboratory analytical methods
- costs of performing the test
- parity of selected chemicals with other national and international surveys and studies
- known data gaps
- commitments under national and international treaties, conventions and agreements
- current and anticipated health policy development and implementation
- volume of biospecimens available from survey

A full list of the chemicals measured in the blood and/or urine of individual respondents in CHMS cycle 6 is presented in Table 3.4.1.

Table 3.4.1

Environmental chemicals measured in blood and/or urine of individual respondents in the Canadian Health Measures Survey cycles 1 to 6 (2007–2019)

Chemical	Cycle 1 (2007–2009)	Cycle 2 (2009–2011)	Cycle 3 (2012–2013)	Cycle 4 (2014–2015)	Cycle 5 (2016–2017)	Cycle 6 (2018–2019)
Metals and trace elements						
Lead	Yes	Yes	Yes	Yes	Yes	Yes
Boron	—	—	—	—	Yes	Yes
Cadmium	Yes	Yes	Yes	Yes	Yes	Yes
Chromium (VI) ^a	—	—	—	—	Yes	Yes
Selenium	Yes	Yes	—	—	Yes	Yes
Arsenic (speciated)						
Inorganic-related arsenic species	—	Yes	Yes	Yes	Yes	Yes
Arsenite	—	Yes	Yes	Yes	Yes	Yes
Arsenate	—	Yes	Yes	Yes	Yes	Yes
Monomethylarsonic acid (MMA)	—	Yes	Yes	Yes	Yes	Yes
Dimethylarsinic acid (DMA)	—	Yes	Yes	Yes	Yes	Yes
Arsenocholine and arsenobetaine	—	Yes	Yes	Yes	Yes	Yes
Mercury						
Mercury (total)	Yes	Yes	Yes	Yes	Yes	Yes
Methylmercury	—	—	Yes	Yes	Yes	Yes
Mercury (inorganic)	Yes	—	Yes	Yes	Yes	Yes
Self-care and consumer product chemicals						
Bisphenol A (BPA)	Yes	Yes	Yes	Yes	Yes	Yes
Parabens						
Methyl paraben	—	—	Yes	Yes	Yes	Yes
Ethyl paraben	—	—	Yes	Yes	Yes	Yes
Propyl paraben	—	—	Yes	Yes	Yes	Yes
Butyl paraben	—	—	Yes	Yes	Yes	Yes
Nicotine						
Cotinine	Yes	Yes	Yes	Yes	Yes	Yes
Acrylamide						
Acrylamide haemoglobin adduct	—	—	Yes	Yes	Yes	Yes
Glycidamide haemoglobin adduct	—	—	Yes	Yes	Yes	Yes
Per- and polyfluoroalkyl substances						
Perfluorobutanoic acid (PFBA)	—	Yes	—	—	Yes	Yes
Perfluorobutane sulfonate (PFBS)	—	Yes	—	—	Yes	Yes
Perfluorohexanoic acid (PFHxA)	—	Yes	—	—	Yes	Yes
Perfluorohexane sulfonate (PFHxS)	Yes	Yes	—	—	Yes	Yes
Perfluorooctanoic acid (PFOA)	Yes	Yes	—	—	Yes	Yes
Perfluorooctane sulfonate (PFOS)	Yes	Yes	—	—	Yes	Yes
Perfluorononanoic acid (PFNA)	—	Yes	—	—	Yes	Yes
Perfluorodecanoic acid (PFDA)	—	Yes	—	—	Yes	Yes
Perfluoroundecanoic acid (PFUnDA)	—	Yes	—	—	Yes	Yes

Chemical	Cycle 1 (2007–2009)	Cycle 2 (2009–2011)	Cycle 3 (2012–2013)	Cycle 4 (2014–2015)	Cycle 5 (2016–2017)	Cycle 6 (2018–2019)
Pesticides						
Organophosphate pesticides						
Dimethylphosphate (DMP)	Yes	Yes	—	—	Yes	Yes
Dimethylthiophosphate (DMTP)	Yes	Yes	—	—	Yes	Yes
Dimethyldithiophosphate (DMDTP)	Yes	Yes	—	—	Yes	Yes
Diethyl phosphate (DEP)	Yes	Yes	—	—	Yes	Yes
Diethylthiophosphate (DETP)	Yes	Yes	—	—	Yes	Yes
Diethyldithiophosphate (DEDTP)	Yes	Yes	—	—	Yes	Yes
Pyrethroids						
3-Phenoxybenzoic acid (3-PBA)	Yes	Yes	—	—	Yes	Yes
4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA)	Yes	Yes	—	—	Yes	Yes
<i>cis</i> -3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (<i>cis</i> -DBCA)	Yes	Yes	—	—	Yes	Yes
<i>cis</i> -3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (<i>cis</i> -DCCA)	Yes	Yes	—	—	Yes	Yes
<i>trans</i> -3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (<i>trans</i> -DCCA)	Yes	Yes	—	—	Yes	Yes
Ethylene bisdithiocarbamates						
Ethylene thiourea (ETU)	—	—	—	—	Yes	Yes
<i>ortho</i> -Phenylphenol (OPP)						
OPP-glucuronide	—	—	—	—	Yes	Yes
OPP-sulfate	—	—	—	—	Yes	Yes
Plasticizers						
Phthalates						
Monomethyl phthalate (MMP)	Yes	Yes	—	—	Yes	Yes
Monoethyl phthalate (MEP)	Yes	Yes	—	—	Yes	Yes
Mono-3-carboxypropyl phthalate (MCPP)	Yes	Yes	—	—	Yes	Yes
Mono- <i>n</i> -butyl phthalate (MnBP)	Yes	Yes	—	—	Yes	Yes
Monoisobutyl phthalate (MiBP)	—	Yes	—	—	Yes	Yes
Mono-3-hydroxy- <i>n</i> -butyl phthalate (3OH-MBP)	—	—	—	—	Yes	Yes
Monocyclohexyl phthalate (MCHP)	Yes	Yes	—	—	Yes	Yes
Monobenzyl phthalate (MBzP)	Yes	Yes	—	—	Yes	Yes
Mono[2-(carboxymethyl)hexyl] phthalate (MCMHP)	—	—	—	—	Yes	Yes
Mono-2-ethylhexyl phthalate (MEHP)	Yes	Yes	—	—	Yes	Yes
Mono-(2-ethyl-5-carboxypentyl) phthalate (MECPP)	—	—	—	—	Yes	Yes
Mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP)	Yes	Yes	—	—	Yes	Yes
Mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP)	Yes	Yes	—	—	Yes	Yes
Mono-carboxy- <i>n</i> -heptyl phthalate (MCHpP)	—	—	—	—	Yes	Yes
Mono- <i>n</i> -octyl phthalate (MOP)	Yes	Yes	—	—	Yes	Yes
Mono-(carboxyisooctyl) phthalate (MCIOP)	—	—	—	—	Yes	Yes
Monoisononyl phthalate (MiNP)	Yes	Yes	—	—	Yes	Yes
Monocarboxyisononyl phthalate (MCIiNP)	—	—	—	—	Yes	Yes
Monooxoisononyl phthalate (MOiNP)	—	—	—	—	Yes	Yes
Monohydroxyisononyl phthalate (MHiNP)	—	—	—	—	Yes	Yes

Chemical	Cycle 1 (2007–2009)	Cycle 2 (2009–2011)	Cycle 3 (2012–2013)	Cycle 4 (2014–2015)	Cycle 5 (2016–2017)	Cycle 6 (2018–2019)
Monoisodecyl phthalate (MiDP)	—	—	—	—	Yes	Yes
Monooxoisodecyl phthalate (MOiDP)	—	—	—	—	Yes	Yes
Monohydroxyisodecyl phthalate (MHiDP)	—	—	—	—	Yes	Yes
Di(isononyl)cyclohexane-1,2-dicarboxylate (DINCH)						
<i>trans</i> -Cyclohexane-1,2-dicarboxylic mono isononyl ester (<i>trans</i> -MINCH)	—	—	—	—	Yes	Yes
Cyclohexane-1,2-dicarboxylic mono oxoisononyl ester (oxo-MINCH)	—	—	—	—	Yes	Yes
Cyclohexane-1,2-dicarboxylic mono hydroxyisononyl ester (OH-MINCH)	—	—	—	—	Yes	Yes
<i>cis</i> -Cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (<i>cis</i> -cx-MINCH)	—	—	—	—	Yes	Yes
<i>trans</i> -Cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (<i>trans</i> -cx-MINCH)	—	—	—	—	Yes	Yes
Cyclohexane-1,2-dicarboxylic acid (CHDA)	—	—	—	—	Yes	Yes
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate (TXIB)						
2,2,4-Trimethyl-1,3-pentanediol (TMPD)	—	—	—	—	Yes	Yes
2,2,4-Trimethyl-3-hydroxy valeric acid (HTMV)	—	—	—	—	Yes	Yes
Tri-(2-ethylhexyl) trimellitate (TEHT)						
1-Mono(2-ethylhexyl)trimellitate (1-MEHTM)	—	—	—	—	Yes	Yes
2-Mono(2-ethylhexyl)trimellitate (2-MEHTM)	—	—	—	—	Yes	Yes
4-Mono(2-ethylhexyl)trimellitate (4-MEHTM)	—	—	—	—	Yes	Yes

a Chromium (VI) was measured indirectly as total chromium in red blood cells.

Owing to the high cost of laboratory analyses, some environmental chemicals were not measured for all CHMS participants in cycle 6. The majority of the environmental chemicals were measured in a target subsample of approximately 2,500 participants aged 3–79 (Table 3.4.2), with the following exceptions: lead, cadmium, total mercury and selenium in blood were measured in approximately 4,500 participants; methylmercury and inorganic mercury were measured

only in participants aged 3–19; cotinine in urine was measured in participants aged 6–79; and cotinine in serum was measured in all participants aged 6–79. Further details on the subsampling for environmental chemicals are available in the *Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 6* (StatCan, 2021) and in *Sampling documentation for cycle 6 of the Canadian Health Measures Survey* (Mather, 2020).

Table 3.4.2
Environmental chemicals and chemical groups measured by age group

Measure	Matrix	Target sample size	Age (years)					
			3–5	6–11	12–19	20–39	40–59	60–79
Metals and trace elements	Blood	4,500	Yes	Yes	Yes	Yes	Yes	Yes
Boron and cadmium	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Chromium (VI) ^a	Red blood cells	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Arsenic (speciated)	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Methylmercury and inorganic mercury	Blood	1,500	Yes	Yes	Yes	—	—	—
Bisphenol A (BPA)	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Parabens	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Cotinine	Urine	2,500	—	Yes	Yes	Yes	Yes	Yes
Cotinine	Serum	5,100	—	Yes	Yes	Yes	Yes	Yes
Acrylamide	Blood	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Per- and polyfluoroalkyl substances	Plasma	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Organophosphate pesticides	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Pyrethroids	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Ethylene thiourea (ETU)	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes
<i>ortho</i> -Phenylphenol (OPP)	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Phthalates	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes
Di(isononyl)cyclohexane-1,2-dicarboxylate (DINCH) and tri-(2-ethylhexyl) trimellitate (TEHT)	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate (TXIB)	Urine	2,500	Yes	Yes	Yes	Yes	Yes	Yes

a Chromium (VI) was measured indirectly as total chromium in red blood cells.

3.5 ETHICAL CONSIDERATIONS

Personal information collected through the CHMS is protected under the federal *Statistics Act* (Canada, 1970-71-72). Under the act, Statistics Canada is obliged to safeguard and keep in trust the information it obtains from the Canadian public. Consequently, Statistics Canada has established a comprehensive framework of policies, procedures and practices to protect confidential information against loss, theft, unauthorized access, disclosure, copying or use; this includes physical, organizational and technological measures. The steps taken by Statistics Canada to safeguard the information collected in the CHMS have been described previously (Day et al., 2007).

Ethics approval for all components of the CHMS was obtained from the Health Canada and Public Health Agency of Canada Research Ethics Board. Informed written consent for the MEC portion of the CHMS was obtained from participants older than age 14. For younger children, a parent or legal guardian provided written consent, and children aged 6–13 provided assent. Participation in this survey was voluntary, and participants could opt out of any part of the survey at any time.

A strategy was developed to communicate results to survey participants with the advice and expert opinion of the CHMS Laboratory Advisory Committee, the Physician Advisory Committee, l'Institut national de santé publique du Québec (the reference laboratory performing some of the environmental chemical analyses) and Health Canada's Research Ethics Board (Day et al., 2007). For the environmental chemicals, only results for cadmium, lead and mercury were actively reported to participants from all sites. However, participants could receive all other test results upon request to Statistics Canada. More information on reporting to participants, including the ethical challenges encountered, can be found in Haines et al. (2011).

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FIELDWORK 4

Fieldwork for the Canadian Health Measures Survey (CHMS) cycle 6 took place over a period of 2 years, from January 2018 to December 2019. Data were collected sequentially at 16 sites across Canada. The sites were ordered to take into account seasonality by region and the temporal effect, subject to operational and logistical constraints.

Statistics Canada mailed advance letters and brochures to households that were selected as outlined in Section 3.3.2 of this report, Dwelling and participant sampling. The mailing informed potential participants that they would be contacted for the survey's data collection.

Data were collected from each consenting survey participant through a household personal interview, using a computer-assisted method, and through a visit to a mobile examination centre (MEC) for physical measures and biospecimen collection. The field team consisted of household interviewers and the CHMS MEC staff, including trained health professionals who performed the physical measures testing (StatCan, 2021).

Participants were first administered a household questionnaire in their homes. Using a computer application, the interviewer randomly selected 1 or 2 participants and conducted separate 45- to 60-minute health interviews (StatCan, 2019; 2021). The interviews collected demographic and socio-economic data, including information about lifestyle, medical history, current health status, smoking status, electronic cigarette use and neighbourhood environment. Participants were also informed that Statistics Canada would link the information collected during the interview to information from the tax data of all

members of their household. Within approximately 2 weeks of the home visit, participants visited the MECs. Each MEC consisted of 3 trailers linked by enclosed pedestrian walkways. One trailer was for reception and contained an administration area and an examination room; the second trailer contained a laboratory, a phlebotomy (blood collection) area and examination rooms; and the third trailer contained additional examination rooms. The MEC operated for 5 to 6 weeks at each site to complete approximately 350 visits (StatCan, 2021). MEC appointments averaged 2 hours. A parent or legal guardian accompanied children under the age of 14. To maximize response rates, participants who were unable or unwilling to go to the MEC were offered the option of a home visit by CHMS MEC staff members to perform some of the physical measures and the biospecimen collection portion of the survey; there were 2 home visits in total in cycle 6 (StatCan, 2021).

At each MEC visit, participants signed consent/assent forms prior to any testing, and in most cases provided a urine sample immediately thereafter. For logistical purposes, spot samples were collected rather than 24-hour urine samples. The urine samples were collected using first-catch urine. (To note, as an exception, mid-stream urine was collected in cycle 1.) Guidelines were provided to participants asking them to abstain from urinating 2 hours prior to their MEC visit. Samples were collected in 120 mL urine specimen containers.

Trained health professionals took physical health measurements, such as for height, weight, blood pressure and physical fitness. A series of screening questions were administered to participants to

determine their eligibility for the various tests, including phlebotomy, based on pre-existing exclusion criteria (StatCan, 2021). Blood specimens were drawn by a certified phlebotomist; the maximum amount depended upon the age of the participant and consent to storage. The approximate volumes drawn with and without consent to storage from participants 3–5 years old were 25.0 mL and 22.0 mL; 6–11 years old, 40.0 mL and 37.0 mL; 12–13 years old, 58.0 mL and 38.0 mL; 14–19 years old, 72.0 mL and 44.0 mL; and 20–79 years old, 78.0 mL and 48.0 mL.

Standardized operating procedures were developed for the collection of blood and urine specimens, the processing and aliquoting procedures and the shipping of biospecimens to ensure adequate data quality and standardize data collection. All blood and urine specimens collected in the MEC were processed and aliquoted in the MEC. Blood and urine specimens were stored in the MEC in either the refrigerator or the freezer, depending on the test. All specimens were stored as soon as processing was complete to maintain sample integrity. A 4-hour time limit from the point of collection was set for blood samples to be processed and stored; however, for most samples, this was completed within 2 hours. Given specific pre-analytical requirements for chromium (VI) in red blood cells, a time limit of 3 hours was set for processing and storing the samples. Once a week, the specimens were shipped on dry ice or in monitored refrigerated conditions to the reference laboratory for analyses. A priority sequence for laboratory analyses was established in the event that an insufficient volume of biospecimen was collected for complete analyses of the environmental chemicals as well as for analyses of infectious diseases, nutritional status and chronic diseases.

To maximize the reliability and validity of the data and reduce systematic bias, the CHMS developed quality assurance and quality control protocols for all aspects of the fieldwork. Quality assurance for the MEC covered staff selection and training, instructions to respondents (pre-testing guidelines) and issues related to data collection. All staff had appropriate education and training for their respective positions. To ensure consistent measurement techniques, procedure manuals and training guides were developed in consultation with, and reviewed by, experts in the field. Quality control samples were evaluated for each site and consisted of field blanks and blind replicates. Three field blanks (deionized water) were analyzed per site

for all analytes except acrylamide, chromium (VI) in red blood cells and cotinine in blood, and creatinine and cotinine in urine. Three pairs of blind replicates were assessed per site for all analytes. Blind controls were also evaluated for analytical methods for which the laboratory did not participate in an interlaboratory comparison program. Approximately 6 blind control samples were evaluated at every second site for cotinine in blood and for parabens, ethylene thiourea, *ortho*-phenylphenol, di(isononyl)cyclohexane-1,2-dicarboxylate (DINCH), 2,2,4-trimethyl-1,3-pentanediol diisobutyrate (TXIB) and tri-(2-ethylhexyl) trimellitate (TEHT) metabolites in urine. Approximately 3 blind control samples were evaluated at every second site for acrylamide in blood.

Field blanks were sent to the reference laboratories at the start of each site, and results were expeditiously returned directly to the laboratory coordinators at Statistics Canada. Blind replicate and blind control samples were sent to the reference laboratories with regular specimen shipments. Quality control sample results were sent to Statistics Canada's CHMS headquarters along with all other respondent results. If required, feedback was promptly provided to the relevant reference laboratory for review and remedial action.

Detailed descriptions of the CHMS MEC operations and logistics have been described previously in Bryan et al. (2007) and are presented in the *Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 6* (StatCan, 2021).

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LABORATORY ANALYSES

5

Laboratory analyses of environmental chemicals and creatinine were performed at analytical laboratories within Health Canada and at l'Institut national de santé publique du Québec (INSPQ). Laboratories developed standardized operating procedures for the analytical methods used to measure environmental chemicals or their metabolites in biological samples. Analytical accuracy and the precision of measurements were evaluated through rigorous method validation programs at each laboratory.

To ensure ongoing accuracy and precision of results, several quality control measures were employed as part of the Canadian Health Measures Survey (CHMS). Field blanks were used to confirm that samples had not been contaminated during collection, processing, storage or shipping. Blind replicate samples were used as indicators of the precision of sample analysis, while blind control samples were used as indicators of the accuracy of sample analysis. Laboratories also participated in external quality control programs and interlaboratory comparison studies, as outlined in the sections below. The methods used in the analyses of the environmental chemicals and creatinine are described below.

5.1 METALS AND TRACE ELEMENTS

5.1.1 Blood analyses

5.1.1.1 *Lead, cadmium, selenium and total mercury*

Analyses of lead, cadmium, selenium and mercury in whole blood were performed at the Centre de toxicologie du Québec (CTQ), INSPQ (INSPQ, 2018r). Briefly, whole blood samples were diluted in a basic solution containing octylphenol ethoxylate and ammonium hydroxide and analyzed for lead, cadmium, selenium and mercury using inductively coupled plasma mass spectrometry (ICP-MS). The ICP-MS method employed a Perkin Elmer Sciex Elan DRC II with an ESI SC-4 autosampler and an Elan workstation version 3.0. Matrix-matched calibration was performed using blood from non-exposed individuals. Internal quality control was ensured by analyzing 2 different reference materials from the Québec Multielement External Quality Assessment Scheme (QMEQAS) in each analysis sequence. The external quality and accuracy of the analytical method were assessed by participating in interlaboratory comparison programs, including the internal CTQ Programme de comparaisons interlaboratoires pour les métaux en milieu biologique (PCI); QMEQAS; the German External Quality Assessment Scheme (G-EQUAS); the U.S. Centers for Disease Control and Prevention's Lead and Multielement Proficiency Program; and the New York State Department of Health's Proficiency Program for Trace Elements in Whole Blood.

5.1.1.2 Chromium (VI)

Analyses of chromium (VI) in red blood cells were performed at the CTQ, INSPQ (INSPQ, 2018h). The analysis was an indirect measurement of chromium (VI) and was based on the fact that chromium (VI) is the only form of inorganic chromium that substantially penetrates cells. As such, chromium measured in red blood cells is attributed specifically to chromium (VI) exposure (Devoy et al., 2016).

Briefly, red blood cells were purified shortly after collection via a saline wash. Purified red blood cells were digested with concentrated nitric acid and hydrogen peroxide, and diluted in water to reduce viscosity and decrease the concentration of nitric acid. The samples were then analyzed using inductively coupled plasma tandem mass spectrometry (ICP-MS-MS). The ICP-MS-MS method employed an Agilent Technologies 8800 ICP-QQQ with a CETAC ASX-500 autosampler and a MassHunter 4.2 workstation version C.01.02. Terbium was used as an internal standard. Internal quality control was ensured by analyzing 3 different in-house reference materials (low, medium and high) in each analysis sequence.

5.1.1.3 Methylmercury and inorganic mercury

Analyses of methylmercury and inorganic mercury in whole blood were performed at the CTQ, INSPQ (INSPQ, 2018m). Briefly, whole blood samples were digested with tetramethylammonium hydroxide, and mercury species were derivatized into volatile compounds by sodium tetra-*n*-propylborate. Mercury was extracted in the gas phase by solid-phase microextraction with polydimethylsiloxane/divinylbenzene fibre. Ultimately, mercury species were analyzed using isotopic dilution in tandem gas chromatography and inductively coupled plasma mass spectrometry (ID-GC-ICP-MS). The ID-GC-ICP-MS method employed a Perkin Elmer Clarus 580 gas chromatograph with a Zebtron ZB-5 column (Phenomenex), a CTC Analytics CombiPAL autosampler and an Empower chromatograph workstation version 3 alongside a Perkin Elmer NexION 350s ICP-MS with a Syngistix workstation version 1.1. Quantification was obtained by isotope dilution calculation. Internal quality control was ensured by analyzing 3 different in-house reference materials (low, medium and high) in each analysis sequence.

5.1.2 Urine analyses

5.1.2.1 Arsenic

Analyses of speciated arsenic in urine were performed at the CTQ, INSPQ (INSPQ, 2018j). The analyses measured arsenite (III), arsenate (V), monomethylarsonic acid, dimethylarsinic acid and the sum of arsenobetaine and arsenocholine. Briefly, urine samples were diluted tenfold in an ammonium carbonate solution (dilution solvent) compatible with the initial eluent, then analyzed on the high-performance liquid chromatography system, used in high pressure mode only, combined with inductively coupled plasma mass spectrometry (HPLC-ICP-MS). The HPLC-ICP-MS method employed a Waters ACQUITY HPLC with an Empower chromatograph workstation version 3 and a Perkin Elmer NexION 350s ICP-MS with a Syngistix workstation version 1.1. Methylseleno-L-cysteine was used as an internal standard. Internal quality control was ensured by analyzing 3 non-certified, in-house reference materials in each analysis sequence. External quality and the accuracy of the analytical method were assessed by participating in interlaboratory comparison programs, including the G-EQUAS.

5.1.2.2 Boron

Analyses of boron in urine were performed at the CTQ, INSPQ (INSPQ, 2018g). Briefly, urine samples were diluted in 0.5% nitric acid and analyzed for boron using ICP-MS-MS. The ICP-MS-MS method employed an Agilent Technologies 8800 ICP-QQQ with a CETAC ASX-500 autosampler and a MassHunter 4.2 workstation version C.01.02. Beryllium was used as an internal standard. Internal quality control was ensured by analyzing 3 different in-house reference materials (low, medium and high) in each analysis sequence.

5.1.2.3 Cadmium

Analyses of cadmium in urine were performed at the CTQ, INSPQ (INSPQ, 2018s). Briefly, urine samples were diluted in 0.5% nitric acid and analyzed for cadmium using ICP-MS. The ICP-MS method employed a Perkin Elmer Sciex Elan DRC II with an ESI SC-4 autosampler and an Elan workstation version 3.0. Matrix-matched calibration was performed using urine from non-exposed individuals. Correction of molybdenum-based interference on cadmium concentrations was performed mathematically using equations derived following the addition of

molybdenum to urine samples. Internal quality control was ensured by analyzing 3 different reference materials from the QMEQAS in each analysis sequence. The external quality and accuracy of the analytical method were assessed by participating in interlaboratory comparison programs, including the internal CTQ PCI, QMEQAS, G-EQUAS and New York State Department of Health's Proficiency Program for Trace Elements in Urine.

5.2 SELF-CARE AND CONSUMER PRODUCT CHEMICALS

5.2.1 Bisphenol A

Analyses of bisphenol A in urine were performed at the CTQ, INSPQ (INSPQ, 2018f). Briefly, urine samples were hydrolyzed using β -glucuronidase and derivatized with pentafluorobenzyl bromide. The derivatized products were then extracted with a mixture of dichloromethane and hexane. Extracts were then evaporated and redissolved, and the sum of free and conjugated forms of bisphenol A was analyzed by gas chromatography coupled with tandem mass spectrometry (GC-MS-MS). The GC-MS-MS method employed an Agilent 6890 gas chromatograph with an Agilent 7683 automatic injector and sampler coupled to a Waters Quattro Micro-GC tandem quadrupole mass spectrometer and a workstation equipped with Waters MassLynx software version 4.1; measurements were carried out in multiple reaction monitoring (MRM) mode with a source in negative chemical ionization mode. Carbon-13-labelled bisphenol A analogues were used as internal standards. Internal quality control was ensured by analyzing 3 different in-house reference materials (low, medium and high) in each analysis sequence. The external quality and accuracy of the analytical method were assessed by participating in interlaboratory comparison programs, including the G-EQUAS.

5.2.2 Parabens

Analyses of parabens in urine were performed at the Food Program Western Region Laboratory, Health Canada, British Columbia, Canada (HC, 2017) using a method adapted from the U.S. Centers for

Disease Control and Prevention (CDC, 2011). In these analyses, free and conjugated forms of butyl paraben, ethyl paraben, methyl paraben and propyl paraben were measured together. Briefly, urine samples were hydrolyzed using β -glucuronidase/sulfatase (Helix pomatia type H1). After enzymatic hydrolysis, samples were acidified with formic acid and pre-concentrated using solid-phase extraction (Waters Oasis HLB SPE tubes). The sum of free and conjugated parabens was detected and quantified using ultra-performance liquid chromatography coupled with tandem mass spectrometry (UPLC-MS-MS). The UPLC-MS-MS method employed a Waters ACQUITY UPLC coupled to a Waters Quattro Premier XE tandem mass spectrometer; data were collected as MRM data in electrospray ionization-negative mode. Deuterated parabens (D4-methyl paraben, D4-ethyl paraben, D4-propyl paraben and D4-butyl paraben) were used as the internal standards. Internal quality control was ensured by analyzing 2 in-house quality control pools (low and high) in each batch of analyses.

5.3 COTININE

5.3.1 Urine analysis

Analyses of free cotinine in urine were performed at the CTQ, INSPQ. One method was used for participants aged 6–11 (INSPQ, 2018c) and another for participants aged 12–79 (INSPQ, 2018e). Data from the 2 methods were combined and are presented separately for smokers aged 12–79 and non-smokers aged 6–79 for cycle 6. Briefly, for both methods, free cotinine was extracted from urine samples by solid-phase extraction via mixed cation-exchange and reverse-phase support on a Perkin Elmer JANUS automated liquid-handling workstation. The extracts were redissolved in the mobile phase and analyzed by UPLC-MS-MS. The UPLC-MS-MS method employed a Waters ACQUITY UPLC coupled to a Waters Xevo TQ-S or Quattro Premier XE tandem mass spectrometer and a workstation equipped with Waters MassLynx software version 4.1; measurements were carried out in MRM mode with an electrospray source-positive mode. For participants aged 12–79, within each analysis sequence, samples from non-smokers were analyzed first, followed by samples from smokers, to avoid contamination between samples. Deuterated cotinine was used as an internal standard. Internal quality control was ensured by analyzing 3

different in-house reference materials (low, medium and high) in each analysis sequence. The external quality and accuracy of the analytical method were assessed by participating in interlaboratory comparison programs, including the G-EQUAS.

5.3.2 Serum analysis

Analyses of free cotinine in serum were performed at the CTQ, INSPQ. One method was used for smokers (INSPQ, 2018a) and another for non-smokers (INSPQ, 2018b). Data from the 2 methods were combined and are presented separately for smokers and non-smokers. Briefly, for both methods, free cotinine was extracted from serum samples by solid-phase extraction via mixed cation-exchange and reverse-phase support on a Perkin Elmer JANUS automated liquid-handling workstation. The extracts were redissolved in the mobile phase and analyzed by UPLC-MS-MS. The UPLC-MS-MS method employed a Waters ACQUITY UPLC coupled to a Waters Xevo TQ-S micro tandem mass spectrometer and a workstation equipped with Waters MassLynx software version 4.1; measurements were carried out in MRM mode with an electrospray source-positive mode. Within each analysis sequence, samples from non-smokers were analyzed first, followed by samples from smokers, to avoid contamination between samples. Deuterated cotinine was used as an internal standard. Internal quality control was ensured by analyzing 3 different in-house reference materials (low, medium and high) in each analysis sequence.

5.4 ACRYLAMIDE

Analyses of acrylamide and glycidamide hemoglobin adducts in whole blood were performed at the Ontario Food Laboratory, Health Canada, Ontario, Canada (HC, 2014). Briefly, whole blood samples were reacted with modified Edman reagent (pentafluorophenyl isothiocyanate) and purified using solid-phase extraction on a column of ISOLUTE HM-N sorbent with a diisopropyl ether/ethyl acetate/toluene (50/40/10 v/v/v) eluent. The extract was evaporated, reconstituted and analyzed using UPLC-MS-MS. The UPLC-MS-MS method employed a Waters ACQUITY ultra-performance liquid chromatograph system coupled to a Waters Quattro Premier tandem mass spectrometer

and a workstation equipped with MassLynx software; measurements were carried out in MRM mode with an Atmospheric Pressure Chemical Ionization positive ion mode. Carbon-13 labelled acrylamide octapeptide was used as an internal standard. Internal quality control was ensured by analyzing 2 different in-house reference materials (low and high) in each analysis sequence. Hemoglobin was also measured in whole blood using a commercial HemoCue assay kit; the hemoglobin value was used to adjust the acrylamide and glycidamide hemoglobin adduct results.

5.5 PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES

Analyses of perfluoroalkyl substances in plasma were performed at the CTQ, INSPQ (INSPQ, 2018k). The analyses measured perfluorobutanoic acid (PFBA), perfluorobutane sulfonate (PFBS), perfluorohexanoic acid (PFHxA), perfluorohexane sulfonate (PFHxS), perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA) and perfluoroundecanoic acid (PFUnDA). Briefly, plasma samples were extracted by solid-phase extraction with a WAX support on a Perkin Elmer JANUS automated liquid-handling workstation. The extracts were redissolved in the mobile phase and analyzed by UPLC-MS-MS. The UPLC-MS-MS method employed a Waters ACQUITY UPLC coupled to a Waters Xevo TQ-S tandem mass spectrometer and a workstation equipped with MassLynx software version 4.1; measurements were carried out in MRM mode with an electrospray ionization-negative mode. Internal quality control was ensured by analyzing 4 different reference materials—3 in-house (low, medium and high) and 1 commercial—in each analysis sequence. External quality and accuracy of the analytical method was assessed by participating in interlaboratory comparison programs, including the internal CTQ Arctic Monitoring and Assessment Program ring test interlaboratory comparison program for persistent organic pollutants in human serum (PFHxA, PFHxS, PFNA, PFOA, PFOS, PFDA, PFUnDA) and the G-EQUAS for PFOS and PFOA.

5.6 PESTICIDES

5.6.1 Organophosphate pesticides

Analyses of dialkyl phosphate metabolites in urine were performed at the CTQ, INSPQ (INSPQ, 2018j). The analyses measured dimethylphosphate (DMP), dimethylthiophosphate (DMTP), dimethyldithiophosphate (DMDTP), diethylphosphate (DEP), diethylthiophosphate (DETP) and diethyldithiophosphate (DEDTP). Briefly, urine samples were hydrolyzed using β -glucuronidase and derivatized with pentafluorobenzyl bromide. The derivatized products were then extracted with a mixture of dichloromethane and hexane. Extracts were redissolved and analyzed by GC-MS-MS. The GC-MS-MS method employed an Agilent 6890 gas chromatograph with an Agilent 7683 automatic injector and sampler coupled to a Waters Quattro Micro-GC tandem quadrupole mass spectrometer and a workstation equipped with Waters MassLynx software version 4.1; measurements were carried out in MRM mode with a source in negative chemical ionization mode. Isotopically labelled dialkyl phosphate metabolite analogues were used as internal standards. Internal quality control was ensured by analyzing 4 different reference materials—3 in-house (low, medium and high) and 1 commercial—in each analysis sequence. External quality and accuracy of the analytical method was assessed by participating in interlaboratory comparison programs, including the G-EQUAS.

5.6.2 Pyrethroids

Analyses of pyrethroids in urine were performed at the CTQ, INSPQ (INSPQ, 2018o). The analyses measured 3-phenoxybenzoic acid (3-PBA), 4-fluoro-3-phenoxybenzoic acid (4-F-3-PBA), *cis*-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DBCA), *cis*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA), and *trans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA). Briefly, urine samples were hydrolyzed using β -glucuronidase and then acidified and extracted with hexane. The extracts were derivatized with hexafluoro-2-propanol (HFIP) and diisopropylcarbodiimide (DIC), and re-extracted with hexane. Extracts were then analyzed by GC-MS. The GC-MS method employed an Agilent 6890 network gas chromatograph with an Agilent 7683B automatic injector and sampler coupled

to an Agilent 5975 mass spectrometer and a workstation equipped with Waters MassHunter software version B.07.01 build 7.1.524.0 and ChemStation G1701EA software version E02.01.1177; measurements were carried out in single ion monitoring modes following negative chemical ionization. Carbon-13 labelled *trans*-DCCA, 4-F-3-PBA and 3-PBA analogues were used as internal standards; the isotopically labelled *trans*-DCCA analogue was used as an internal standard for *cis*-DCCA, *trans*-DCCA and *cis*-DCBA. Internal quality control was ensured by analyzing 4 different reference materials—3 in-house (low, medium and high) and 1 commercial—in each analysis sequence. External quality and accuracy of the analytical method was assessed by participating in interlaboratory comparison programs, including the G-EQUAS, for *cis*-DBCA, *cis*-DCCA, *trans*-DCCA and 3-PBA.

5.6.3 Ethylene bisdithiocarbamates

Analyses of total ethylene thiourea (ETU) in urine were performed at the CTQ, INSPQ (INSPQ, 2018i). Briefly, urine samples were hydrolyzed and derivatized with 2,3,4,5,6-pentafluorobenzyl bromide. The derivatized products were then extracted with hexane. The extracts were analyzed by UPLC-MS-MS. The UPLC-MS-MS method employed a Waters ACQUITY UPLC coupled to a Waters Xevo TQ-S tandem mass spectrometer and a workstation equipped with MassLynx software version 4.1; measurements were carried out in MRM mode with electrospray ionization positive mode. Deuterated ETU was used as an internal standard. Internal quality control was ensured by analyzing 4 different reference materials—3 in-house (low, medium and high) and 1 commercial—in each analysis sequence.

5.6.4 *ortho*-Phenylphenol

Analyses of *ortho*-phenylphenol in urine were performed at the CTQ, INSPQ (INSPQ, 2018t). In these analyses, glucuronide- and sulfate-conjugated forms of *ortho*-phenylphenol were measured. Briefly, urine samples were extracted on an ion-exchange cartridge, eluted and evaporated to dryness. The extracts were redissolved in a mixture of methanol and demineralized water (25:75), then analyzed by UPLC-MS-MS. The UPLC-MS-MS method employed a Waters ACQUITY UPLC coupled to a Waters Xevo TQ-S tandem mass spectrometer and a workstation equipped with MassLynx software version 4.1; measurements were carried out in MRM mode with an electrospray ionization-negative mode.

Carbon-13 labelled *ortho*-phenylphenol was used as an internal standard. Internal quality control was ensured by analyzing 3 different in-house reference materials (low, medium and high) in each analysis sequence.

5.7 PLASTICIZERS

5.7.1 Phthalates

Analyses of phthalate metabolites in urine were performed at the CTQ, INSPQ (INSPQ, 2018n). The analyses measured 23 phthalate metabolites (see Table 3.4.1 for complete analyte list). Briefly, urine samples were hydrolyzed using β -glucuronidase, and the analytes were extracted using liquid-liquid extraction with a hexane:ethyl acetate solution (50:50) on a Perkin Elmer JANUS automated liquid-handling workstation. The extracts were analyzed by UPLC-MS-MS. The UPLC-MS-MS method employed a Waters ACQUITY UPLC coupled to a Waters Xevo TQ-S tandem mass spectrometer and a workstation equipped with MassLynx software version 4.1; measurements were carried out in MRM mode with an electrospray ionization-negative mode. Various internal standards were used, including deuterated monoisobutyl phthalate (MiBP) and carbon-13 labelled monobenzyl phthalate (MBzP), monocyclohexyl phthalate (MCHP), monoisononyl phthalate (MiNP), monoethyl phthalate (MEP), monomethyl phthalate (MMP), mono-*n*-butyl phthalate (*Mn*BP), mono-*n*-octyl phthalate (MOP), mono(2-ethylhexyl) phthalate (MEHP), mono(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP), mono(2-ethyl-5-oxohexyl) phthalate (MEOHP), mono(3-carboxypropyl) phthalate (MCP), mono(2-ethyl-5-carboxypentyl) phthalate (MECPP) analogues and deuterated mono[2-(carboxymethyl)hexyl] phthalate (MCMHP), monoisodecyl phthalate (MiDP) and mono-3-hydroxy-*n*-butyl phthalate (3OH-MBP). In addition to MEHHP, the isotopically labelled MEHHP was used as an internal standard for mono-carboxy-*n*-heptyl phthalate (MCHpP), monocarboxyisononyl phthalate (MCiNP), mono(carboxyisooctyl) phthalate (MCiOP), monohydroxyisodecyl phthalate (MHiDP), monohydroxyisononyl phthalate (MHiNP), monooxoisodecyl phthalate (MOiDP) and monooxoisononyl phthalate (MOiNP). Internal quality control was ensured by analyzing 3 different in-house reference materials (low, medium and high) in each analysis sequence. External quality and accuracy of

the analytical method was assessed by participating in interlaboratory comparison programs, including the G-EQUAS, for MEHHP, MEOHP, MECPP, MEHP, *Mn*BP, MiBP and MBzP. Due to issues during the peak integration process, results were reported for MCiOP, MiNP and MCiNP semi-quantitatively. Results for all other analytes were reported quantitatively.

5.7.2 Di(isononyl)cyclohexane-1,2-dicarboxylate (DINCH) and tri-(2-ethylhexyl) trimellitate (TEHT)

Analyses of di(isononyl)cyclohexane-1,2-dicarboxylate (DINCH) and tri-(2-ethylhexyl) trimellitate (TEHT) metabolites in urine were performed at the CTQ, INSPQ (INSPQ, 2018p). The analyses measured the DINCH metabolites *trans*-cyclohexane-1,2-dicarboxylic mono isononyl ester (*trans*-MINCH), cyclohexane-1,2-dicarboxylic mono oxoisononyl ester (oxo-MINCH), cyclohexane-1,2-dicarboxylic mono hydroxyisononyl ester (OH-MINCH), *cis*-cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (*cis*-cx-MINCH) and *trans*-cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (*trans*-cx-MINCH). The analyses also measured the TEHT metabolites 1-mono(2-ethylhexyl)trimellitate (1-MEHTM), 2-mono(2-ethylhexyl)trimellitate (2-MEHTM) and 4-mono(2-ethylhexyl)trimellitate (4-MEHTM). Briefly, urine samples were hydrolyzed using β -glucuronidase, and the analytes were extracted using liquid-liquid extraction with a 50:50 hexane:ethyl acetate solution on a Perkin Elmer JANUS automated liquid-handling workstation. The extracts were taken up with a mixture of acetonitrile and demineralized water and analyzed by UPLC-MS-MS. The UPLC-MS-MS method employed a Waters ACQUITY UPLC coupled to a Waters Xevo TQ-S tandem mass spectrometer and a workstation equipped with MassLynx software version 4.1; measurements were carried out in MRM mode with an electrospray ionization-negative mode. Deuterated *trans*-cx-MINCH was used as an internal standard for *trans*-cx-MINCH, *cis*-cx-MINCH, oxo-MINCH, 1-MEHTM, 2-MEHTM and 4-MEHTM. Deuterated *trans*-cyclohexane-1,2-dicarboxylic mono hydroxyisononyl ester (*trans*-OH-MINCH) was used as an internal standard for OH-MINCH, and deuterated *trans*-MINCH was used as an internal standard for *trans*-MINCH. Internal quality control was ensured by analyzing 3 different in-house reference materials (low, medium and high) in each analysis sequence.

5.7.3 2,2,4-Trimethyl-1,3-pentanediol diisobutyrate (TXIB) and cyclohexane-1,2-dicarboxylic acid (CHDA)

Analyses of cyclohexane-1,2-dicarboxylic acid (CHDA) and 2,2,4-trimethyl-1,3-pentanediol diisobutyrate (TXIB) metabolites in urine were performed at the CTQ, INSPQ (INSPQ, 2018q). The analyses measured the di(isononyl) cyclohexane-1,2-dicarboxylate (DINCH) metabolite CHDA and the TXIB metabolites 2,2,4-trimethyl-1,3-pentanediol (TMPD) and 2,2,4-trimethyl-3-hydroxy valeric acid (HTMV). Briefly, urine samples were hydrolyzed using β -glucuronidase and arylsulfatase, acidified and extracted with ethyl acetate on a Perkin Elmer JANUS automated liquid-handling workstation. The extracts were taken up with a mixture of methanol and water and analyzed by UPLC-MS-MS. The UPLC-MS-MS method employed a Waters ACQUITY UPLC coupled to a Waters Xevo TQ-S tandem mass spectrometer and a workstation equipped with MassLynx software version 4.1; measurements were carried out in MRM mode with an electrospray ionization-negative mode for HTMV and CHDA and positive mode for TMPD. Deuterated 2,2-bis(hydroxymethyl)pentane was used as an internal standard for TMPD. Deuterated HTMV and CHDA analogues were used as internal standards for HTMV and CHDA, respectively. Internal quality control was ensured by analyzing 3 different in-house reference materials (low, medium and high) in each analysis sequence.

5.8 CREATININE

Analyses of creatinine in urine were performed at the CTQ, INSPQ (INSPQ, 2018d) using the colorimetric end point Jaffe method. Briefly, urine samples were reacted with an alkaline solution of sodium picrate to form a red Janovski complex. The complex was analyzed by spectrophotometry at 510 nm. The method employed a Thermo Fischer Scientific Indiko Plus automatic analyzer and a workstation equipped with Indiko software version 5.3; measurements were carried out in kinetic mode. Internal quality control was ensured by analyzing 2 commercial reference materials in each analysis sequence. The external quality and accuracy of the analytical method were assessed by participating in interlaboratory comparison programs, including the College of American Pathologists Forensic Urine Drug Testing (Confirmatory) Survey.

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STATISTICAL DATA ANALYSES

6

Descriptive statistics on the concentrations of environmental chemicals in the blood and urine of Canadians were generated using the Statistical Analysis System software (SAS Institute Inc., version 9.4, 2014) and the SUDAAN® (SUDAAN Release 11.0.3, 2018) statistical software package.

The Canadian Health Measures Survey (CHMS) is a sample survey. This means the participants represent many other Canadians who were not included in the survey. To ensure that the results would be representative of the entire population, sample weights were generated by Statistics Canada and incorporated into all estimates presented in the data tables. Survey weights were used to take into account the unequal probability of selection into the survey as well as non-response. Further, to account for the complex survey design of the CHMS, the set of bootstrap weights included with the data set was used to estimate the 95% confidence intervals (CIs) for all means, percentiles and detection frequencies (Rao et al., 1992; Rust and Rao, 1996). Further details on sample weights are available in the *Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 6* (StatCan, 2021).

Data tables are presented for each chemical measured in cycle 6. When available, data from previous cycles are also provided within the tables. In the first *Report on Biomonitoring of Environmental Chemicals in Canada*, all results were reported to 2 decimal places. For subsequent cycles of the CHMS the reporting protocol changed, and the results were reported to 2 significant digits. For consistency, cycle 1 data were adjusted to 2 significant digits before generating the descriptive

statistics, and data from all cycles are presented to 2 significant digits. Therefore, the descriptive statistics presented for cycle 1 may differ from those presented in the first report. The differences are not significant, and the values presented in the first report are still considered to be accurate.

The data tables include the sample size (n); the percentage of the population with concentrations at or above the limit of detection (LOD), termed detection frequency; the geometric mean (GM); and the 10th, 50th, 90th and 95th percentiles, with associated 95% CIs. For each chemical, results are presented for the total population as well as by age group and sex. Measurements that fell below the LOD for the laboratory analytical method were assigned a value equal to half the LOD. If the proportion of results below the LOD was greater than 40%, GMs were not calculated. Percentile estimates that are less than the LOD are reported as <LOD. LOD values for each chemical are provided alongside their respective data tables and in Appendix A. Conversion factors to assist in the comparison of data from other studies that report different units are provided in Appendix B.

Chemicals measured in whole blood, plasma or serum are presented as weight of chemical per volume of a given blood matrix (μg chemical/L blood or plasma or serum). Data for hemoglobin adducts are presented as the amount of hemoglobin adduct per weight of hemoglobin (pmol adduct/g hemoglobin). Chromium (VI) measures in red blood cells are presented as weight of chromium per volume of red blood cells (μg /L red blood cells).

For urine measurements, concentrations are presented as weight of chemical per volume of urine (μg chemical/L urine) and adjusted for urinary creatinine (μg chemical/g creatinine). Urinary creatinine is a chemical by-product generated from muscle metabolism; it is frequently used to adjust for urine concentration (or dilution) in spot urine samples because its production and excretion are relatively constant over 24 hours owing to homeostatic controls (Barr et al., 2005; Boeniger et al., 1993; Pearson et al., 2009). If the chemical measured behaves similarly to creatinine in the kidney, it will be filtered at the same rate; thus, expressing the chemical per gram of creatinine helps adjust for the effect of urinary dilution as well as some differences in renal function and lean body mass (Barr et al., 2005; CDC, 2009; Pearson et al., 2009). Creatinine is primarily excreted by glomerular filtration; therefore, creatinine adjustment may not be appropriate for compounds that are excreted primarily by tubular secretion in the kidney (Barr et al., 2005; Teass et al., 2003). In addition, creatinine excretion can vary based on age, sex and ethnicity; therefore, it may not be appropriate to compare creatinine-adjusted concentrations among different demographic groups (e.g., children versus adults) (Barr et al., 2005). Where urinary creatinine values were missing or $<\text{LOD}$, the estimate of that participant's creatinine-adjusted chemical was not calculated and was also listed as missing.

Descriptive statistics are available for creatinine (mg/dL) (Appendix C). These include n ; detection frequency; GM; the 10th, 50th, 90th and 95th percentiles; and associated 95% CIs for the total population as well as by age group and sex. Measurements that fell below the LOD for the laboratory analytical method were assigned a value equal to half the LOD.

Specific gravity was also measured in all urine samples immediately following sample collection at the mobile examination centre. Urinary specific gravity is the ratio of densities between urine and pure water, and can be used to adjust for variations in urine output, similar to urinary creatinine adjustment. Urinary specific gravity adjustment has not been presented for any of the chemicals; however, specific gravity data are available upon request by contacting Statistics Canada at infostats@canada.ca should researchers wish to perform this adjustment for their own data analyses.

Under the *Statistics Act*, Statistics Canada is required to ensure participant confidentiality. Therefore, estimates based on a small number of participants are suppressed. Following suppression rules for the CHMS, any estimate based on fewer than 10 participants is suppressed in the data tables. To avoid suppression, estimates at the 95th percentile require at least 100 participants; estimates at the 10th and 90th percentiles require at least 50 participants; estimates at the 50th percentile require at least 10 participants; and estimates of the GM require at least 5 participants.

Estimates from a sample survey will inevitably include sampling errors. Measuring the possible scope of sampling errors is based on the standard error of the estimates drawn from the survey results. To get a better indication of the size of the standard error, it is often more useful to express the standard error in terms of the estimate being measured. The resulting measure, called the coefficient of variation (CV), is obtained by dividing the standard error of the estimate by the estimate itself; it is expressed as a percentage of the estimate. This report uses the data quality symbol E adapted from Statistics Canada guidelines for releasing estimates based on their CVs. When a CV is greater than 16.6%, the estimate is identified by the superscript letter E and accompanied by a warning that cautions users of the high sampling variability associated with the estimate.

Previously, when a CV for an estimate was greater than 33.3%, the data were not published. To promote understanding of biomonitoring data and maximize its use, estimates are no longer suppressed based upon their CVs. Rather, users are encouraged to consider the confidence interval that accompanies each estimate as an indicator of the estimate's reliability. A narrow confidence interval closer to the estimate indicates lower sampling variability and greater reliability of the estimate. Conversely, a wider confidence interval further from the estimate indicates higher sampling variability and lower reliability of the estimate. Incorporating the confidence intervals alongside estimates is encouraged when using or reporting the data presented in this report.

6.1 DATA MODIFICATION AND CORRECTIONS

Certain data in the present report differ from what has appeared in previous CHMS biomonitoring reports; data modification and corrections include the following:

- previously suppressed data that had been replaced by the letter F in past reports are now published
- corrected cycle 5 data for lead, cadmium, mercury and selenium measured in blood
- corrected cycle 5 data for monohydroxyisononyl phthalate (MHiNP)
- corrected cycle 1 LODs for organophosphate pesticide metabolites (see Appendix A)

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CONSIDERATIONS FOR INTERPRETING THE BIOMONITORING DATA

7

The Canadian Health Measures Survey (CHMS) was designed to provide estimates of environmental chemical concentrations in blood or urine for the Canadian population as a whole. The first cycle of the survey covered approximately 96% of the Canadian population aged 6–79. The subsequent cycles included children as young as 3 years of age and covered approximately 96% to 97% of the Canadian population aged 3–79. The survey was not designed to permit breakdown of data by region, province or collection site, although some analysis is possible if data from more than 1 cycle are combined (see *Instructions for Combining Multiple Cycles of Canadian Health Measures Survey [CHMS] Data* [Statistics Canada, 2015]). In addition, the CHMS design did not target specific exposure scenarios; consequently, it did not select or exclude participants on the basis of their potential for low or high exposures to environmental chemicals.

Biomonitoring can estimate how much of a chemical is present in a person, but it cannot say what health effects, if any, may result from that exposure. The ability to measure environmental chemicals at very low concentrations has advanced in recent years. However, the presence alone of a chemical in a person's body does not necessarily mean that it will cause a health effect. Factors such as the dose, the toxicity of the chemical, and the duration and timing of exposure are important to determine whether potential adverse health effects may occur. For chemicals such as lead or mercury, research studies have provided a good understanding of the health risks associated with different concentrations in blood. However, for many chemicals, further research is needed to understand the potential health

effects, if any, associated with different blood or urine concentrations. Furthermore, small amounts of certain chemicals, such as selenium, are essential for the maintenance of good health and would be expected to be present in the body. In addition, the way in which a chemical will act in the body will differ among individuals and cannot be predicted with certainty. Certain populations (children, pregnant women, the elderly, or immunocompromised people) may be more susceptible to the effects of exposure.

The absence of a chemical does not necessarily mean a person has not been exposed. It may be that the technology is not capable of detecting such a small amount, or that the exposure occurred at an earlier point in time, allowing for the chemical to be eliminated from the person's body before the measurement took place.

Biomonitoring cannot tell us the source or route of the exposure. The amount of chemical measured indicates the total amount that has entered the body through all routes of exposure (ingestion, inhalation, and skin contact) and from all sources (air, water, soil, food and consumer products). The detection of the chemical may be the result of exposure to a single source or multiple sources. In addition, in most cases, biomonitoring cannot distinguish between natural and anthropogenic sources. Many chemicals (lead, mercury, cadmium, and arsenic) occur naturally in the environment and are also present in human-made products.

While most metals are measured as the parent compounds, many other chemicals are measured as metabolites. For many chemicals, parent compounds

may be broken down (i.e., metabolized) in the body into 1 or more metabolites. Some metabolites are specific to 1 parent compound, whereas others are common to several parent compounds. As well, several metabolites found in urine are also found in the environment as a result of other processes (e.g., dialkyl phosphate metabolites). Their presence in urine does not necessarily mean that an exposure to the parent chemical has occurred; rather, exposure could be to the metabolite itself in media such as food, water or air.

Factors that contribute to the concentrations of chemicals measured in blood and urine include the quantity entering the body through all routes of exposure, absorption rates, distribution to various tissues in the body, metabolism, and excretion of the chemical and/or its metabolites from the body. These processes, also called toxicokinetics, depend on both the characteristics of the chemical, including its solubility in fat (or lipophilicity), its pH, its particle size and the characteristics of the individual being exposed, such as age, diet, health status and ethnicity. For these reasons, the way in which a chemical will act in the body will differ among individuals and cannot be predicted with certainty.

The CHMS biomonitoring data currently available include temporal data for substances measured in individual participants in cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019), as well as for measures in pooled serum in cycles 1, 3, 4 and 5 (2007–2017). Results from multiple cycles can be compared in order to examine trends in Canadians' exposures to selected environmental chemicals. It is important to note that some sampling and analytical modifications between cycles may have contributed some variation in results for those substances measured in multiple cycles. The limits of detection (LODs) for certain analytical methods have changed from cycle to cycle (Appendix A). Although the LOD values did not change by a large margin, this difference should be noted when comparing data from multiple cycles. In addition, the urine collection protocol and guidelines were changed in cycle 2, and this may have resulted in a shift in creatinine levels when cycle 1 data are compared with those from subsequent cycles. This, in turn, could affect creatinine-adjusted levels of some chemicals. For more information on trends in chemical concentrations measured as part of the CHMS, please refer to chemical-specific biomonitoring fact sheets available on the [Human Biomonitoring Resources](#) web page.

Urinary creatinine concentrations can also be affected by variables such as age, sex and ethnicity, resulting in differences among demographic groups within a single cycle (Mage et al., 2004). In particular, creatinine excretion per unit of body weight increases substantially with increasing age in children (Aylward et al., 2011; Remer et al., 2002). As a result, it is acceptable to compare creatinine-adjusted concentrations among similar demographic groups (e.g., children with children, adults with adults, males with males) but not among 2 different demographic groups (e.g., children versus adults, males versus females) (Barr et al., 2005).

More in-depth statistical analyses of the CHMS biomonitoring data—including time trends, exploring relationships among environmental chemicals, other physical measures and self-reported information—are being published by researchers in scientific literature. A [bibliography](#) of publications using CHMS data is available. CHMS data are available to scientists through Statistics Canada's [Research Data Centres](#) Program and are a resource for additional scientific analyses. Further information about the CHMS can be obtained by contacting Statistics Canada at infostats@canada.ca.

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SUMMARIES AND RESULTS FOR METALS AND TRACE ELEMENTS

8

8.1 LEAD

Lead (CASRN 7439-92-1) is a naturally occurring element. It is a base metal and can exist in various oxidation states in both inorganic and organic forms (ATSDR, 2020). Elemental lead is an inorganic form, while organic lead compounds include dialkyl, trialkyl and tetra-alkyl lead.

Lead is found in bedrock, soils, sediments, surface water, groundwater and sea water (HC, 2013a). It enters the environment from a variety of natural and anthropogenic sources. Natural processes include soil weathering, erosion and volcanic activity (ATSDR, 2020; IARC, 2006). Lead released from industrial emissions can be a major source of environmental contamination, especially near point sources, such as smelters or refineries (ATSDR, 2020). Historical use of leaded motor fuels has contributed to the ubiquitous distribution of lead throughout the world (WHO, 2000).

In North America, tetraethyl and tetramethyl lead were added to motor vehicle fuels as an anti-knock agent until the 1990s. Today in Canada, the addition of lead to gasoline is prohibited, with the exception of fuels for piston engine aircraft and racing fuels for competition vehicles (Canada, 1990; HC, 2013a). Lead is currently used in the refining and manufacturing of products such as lead acid automotive batteries, lead shot and fishing weights, sheet lead, lead solder, some brass and bronze products, and some ceramic glazes (ATSDR, 2020; WHO, 2000). Other uses of lead include dyes in paints and pigments. It is also used

in scientific equipment, as a stabilizer in plastics, in military equipment and ammunition, and in radiation detection and medical equipment for radiation shielding (ATSDR, 2020; WHO, 2000). Lead is also used in the manufacturing of cable sheathing, circuit boards, chemical baths and storage vessel linings, chemical transmission pipes, electrical components and polyvinyl chloride (HC, 2013a).

Everyone is exposed to trace amounts of lead through food, drinking water, soil, household dust, air and some consumer products. However, lead exposure in Canada has decreased by approximately 80% over the past 40 years (ECCC, 2020). 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 the elimination of lead solder in food cans. Today, the main route of exposure for the general adult population is ingestion via food and drinking water (ATSDR, 2020; HC, 2013a). For infants and children, the primary sources of exposure are food, drinking water, and non-food items containing lead, such as house dust, paint, soil and consumer products (HC, 2013a). Lead can enter the water supply from lead service lines in older homes, brass plumbing fittings that contain lead, or lead solder in the plumbing in homes (HC, 2016). Other potential sources of exposure include: costume jewellery, art supplies, leaded crystal and glazes on ceramics and pottery; having a hobby (or living with someone who has) that requires the use of lead or lead solder, such as refinishing furniture or making stained glass, ceramic glazing, lead shot or lead fishing weights; living near airports with piston aircraft activity; and smoking (HC, 2013b). The Canadian House Dust Study reported that

lead is enriched in house dust compared with the natural geochemical background as a result of the use of lead in consumer products, paints and building materials as well as infiltration from outdoor sources (Rasmussen et al., 2013).

Approximately 3% to 10% of ingested lead is absorbed into blood in adults; the amount absorbed can increase to up to 40% to 50% in children (HC, 2013a). Nutritional calcium and iron deficiencies in children appear to increase lead absorption and decrease lead excretion (HC, 2013a). Once absorbed by the human body, lead circulates in the bloodstream, where it accumulates in tissues, particularly bone, and is excreted from the body. Some lead may also be sequestered in soft tissues, such as the liver, kidneys and lungs. Bones account for approximately 70% of the total body burden of lead in children and more than 90% of the total body burden in adults (EPA, 2006). Lead stored in bone can be remobilized and released back into circulating blood. Pregnancy, lactation, menopause, andropause, post-menopause, extended bed rest, hyperparathyroidism and osteoporosis are all conditions that can increase remobilization of lead from bone, increasing blood lead levels (HC, 2013a).

During pregnancy, lead stored in maternal bone becomes a source of exposure for both fetus and mother (Rothenberg et al., 2000). Lead can also be present in breast milk and transferred from lactating mothers to infants (ATSDR, 2020; EPA, 2006). The half-life for lead in blood is approximately 30 days, whereas the half-life for lead accumulated in the body, such as in bone, is in the range of 10 to 30 years (ATSDR, 2020; HC, 2009a; 2013a). Excretion of absorbed lead occurs primarily through urine and feces, regardless of the route of exposure (ATSDR, 2020). Blood lead is the preferred indicator of human exposure to lead, although other matrices—such as urine, bone and teeth—also have been used (ATSDR, 2020; CDC, 2009). Lead is considered a cumulative general toxicant, with developing fetuses, infants, toddlers and children being most susceptible and vulnerable to adverse health effects (WHO, 2011). Following acute exposure, a variety of metabolic processes may be affected. Very high exposure may result in vomiting, diarrhea, convulsions, coma and death. Cases of lead poisoning are rare in Canada (HC, 2009a).

Chronic low-level exposure may affect both the central and peripheral nervous systems; however, the

symptoms of relatively low exposure levels are often not apparent (ATSDR, 2020; HC, 2013a). Chronic low-level exposure to lead has also been associated with developmental neurotoxicity, neurodegenerative effects, cardiovascular disease, decreased renal functioning, reproductive problems and other health responses (ATSDR, 2020; Bushnik et al., 2014; HC, 2013a; Lanphear et al., 2018). Cognitive and neurobehavioural effects have been recognized as major concerns for exposed children. In infants and children, exposure to lead is most strongly associated with neurodevelopmental effects, specifically the reduction of intelligence quotient (IQ) (Lanphear et al., 2005) and an increased risk of attention-related behaviours (HC, 2013a). Based on available data, no threshold has yet been identified for the effects of lead exposure on cognitive function and neurobehavioural development, meaning that no safe level of exposure is known to exist (CDC, 2012; EPA, 2006; HC, 2013a). Developmental neurotoxicity has been associated with the lowest levels of lead exposure measured to date, although there is uncertainty associated with effects observed at these levels (HC, 2013a). The International Agency for Research on Cancer classifies inorganic lead compounds as Group 2A, probably carcinogenic to humans (IARC 2006).

Lead is listed on Schedule 1, List of Toxic Substances, under the *Canadian Environmental Protection Act, 1999* (CEPA 1999). The act allows the federal government to control the importation, manufacture, distribution and use of lead and lead compounds in Canada (Canada, 1999; HC, 2009a). Lead is subject to numerous federal risk management initiatives in Canada directed toward industrial releases, consumer products, cosmetics, drinking water, food, natural health products, therapeutic products, tobacco and environmental media, including household dust, soil and air. CEPA 1999 prohibits the addition of lead in gasoline and controls its release from secondary lead smelters, steel manufacturing and mining effluents (ECCC, 2018). The use of lead in toys, children's jewellery, clothing and accessories, and other products intended for children—along with consumer paints and surface coatings, glazed ceramics and glassware for food storage, and other consumer products that represent a potential risk of lead exposure—is limited under the *Canada Consumer Product Safety Act* and its associated regulations (Canada, 2010a; Canada, 2010b; HC, 2013a). These include the Children's Jewellery Regulations, which establish a new guideline limit for

lead in children's jewellery (Canada, 2016a). In addition, the Consumer Products Containing Lead Regulations limit the total lead content in an expanded scope of consumer products intended for use by a child or an adult in caring for a child (Canada, 2016b). Lead and its compounds are on the List of Ingredients that are Prohibited for Use in Cosmetic Products (HC, 2019b).

On the basis of treatment achievability, Health Canada, in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water, developed a guideline for Canadian drinking water quality that establishes the maximum acceptable concentration for lead (HC, 2019a). Health Canada has also published guidance on controlling corrosion in drinking water distribution systems to help control the leaching of metals, including lead, from system materials and components (HC, 2009b). The concentration of lead in specific foods is managed by Health Canada under the Food and Drug Regulations (Canada, 1978); the existing maximum levels for lead in foods are found in the List of Contaminants and Other Adulterating Substances in Foods. Health Canada has updated the maximum level for lead in fruit juice, fruit nectar and water in sealed containers (HC, 2020b), and for lead in concentrated and ready-to-serve infant formula (HC, 2020d). Maximum levels for other foods and beverages are scheduled for review and update. These regulatory updates are among several Health Canada activities that are underway to ensure that dietary exposure to lead is as low as is reasonably achievable (HC, 2017). Lead is also included in the list of trace elements analyzed as part of Health Canada's ongoing Total Diet Study surveys (HC, 2020a). The food items analyzed represent those that are most typical of the Canadian diet, and the surveys are used to provide dietary exposure estimates for chemicals that Canadians in

different age-sex groups are exposed to through the food supply. From 1981 to 2000, Canadians' average dietary exposure to lead decreased approximately eightfold and has remained stable at low levels since that time (HC, 2020c).

In 1994, the Federal-Provincial-Territorial Committee on Environmental and Occupational Health recommended a blood-lead intervention level of 10 µg/dL as guidance for low-level exposure to lead (CEOH, 1994). Scientific assessments indicate that chronic health effects are occurring in children at blood-lead levels below 10 µg/dL, and that there is sufficient evidence that blood-lead levels below 5 µg/dL are associated with adverse health effects (HC, 2013a). Despite some uncertainties, the evidence for an association between neurodevelopmental effects in children and blood-lead levels in the lower range of exposure is of concern. The current guidance for lead in blood (CEOH, 1994) is under review by the federal, provincial and territorial Council of Chief Medical Officers of Health.

Blood-lead levels have been measured in a number of biomonitoring studies conducted in Canada, including the Maternal–Infant Research on Environmental Chemicals study (Arbuckle et al., 2016) and the First Nations Biomonitoring Initiative (AFN, 2013).

Lead was analyzed in the whole blood of Canadian Health Measures Survey (CHMS) participants aged 6–79 in cycle 1 (2007–2009), and aged 3–79 in cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented in blood as µg/dL. Lead was also analyzed in hair from CHMS participants aged 20–59 in cycle 5.

Table 8.1.1

Lead—Geometric means and selected percentiles of whole blood concentrations ($\mu\text{g}/\text{dL}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	6070	100	1.2 (1.1–1.2)	0.54 (0.50–0.59)	1.1 (1.1–1.2)	2.5 (2.3–2.7)	3.2 (2.9–3.4)
3 (2012–2013)	5538	99.8 (98.7–100)	1.1 (1.0–1.1)	0.49 (0.46–0.52)	1.0 (0.95–1.1)	2.4 (2.3–2.5)	3.2 (2.9–3.4)
4 (2014–2015)	5498	99.9 (99.7–100)	0.95 (0.90–1.0)	0.43 (0.40–0.46)	0.92 (0.88–0.95)	2.1 (1.8–2.3)	2.7 (2.4–3.0)
5 (2016–2017)	4517	99.7 (98.5–99.9)	0.89 (0.82–0.96)	0.37 (0.35–0.40)	0.88 (0.80–0.95)	2.0 (1.8–2.1)	2.4 (2.1–2.8)
6 (2018–2019)	4596	99.6 (98.6–99.9)	0.81 (0.77–0.85)	0.34 (0.32–0.37)	0.78 (0.72–0.84)	1.8 (1.6–2.0)	2.3 (2.0–2.5)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2940	100	1.3 (1.3–1.4)	0.62 (0.56–0.67)	1.2 (1.2–1.3)	2.8 (2.5–3.1)	3.4 (3.1–3.7)
3 (2012–2013)	2769	99.9 (99.1–100)	1.2 (1.2–1.3)	0.56 (0.55–0.58)	1.1 (1.0–1.2)	2.6 (2.4–2.9)	3.6 (3.1–4.0)
4 (2014–2015)	2754	100 (99.4–100)	1.0 (0.98–1.1)	0.47 (0.45–0.49)	1.0 (0.97–1.0)	2.2 (1.9–2.4)	2.9 (2.3–3.5)
5 (2016–2017)	2257	100	1.0 (0.89–1.1)	0.45 (0.40–0.51)	0.99 (0.90–1.1)	2.1 (1.8–2.4)	2.7 (2.0–3.3)
6 (2018–2019)	2330	99.8 (99.5–99.9)	0.87 (0.82–0.93)	0.38 (0.35–0.41)	0.86 (0.80–0.92)	2.0 (1.8–2.1)	2.3 (2.0–2.7)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	3130	100	1.1 (1.0–1.1)	0.50 (0.46–0.54)	1.0 (0.96–1.1)	2.3 (2.1–2.5)	2.8 (2.6–3.0)
3 (2012–2013)	2769	99.6 (97.1–100)	0.96 (0.90–1.0)	0.42 (0.37–0.47)	0.93 (0.87–1.0)	2.2 (2.1–2.3)	2.6 (2.2–3.1)
4 (2014–2015)	2744	99.9 (99.8–100)	0.87 (0.81–0.94)	0.40 (0.36–0.43)	0.83 (0.78–0.89)	2.0 (1.6–2.3)	2.6 (2.3–2.8)
5 (2016–2017)	2260	99.4 (97.0–99.9)	0.79 (0.74–0.84)	0.33 (0.30–0.35)	0.77 (0.68–0.86)	1.8 (1.6–1.9)	2.2 (2.0–2.4)
6 (2018–2019)	2266	99.3 (97.1–99.8)	0.75 (0.70–0.80)	0.32 (0.29–0.35)	0.72 (0.66–0.78)	1.7 (1.5–1.8)	2.2 (1.9–2.6)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	495	100	0.93 (0.87–1.0)	0.51 (0.44–0.58)	0.93 (0.86–1.0)	1.6 (1.5–1.8)	2.1 (1.8–2.4)
3 (2012–2013)	471	100	0.77 (0.73–0.82)	0.40 (0.33–0.47)	0.72 (0.68–0.77)	1.4 (1.0–1.8)	2.2 (1.4–2.9)
4 (2014–2015)	479	100	0.67 (0.61–0.73)	0.37 (0.32–0.42)	0.64 (0.60–0.69)	1.2 (0.90–1.5)	1.7 (1.4–2.0)
5 (2016–2017)	473	99.9 (99.4–100)	0.56 (0.43–0.72)	0.31 (0.26–0.36)	0.52 (0.39–0.65)	1.0 ^E (0.39–1.6)	1.3 ^E (0.20–2.4)
6 (2018–2019)	482	99.3 (96.2–99.9)	0.50 (0.44–0.58)	0.29 (0.27–0.31)	0.46 (0.40–0.52)	0.99 (0.74–1.2)	1.2 ^E (0.39–2.0)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
6–11 years							
1 (2007–2009)	910	100	0.90 (0.81–0.99)	0.53 (0.49–0.56)	0.87 (0.77–0.97)	1.6 (1.4–1.7)	1.9 (1.6–2.2)
2 (2009–2011)	961	100	0.79 (0.74–0.84)	0.44 (0.38–0.50)	0.74 (0.68–0.81)	1.4 (1.2–1.6)	1.7 (1.5–1.9)
3 (2012–2013)	944	100	0.71 (0.67–0.76)	0.39 (0.36–0.42)	0.67 (0.64–0.71)	1.3 (1.1–1.5)	1.6 (1.3–1.9)
4 (2014–2015)	925	99.9 (99.0–100)	0.59 (0.55–0.62)	0.33 (0.31–0.35)	0.56 (0.52–0.59)	1.0 (0.89–1.1)	1.3 (1.0–1.5)
5 (2016–2017)	511	100	0.54 (0.47–0.62)	0.28 (0.26–0.31)	0.52 (0.44–0.60)	1.0 (0.71–1.3)	1.3 (0.98–1.6)
6 (2018–2019)	500	98.9 (95.9–99.7)	0.49 (0.44–0.55)	0.24 (0.20–0.29)	0.47 (0.43–0.51)	0.99 (0.79–1.2)	1.2 ^E (0.31–2.0)
12–19 years							
1 (2007–2009)	945	100	0.80 (0.74–0.85)	0.47 (0.44–0.50)	0.76 (0.70–0.82)	1.3 (1.1–1.5)	1.6 (1.4–1.8)
2 (2009–2011)	997	100	0.71 (0.68–0.75)	0.39 (0.35–0.43)	0.68 (0.63–0.72)	1.2 (1.1–1.2)	1.6 (1.3–1.8)
3 (2012–2013)	977	100 (99.5–100)	0.64 (0.60–0.69)	0.34 (0.32–0.36)	0.60 (0.56–0.64)	1.2 (1.1–1.4)	1.5 (1.3–1.6)
4 (2014–2015)	974	99.7 (98.6–99.9)	0.54 (0.50–0.57)	0.30 (0.28–0.33)	0.51 (0.47–0.54)	0.98 (0.91–1.0)	1.1 (0.94–1.2)
5 (2016–2017)	521	100	0.49 (0.44–0.54)	0.26 (0.22–0.29)	0.47 (0.43–0.51)	0.94 (0.81–1.1)	1.0 (0.79–1.3)
6 (2018–2019)	504	99.0 (97.1–99.7)	0.47 (0.43–0.52)	0.26 (0.23–0.28)	0.45 (0.40–0.50)	0.89 (0.71–1.1)	1.2 (0.82–1.5)
20–39 years							
1 (2007–2009)	1165	100 (99.6–100)	1.1 (1.0–1.2)	0.57 (0.52–0.61)	1.0 (0.95–1.1)	2.3 (2.0–2.6)	3.1 (2.7–3.4)
2 (2009–2011)	1313	100	0.98 (0.88–1.1)	0.50 (0.43–0.57)	0.94 (0.87–1.0)	1.8 (1.5–2.1)	2.2 (1.6–2.9)
3 (2012–2013)	1032	99.4 (96.0–99.9)	0.90 (0.79–1.0)	0.44 (0.36–0.53)	0.88 (0.79–0.97)	1.7 (1.5–2.0)	2.1 (1.8–2.4)
4 (2014–2015)	1074	99.9 (98.9–100)	0.80 (0.74–0.88)	0.43 (0.39–0.47)	0.78 (0.67–0.88)	1.5 (1.2–1.7)	2.0 (1.6–2.5)
5 (2016–2017)	1038	99.8 (99.4–99.9)	0.78 (0.71–0.86)	0.35 (0.29–0.41)	0.83 (0.69–0.97)	1.5 (1.3–1.7)	1.9 (1.4–2.4)
6 (2018–2019)	1053	99.6 (96.8–100)	0.71 (0.66–0.76)	0.34 (0.28–0.40)	0.68 (0.62–0.73)	1.5 (1.3–1.7)	1.9 (1.4–2.5)
40–59 years							
1 (2007–2009)	1220	100	1.6 (1.5–1.8)	0.82 (0.69–0.94)	1.5 (1.4–1.6)	3.1 (2.6–3.6)	3.8 (3.1–4.5)
2 (2009–2011)	1222	100	1.4 (1.3–1.5)	0.70 (0.61–0.79)	1.4 (1.3–1.4)	2.7 (2.4–3.0)	3.2 (2.9–3.5)
3 (2012–2013)	1071	99.9 (98.4–100)	1.3 (1.3–1.4)	0.61 (0.55–0.68)	1.3 (1.2–1.4)	2.6 (2.2–2.9)	3.5 (2.9–4.2)
4 (2014–2015)	1051	100	1.2 (1.0–1.3)	0.58 (0.53–0.63)	1.1 (1.0–1.1)	2.4 (1.9–2.9)	3.2 (2.3–4.0)
5 (2016–2017)	990	99.2 (94.2–99.9)	1.1 (0.94–1.2)	0.50 (0.42–0.57)	1.0 (0.91–1.1)	2.1 (1.8–2.4)	2.6 (1.7–3.4)
6 (2018–2019)	1083	99.7 (91.3–100)	0.92 (0.86–1.0)	0.44 (0.37–0.51)	0.96 (0.88–1.1)	1.7 (1.5–2.0)	2.2 (1.9–2.5)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
60–79 years							
1 (2007–2009)	1079	100	2.1 (1.9–2.3)	1.0 (0.92–1.1)	2.0 (1.8–2.2)	4.1 (3.5–4.8)	5.2 (4.2–6.2)
2 (2009–2011)	1082	100	1.9 (1.8–1.9)	1.0 (0.94–1.1)	1.7 (1.7–1.8)	3.5 (3.2–3.8)	4.2 (3.8–4.6)
3 (2012–2013)	1043	99.9 (98.8–100)	1.6 (1.6–1.7)	0.81 (0.78–0.85)	1.6 (1.4–1.7)	3.3 (3.0–3.5)	4.0 (3.6–4.4)
4 (2014–2015)	995	100	1.5 (1.4–1.6)	0.74 (0.66–0.81)	1.4 (1.3–1.5)	2.9 (2.5–3.3)	3.8 (3.0–4.6)
5 (2016–2017)	984	100	1.4 (1.3–1.5)	0.70 (0.62–0.77)	1.4 (1.3–1.6)	2.5 (2.3–2.7)	3.1 (2.6–3.6)
6 (2018–2019)	974	99.9 (88.7–100)	1.3 (1.2–1.4)	0.66 (0.58–0.73)	1.2 (1.1–1.4)	2.4 (2.2–2.7)	3.1 (2.8–3.5)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 3, 4, 5 and 6 are 0.02, 0.1, 0.16, 0.16, 0.17 and 0.17 µg/dL, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

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8.2 ARSENIC

Arsenic (CASRN 7440-38-2) is a naturally occurring element. It is classified as a metalloid, exhibiting properties of both a metal and a non-metal. Arsenic is commonly found as an inorganic sulphide complexed with other metals (CCME, 1997). It also forms stable organic compounds in its trivalent (III) and pentavalent (V) states. Common organic arsenic compounds include monomethylarsonic acid (MMA), dimethylarsinic acid (DMA), arsenobetaine and arsenocholine (WHO, 2001).

Arsenic may enter lakes, rivers or groundwater naturally through erosion and weathering of soils, minerals and ores (HC, 2006). Anthropogenic sources of arsenic in the environment include the smelting of metal ores, the use of arsenical pesticides and the burning of fossil fuels (WHO, 2001).

Arsenic is used in the manufacture of transistors, lasers and semiconductors and in the processing of glass, pigments, textiles, paper, metal adhesives, ceramics, wood preservatives, ammunition and explosives. Historical uses include application of lead arsenate as a pesticide in apple orchards and vineyards and arsenic trioxide as an herbicide (ATSDR, 2007; HC, 2006). Chromated copper arsenate has been used as a wood preservative in residential construction projects, such

as playground structures and decks; however, it is now approved only for industrial purposes and domestic wood foundations (HC, 2011). In 2004, the wood-treatment industry in the U.S. and Canada began to transition away from chromated copper arsenate for most residential uses. Organic arsenical herbicides are no longer registered for use in Canada (HC, 2019).

The public can be exposed to arsenic through food, drinking water, soil, and ambient air (EC and HC, 1993). Food is the major source of exposure, with total arsenic concentrations being highest in seafood (IARC 2012). Organic forms of arsenic, including arsenobetaine and arsenocholine, make up the majority of arsenic in seafood (Ackley et al., 1999; Leufroy et al., 2011; Ruttens et al., 2012), while in other foods, the proportions of organic and inorganic arsenic forms may vary (Batista et al., 2011; CFIA, 2013; Conklin and Chen, 2012; FDA, 2016; Huang et al., 2012). Exposure may also arise from indoor house dust; levels of arsenic in dust can exceed levels in soil (Rasmussen et al., 2001). Further, exposure to arsenic may be elevated in populations residing in areas where industrial or natural sources occur.

Inorganic and organic arsenic can be absorbed via oral and inhalation routes; arsenic in all its forms is not readily absorbed via skin contact. Absorption of arsenic is much lower for highly insoluble forms of arsenic, such as arsenic sulfide, arsenic triselenide and lead arsenate (ATSDR, 2007). Following absorption, arsenic appears rapidly in blood circulation, where it binds primarily to haemoglobin. Within 24 hours, it is found in the liver, kidney, lung, spleen and skin. Skin, bone and muscle represent the major storage organs. In cases of chronic exposure, arsenic will preferentially accumulate in tissues rich in keratin or sulphhydryl functional groups, such as hair, nails and skin (HBM Commission, 2003). Metabolism of inorganic arsenic begins with a reduction of pentavalent to trivalent arsenic followed by oxidative methylation to monomethylated, dimethylated, and trimethylated products, including MMA and DMA (WHO, 2011). Methylation facilitates the excretion of inorganic arsenic from the body because the end products MMA and DMA are water soluble and readily excreted in urine (WHO, 2001). Absorbed organic arsenic species do not undergo significant metabolism and are predominantly and rapidly eliminated in urine (WHO, 2001).

Biomarkers of arsenic exposure include the levels of arsenic or its metabolites in blood, hair, nails and urine (WHO, 2001). Measurements of speciated metabolites

in urine expressed either as inorganic arsenic or as the sum of metabolites (inorganic arsenic + MMA + DMA) are generally accepted as the most reliable indicator of recent arsenic exposure (ATSDR, 2007; WHO, 2001). Measurements of arsenic in urine have been used to identify recent arsenic ingestion or above-average exposures in populations living near industrial point sources of arsenic (ATSDR, 2007).

Acute oral arsenic exposure may cause gastrointestinal effects in humans as well as pain in the extremities and muscles (HC, 2006). These symptoms are often followed by numbness and tingling of the extremities and muscular cramping, and may progress to burning paraesthesias of the extremities, palmoplantar hyperkeratosis, and deterioration in motor and sensory responses (HC, 2006).

Chronic exposure to inorganic arsenic has been associated with decreased lung function, non-cancer skin effects and cardiovascular effects, including increased incidence of high blood pressure and circulatory problems (ATSDR, 2007; EC and HC, 1993). In addition, increased incidences of skin cancer and various cancers of the internal organs have been associated with chronic ingestion of inorganic arsenic-contaminated drinking water (HC, 2006). Much of the evidence on the carcinogenicity of arsenic in humans comes from epidemiological studies conducted in populations consuming high levels of inorganic arsenic through drinking water, including those from Taiwan, Chile and Bangladesh (HC, 2006; 2016). Arsenic and inorganic arsenic compounds are classified as carcinogenic to humans by Health Canada and other international agencies (EPA, 2002; HC, 2006; IARC, 2012). A growing body of evidence suggests that in utero and childhood exposure to high levels of inorganic arsenic may affect fetal and childhood health and development (EFSA CONTAM Panel, 2009; FAO/WHO, 2011; FDA, 2016; NRC, 2013). Although the current amount of information regarding developmental effects in humans is relatively limited and presents some conflicting results, the available data do raise concerns surrounding exposure to inorganic arsenic during critical windows of early development (HC, 2016; Tchounwou et al., 2018). While the majority of assessments of the toxicity of arsenic have focused on the inorganic forms, studies have highlighted the potential for organic arsenic compounds, in particular pentavalent DMA, to be carcinogenic (Cohen et al., 2006; IARC, 2012; Schwerdtle et al., 2003). The

International Agency for Research on Cancer (IARC) has classified the methylated arsenic metabolites MMA and DMA as Group 2B, possibly carcinogenic to humans, based on evidence from experimental animals (IARC, 2012). IARC has also evaluated arsenobetaine and other organic arsenic compounds and concluded that they are not classifiable with respect to their carcinogenicity in humans (Group 3) (IARC 2012).

As part of a risk assessment conducted under the mandate of the *Canadian Environmental Protection Act, 1999* (CEPA 1999), Health Canada and Environment Canada concluded that arsenic and its inorganic compounds in Canada may be harmful to the environment and may constitute a danger to human life or health (EC and HC, 1993). Inorganic arsenic compounds are listed on Schedule 1, List of Toxic Substances, under CEPA 1999, which allows the federal government to control the importation, manufacture, distribution and use of inorganic arsenic compounds in Canada (Canada, 1999; Canada, 2000). Risk management actions under CEPA 1999 have been developed to control releases of arsenic from thermal electric power generation, base-metal smelting, metal mining, wood preservation and steel manufacturing processes (ECCC, 2017). Arsenic and its compounds are on the List of Ingredients that are Prohibited for Use in Cosmetic Products (HC, 2019). The Food and Drug Regulations prohibit the sale in Canada of drugs for human use containing arsenic or any of its salts or derivatives (Canada, 2012). Further, the leachable arsenic content in a variety of consumer products is regulated under the *Canada Consumer Product Safety Act* (Canada, 2010a). These regulated consumer products include paints and other surface coatings on cribs, toys and other products for use by children in learning or play situations (Canada, 2010b; Canada, 2011). The sale and use of arsenical pesticides, such as chromated copper arsenate, are regulated in Canada by the Pest Management Regulatory Agency (PMRA) under the *Pest Control Products Act* (Canada, 2002).

Health Canada, in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water, has developed a guideline for Canadian drinking water quality that establishes a maximum acceptable concentration for arsenic in drinking water (HC, 2006). The guideline was developed based on the incidence of internal (lung, bladder and liver) cancers in humans and the ability of currently available treatment technologies to remove arsenic from drinking water at

or below the guideline level (HC, 2006). Arsenic is also included in the list of trace elements analyzed as part of Health Canada's ongoing Total Diet Study surveys (HC, 2020a). The food items analyzed represent those that are most typical of the Canadian diet, and the surveys are used to provide dietary exposure estimates for chemicals that Canadians in different age-sex groups are exposed to through the food supply. The concentration of arsenic in specific foods is managed by Health Canada under the Food and Drug Regulations (Canada, 1978); the existing maximum levels for arsenic in foods are found in the List of Contaminants and Other Adulterating Substances in Foods. Health Canada has updated the maximum level for total arsenic in bottled water and established new maximum levels for inorganic arsenic in rice (HC, 2017; 2020b); maximum levels for other foods and beverages are scheduled for review and update.

Arsenic concentrations in urine have been measured in a number of biomonitoring studies conducted in Canada, including the Maternal–Infant Research on Environmental Chemicals study (Ettinger et al., 2017) and the First Nations Biomonitoring Initiative (AFN, 2013).

Arsenite (III), arsenate (V) and methylated metabolites of arsenic (MMA and DMA) were analyzed individually in the urine of Canadian Health Measures Survey (CHMS) participants aged 3–79 in cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented as both $\mu\text{g As/L}$ and $\mu\text{g As/g creatinine}$. The organoarsenic compounds arsenobetaine and arsenocholine were analyzed together in the urine of CHMS participants aged 3–79 in cycles 2, 3, 4, 5 and 6; arsenocholine was also analyzed alone in cycles 3 and 4. Data from these cycles are presented as both $\mu\text{g As/L}$ and $\mu\text{g As/g creatinine}$. In addition, total arsenic was measured in the urine of CHMS participants aged 6–79 in cycle 1 and aged 3–79 in cycle 2, and analyzed in hair from CHMS participants aged 20–59 in cycle 5. Finding a measurable amount of arsenic in urine or hair is an indicator of exposure to arsenic and does not necessarily mean that an adverse health effect will occur.

Table 8.2.1

Inorganic-related arsenic species^a—Geometric means and selected percentiles of urine concentrations (µg As/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	GM (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years						
2 (2009–2011)	2537	5.3 (4.7–6.0)	2.1 (2.0–2.3)	4.8 (4.2–5.4)	14 (11–18)	22 ^E (12–33)
3 (2012–2013)	2535	5.4 (4.9–6.0)	2.2 (2.0–2.5)	4.6 (4.2–5.0)	14 (10–18)	21 ^E (12–31)
4 (2014–2015)	2567	5.3 (4.9–5.9)	2.2 (2.1–2.4)	4.7 (4.2–5.3)	14 (12–16)	20 (15–25)
5 (2016–2017)	2615	4.3 (3.5–5.4)	1.3 (0.98–1.6)	4.1 (3.2–5.1)	14 ^E (8.4–19)	20 ^E (9.5–30)
6 (2018–2019)	2531	4.8 (4.2–5.4)	1.4 (1.2–1.6)	4.6 (3.8–5.3)	16 (12–20)	27 ^E (16–38)
Males, 3–79 years						
2 (2009–2011)	1271	5.5 (4.8–6.4)	2.2 (1.8–2.5)	5.0 (3.9–6.1)	15 (11–19)	22 ^E (12–32)
3 (2012–2013)	1250	5.6 (5.0–6.3)	2.4 (1.9–3.0)	5.1 (4.4–5.8)	13 (10–15)	19 ^F (7.9–29)
4 (2014–2015)	1275	5.6 (4.9–6.4)	2.2 (2.0–2.4)	4.9 (4.1–5.7)	15 (12–19)	25 ^E (15–35)
5 (2016–2017)	1299	4.3 (3.5–5.3)	1.3 (0.83–1.7)	4.0 (3.2–4.8)	14 (9.2–20)	20 ^F (12–29)
6 (2018–2019)	1256	5.3 (4.6–6.1)	1.5 (1.3–1.7)	5.2 (4.5–5.8)	21 (15–27)	32 ^E (10–54)
Females, 3–79 years						
2 (2009–2011)	1266	5.1 (4.5–5.8)	2.1 (1.8–2.4)	4.7 (4.2–5.2)	14 (10–18)	22 ^E (8.9–36)
3 (2012–2013)	1285	5.2 (4.5–6.1)	2.2 (2.0–2.3)	4.3 (3.9–4.7)	16 ^F (8.2–23)	26 ^F (5.4–47)
4 (2014–2015)	1292	5.1 (4.6–5.7)	2.3 (2.1–2.5)	4.5 (3.9–5.1)	13 (10–16)	17 (12–23)
5 (2016–2017)	1316	4.4 (3.4–5.7)	1.3 (0.98–1.6)	4.4 (3.2–5.5)	13 ^F (6.4–19)	19 ^F (0–47)
6 (2018–2019)	1275	4.3 (3.7–5.0)	1.3 (1.1–1.5)	4.1 (3.3–4.9)	13 (9.9–16)	19 ^F (3.1–34)
3–5 years						
2 (2009–2011)	516	5.2 (4.6–5.9)	2.5 (2.3–2.7)	4.6 (4.1–5.1)	11 (7.4–15)	16 ^F (10–22)
3 (2012–2013)	500	5.0 (4.6–5.4)	2.2 (1.9–2.5)	4.5 (4.0–5.1)	13 (10–16)	19 ^F (11–26)
4 (2014–2015)	512	5.0 (4.5–5.6)	2.3 (2.0–2.6)	4.6 (4.0–5.1)	12 (9.5–14)	15 ^F (9.6–21)
5 (2016–2017)	535	4.5 (3.7–5.4)	1.4 (0.92–1.9)	4.5 (3.6–5.5)	14 (9.8–18)	23 ^F (13–33)
6 (2018–2019)	513	5.0 (4.1–6.0)	1.6 (1.4–1.9)	4.8 (3.6–6.0)	14 (11–18)	18 ^F (9.8–27)
6–11 years						
2 (2009–2011)	511	5.5 (5.1–6.0)	2.6 (2.3–2.9)	5.4 (4.8–6.1)	12 (9.7–14)	17 (11–23)
3 (2012–2013)	506	5.2 (4.5–6.0)	2.2 (1.7–2.7)	4.9 (4.2–5.6)	11 (7.8–14)	17 ^E (9.1–25)
4 (2014–2015)	514	5.5 (4.9–6.3)	2.5 (2.0–2.9)	5.0 (4.3–5.7)	13 (8.9–18)	20 ^E (8.1–32)
5 (2016–2017)	513	4.4 (4.0–4.8)	1.7 (1.4–1.9)	4.3 (3.8–4.9)	9.7 (8.6–11)	14 (10–18)
6 (2018–2019)	499	5.7 (4.1–7.8)	1.5 ^F (0.74–2.3)	5.1 (4.2–6.0)	18 ^F (0–38)	57 ^F (0–150)

Cycle	n	GM (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years						
2 (2009–2011)	510	5.5 (4.6–6.6)	2.3 (1.9–2.7)	4.8 (3.6–6.0)	15 (11–19)	22 ^E (12–32)
3 (2012–2013)	510	5.4 (4.7–6.3)	2.4 (2.0–2.9)	4.7 (3.5–5.9)	13 (8.4–17)	20 ^E (7.7–31)
4 (2014–2015)	506	5.5 (4.7–6.4)	2.4 (1.9–2.8)	4.6 (3.8–5.5)	14 (9.3–18)	19 (14–24)
5 (2016–2017)	517	4.5 (3.8–5.3)	1.5 (1.1–2.0)	4.5 (3.9–5.1)	12 (9.1–16)	17 ^E (11–24)
6 (2018–2019)	505	5.4 (4.5–6.5)	1.6 (1.2–2.1)	5.0 (3.8–6.2)	19 (13–26)	31 ^E (11–52)
20–39 years						
2 (2009–2011)	355	5.6 (4.6–6.8)	2.1 (1.8–2.4)	5.1 (3.8–6.3)	16 ^E (3.1–28)	28 ^E (16–41)
3 (2012–2013)	355	5.8 (5.0–6.6)	2.4 (1.7–3.1)	4.8 (4.1–5.5)	15 ^E (5.6–25)	31 ^E (9.7–52)
4 (2014–2015)	362	5.5 (4.9–6.1)	2.2 (1.8–2.6)	4.9 (4.2–5.7)	14 (12–16)	16 (13–20)
5 (2016–2017)	357	4.6 (3.2–6.6)	1.5 ^E (0.85–2.2)	3.8 (2.6–5.0)	17 ^E (6.1–29)	27 ^E (0–55)
6 (2018–2019)	330	5.5 (4.3–7.0)	1.5 (1.2–1.8)	5.2 (4.2–6.2)	22 ^E (5.1–38)	42 ^E (8.0–77)
40–59 years						
2 (2009–2011)	356	4.9 (4.2–5.7)	2.0 (1.6–2.5)	4.2 (3.6–4.9)	12 (9.2–15)	15 (12–19)
3 (2012–2013)	312	5.3 (4.3–6.4)	2.2 (1.8–2.6)	4.5 (3.7–5.3)	15 ^E (5.6–23)	21 ^E (1.4–40)
4 (2014–2015)	312	5.1 (4.4–6.0)	2.2 (2.0–2.4)	4.3 (3.4–5.1)	14 ^E (4.8–23)	23 ^E (13–32)
5 (2016–2017)	345	4.5 (3.4–6.0)	1.2 (0.90–1.5)	4.7 (3.2–6.3)	13 ^E (8.2–19)	19 ^E (3.5–34)
6 (2018–2019)	342	4.2 (3.4–5.2)	1.3 (0.94–1.7)	4.1 (3.2–4.9)	13 ^E (7.6–18)	20 ^E (11–29)
60–79 years						
2 (2009–2011)	289	5.4 (4.4–6.6)	2.2 (1.9–2.4)	4.7 (4.1–5.4)	16 ^E (8.9–24)	24 ^E (5.4–42)
3 (2012–2013)	352	5.3 (4.6–6.2)	2.2 (2.0–2.3)	4.7 (3.8–5.5)	14 (11–17)	22 ^E (14–31)
4 (2014–2015)	361	5.4 (4.5–6.5)	2.3 (1.9–2.6)	4.8 (3.7–6.0)	15 (10–19)	18 ^E (6.2–29)
5 (2016–2017)	348	3.8 (3.0–4.7)	1.1 (0.84–1.4)	3.3 (2.3–4.3)	13 (9.0–18)	18 (14–22)
6 (2018–2019)	342	4.2 (3.5–5.1)	1.2 (0.96–1.5)	3.6 (2.5–4.8)	16 (11–20)	21 (15–28)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: There is no LOD for inorganic-related arsenic species because the values are calculated rather than measured. In the absence of an LOD, values as low as zero can appear in the table.

a For each individual within a cycle, the sum of arsenate, arsenite, dimethylarsinic acid, and monomethylarsonic acid is calculated. If the value of a species is less than the LOD, then the imputed value calculated as LOD divided by 2 is used. If all four arsenic species are reported as less than the LOD, then the sum will be the sum of the four imputed values.

E Use data with caution

Table 8.2.2

Inorganic-related arsenic species^a (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/g creatinine}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	GM (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years						
2 (2009–2011)	2527	5.3 (4.6–6.0)	2.3 (2.1–2.5)	4.7 (4.0–5.4)	13 (9.1–17)	20 (13–27)
3 (2012–2013)	2534	5.5 (4.8–6.3)	2.2 (2.0–2.5)	4.9 (4.4–5.5)	14 ^F (7.8–21)	26 ^F (12–39)
4 (2014–2015)	2566	4.8 (4.3–5.4)	2.1 (1.9–2.3)	4.3 (3.8–4.7)	12 (8.7–16)	18 (14–22)
5 (2016–2017)	2605	4.3 (3.5–5.2)	1.6 (1.3–1.9)	3.6 (2.9–4.3)	12 (8.0–16)	18 (12–24)
6 (2018–2019)	2530	5.2 (4.5–6.0)	2.0 (1.7–2.3)	4.6 (4.0–5.3)	16 (12–20)	21 (14–29)
Males, 3–79 years						
2 (2009–2011)	1267	4.7 (4.1–5.5)	2.2 (2.0–2.5)	4.2 (3.4–4.9)	10 (8.0–13)	15 ^E (5.8–24)
3 (2012–2013)	1250	4.6 (4.2–5.1)	2.0 (1.7–2.3)	4.4 (3.7–5.1)	9.6 (7.7–12)	17 ^E (9.2–24)
4 (2014–2015)	1274	4.4 (3.9–5.0)	2.0 (1.8–2.3)	3.9 (3.5–4.4)	10 (7.3–13)	15 (11–19)
5 (2016–2017)	1296	3.7 (3.1–4.5)	1.4 (1.1–1.8)	3.2 (2.7–3.7)	12 (7.7–16)	17 (13–21)
6 (2018–2019)	1255	4.9 (4.3–5.7)	1.8 (1.4–2.2)	4.3 (3.5–5.0)	17 (12–22)	23 ^E (8.3–37)
Females, 3–79 years						
2 (2009–2011)	1260	5.8 (5.1–6.8)	2.4 (2.1–2.8)	5.3 (4.5–6.1)	15 (10–21)	22 ^E (14–30)
3 (2012–2013)	1284	6.6 (5.5–8.0)	2.5 (2.2–2.9)	5.8 (4.8–6.7)	19 ^E (5.6–33)	33 ^E (18–49)
4 (2014–2015)	1292	5.3 (4.5–6.1)	2.4 (2.0–2.7)	4.7 (4.1–5.4)	14 (9.0–18)	20 (15–25)
5 (2016–2017)	1309	4.9 (3.9–6.1)	1.9 (1.5–2.4)	4.3 (3.4–5.3)	12 ^E (7.2–17)	19 ^E (0–51)
6 (2018–2019)	1275	5.5 (4.6–6.4)	2.2 (1.9–2.5)	5.2 (4.4–6.0)	14 (10–19)	20 ^F (6.2–34)
3–5 years						
2 (2009–2011)	515	9.1 (8.1–10)	4.6 (4.0–5.2)	8.0 (7.0–8.9)	19 (15–24)	29 ^F (13–45)
3 (2012–2013)	499	9.6 (8.8–10)	4.7 (4.2–5.2)	8.7 (7.9–9.5)	20 (15–25)	29 ^F (13–45)
4 (2014–2015)	512	8.7 (8.0–9.5)	4.2 (3.6–4.8)	7.9 (7.2–8.6)	19 (15–23)	26 (18–34)
5 (2016–2017)	532	7.5 (6.1–9.1)	3.5 (2.8–4.2)	6.8 (5.3–8.3)	17 ^E (9.7–24)	27 (18–35)
6 (2018–2019)	512	8.2 (6.9–9.6)	3.6 (2.8–4.5)	7.9 (6.4–9.4)	17 ^E (10–24)	30 ^F (16–44)
6–11 years						
2 (2009–2011)	509	6.4 (5.8–7.1)	3.2 (2.9–3.5)	5.9 (5.2–6.5)	14 (10–17)	23 ^F (14–31)
3 (2012–2013)	506	6.6 (5.8–7.5)	3.4 (3.1–3.7)	5.9 (5.3–6.5)	13 (9.2–17)	17 ^E (9.8–25)
4 (2014–2015)	513	6.1 (5.5–6.7)	3.0 (2.8–3.3)	5.5 (4.9–6.0)	14 (9.9–18)	18 ^F (11–25)
5 (2016–2017)	509	5.1 (4.5–5.7)	2.3 (1.7–2.9)	4.9 (4.4–5.3)	11 (8.9–13)	14 (8.7–19)
6 (2018–2019)	499	6.8 (5.1–8.9)	2.7 (2.3–3.1)	5.3 (4.3–6.4)	23 ^F (0–43)	58 ^F (0–140)

Cycle	n	GM (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years						
2 (2009–2011)	508	4.1 (3.6–5.0)	1.9 (1.6–2.2)	3.6 (3.0–4.2)	12 ^E (6.7–16)	17 ^E (9.4–26)
3 (2012–2013)	510	4.1 (3.3–5.0)	1.9 (1.7–2.1)	3.5 (2.8–4.1)	10 ^E (5.5–15)	17 ^E (9.4–24)
4 (2014–2015)	506	4.0 (3.5–4.5)	1.7 (1.4–2.0)	3.6 (3.0–4.2)	9.1 (6.3–12)	13 ^E (8.0–18)
5 (2016–2017)	515	3.4 (3.0–3.9)	1.5 (1.1–1.9)	3.0 (2.6–3.4)	8.1 (6.0–10)	13 ^E (6.1–20)
6 (2018–2019)	505	4.5 (3.6–5.5)	1.6 (1.2–2.0)	3.9 (2.8–5.1)	15 ^E (9.3–20)	19 ^E (12–27)
20–39 years						
2 (2009–2011)	353	4.8 (3.8–5.9)	2.3 (1.9–2.6)	3.9 (2.7–5.1)	12 ^E (4.2–21)	21 ^E (12–31)
3 (2012–2013)	355	4.4 (3.8–5.1)	1.8 (1.3–2.3)	3.8 (3.0–4.5)	11 ^E (0.33–21)	22 ^E (5.1–39)
4 (2014–2015)	362	4.4 (3.8–5.1)	2.0 (1.8–2.3)	3.9 (3.3–4.5)	10 (6.6–14)	15 ^E (7.5–22)
5 (2016–2017)	357	4.2 ^E (2.9–6.1)	1.4 (0.96–1.8)	3.4 (2.2–4.6)	13 ^E (4.1–21)	20 ^E (0–41)
6 (2018–2019)	330	5.2 (4.2–6.4)	1.9 (1.7–2.2)	4.4 (3.5–5.3)	15 ^E (0.31–30)	33 ^E (0–69)
40–59 years						
2 (2009–2011)	354	5.0 (4.5–5.6)	2.3 (2.0–2.5)	4.6 (3.8–5.5)	10 (7.6–13)	14 ^E (9.2–20)
3 (2012–2013)	312	6.2 (5.1–7.6)	2.5 (2.2–2.9)	5.7 (4.7–6.8)	15 ^E (0.95–30)	34 ^E (8.1–60)
4 (2014–2015)	312	4.7 (3.9–5.5)	2.1 (1.7–2.4)	4.2 (3.8–4.6)	11 ^E (5.1–17)	19 ^E (9.6–29)
5 (2016–2017)	345	4.1 (3.3–5.1)	1.6 (1.2–2.1)	3.4 (2.5–4.3)	12 (8.2–16)	20 (13–26)
6 (2018–2019)	342	5.0 (4.2–6.0)	2.1 (1.6–2.5)	4.8 (3.9–5.6)	16 (11–22)	18 (15–21)
60–79 years						
2 (2009–2011)	288	6.4 (5.2–7.8)	2.5 (2.1–3.0)	6.0 (4.7–7.3)	16 ^E (6.2–25)	26 ^E (8.6–43)
3 (2012–2013)	352	6.0 (4.9–7.2)	2.6 (2.1–3.2)	5.1 (4.0–6.2)	15 ^E (3.8–26)	27 ^E (15–40)
4 (2014–2015)	361	5.2 (4.5–6.1)	2.3 (2.1–2.5)	4.5 (3.5–5.5)	13 (9.2–16)	19 ^E (10–28)
5 (2016–2017)	347	4.4 (3.6–5.3)	1.8 (1.6–2.1)	3.9 (3.0–4.8)	11 (7.4–15)	15 (13–18)
6 (2018–2019)	342	5.0 (4.2–5.9)	1.8 ^E (0.98–2.6)	4.4 (3.5–5.3)	12 (8.6–16)	20 (14–26)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: There is no LOD for inorganic-related arsenic species because the values are calculated rather than measured. In the absence of an LOD, values as low as zero can appear in the table.

a For each individual within a cycle, the sum of arsenate, arsenite, dimethylarsinic acid, and monomethylarsonic acid is calculated. If the value of a species is less than the LOD, then the imputed value calculated as LOD divided by 2 is used. If all four arsenic species are reported as less than the LOD, then the sum will be the sum of the four imputed values.

E Use data with caution.

Table 8.2.3

Arsenite—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2537	27.4 (21.0–34.9)	—	<LOD	<LOD	1.7 (1.1–2.3)	2.7 ^E (1.3–4.0)
3 (2012–2013)	2535	25.7 (22.7–29.0)	—	<LOD	<LOD	1.7 ^E (0.92–2.5)	4.1 ^E (<LOD–7.5)
4 (2014–2015)	2567	31.9 (27.0–37.2)	—	<LOD	<LOD	1.9 (1.5–2.3)	2.7 (2.1–3.4)
5 (2016–2017)	2615	60.9 (51.2–69.8)	—	<LOD	0.36 (0.25–0.48)	2.2 ^E (0.91–3.4)	3.5 ^E (0.50–6.5)
6 (2018–2019)	2531	68.3 (62.6–73.5)	0.45 (0.39–0.52)	<LOD	0.42 (0.35–0.49)	2.1 (1.5–2.7)	3.6 ^E (1.8–5.5)
Males, 3–79 years							
2 (2009–2011)	1271	31.7 (23.8–40.7)	—	<LOD	<LOD	1.7 (1.1–2.3)	2.8 ^E (0.88–4.7)
3 (2012–2013)	1250	29.1 (23.9–34.8)	—	<LOD	<LOD	1.4 (1.0–1.8)	2.5 ^E (<LOD–4.8)
4 (2014–2015)	1275	36.0 (29.3–43.4)	—	<LOD	<LOD	2.2 (1.7–2.6)	3.0 (2.3–3.8)
5 (2016–2017)	1299	62.2 (50.8–72.5)	—	<LOD	0.37 (0.26–0.47)	1.9 ^E (0.69–3.0)	3.7 ^E (0.86–6.5)
6 (2018–2019)	1256	71.4 (64.8–77.1)	0.50 (0.43–0.58)	<LOD	0.48 (0.40–0.56)	2.2 ^E (1.2–3.1)	4.3 ^E (0.84–7.7)
Females, 3–79 years							
2 (2009–2011)	1266	23.0 (17.2–30.1)	—	<LOD	<LOD	1.5 ^E (0.72–2.3)	2.4 ^E (1.1–3.7)
3 (2012–2013)	1285	22.3 (16.4–29.7)	—	<LOD	<LOD	2.2 ^E (<LOD–4.4)	4.5 ^E (<LOD–9.5)
4 (2014–2015)	1292	27.8 (21.7–34.8)	—	<LOD	<LOD	1.5 (1.1–2.0)	2.4 ^E (1.3–3.5)
5 (2016–2017)	1316	59.5 (49.9–68.5)	—	<LOD	0.36 ^E (<LOD–0.50)	2.5 ^E (1.0–4.0)	3.2 ^E (<LOD–7.7)
6 (2018–2019)	1275	65.2 (57.1–72.5)	0.40 (0.33–0.48)	<LOD	0.37 (0.30–0.45)	1.9 ^E (1.2–2.6)	2.9 ^E (0.82–5.0)
3–5 years							
2 (2009–2011)	516	14.0 (9.7–19.6)	—	<LOD	<LOD	0.79 ^E (<LOD–1.2)	1.3 ^E (0.74–1.9)
3 (2012–2013)	500	13.9 (10.7–17.9)	—	<LOD	<LOD	0.94 (<LOD–1.2)	1.9 ^E (0.75–3.0)
4 (2014–2015)	512	17.3 (13.1–22.5)	—	<LOD	<LOD	1.1 (0.84–1.3)	1.8 ^E (1.0–2.5)
5 (2016–2017)	535	49.1 (37.4–60.9)	—	<LOD	<LOD	1.3 (0.96–1.5)	1.8 ^E (0.57–3.1)
6 (2018–2019)	513	66.5 (54.2–77.0)	0.37 (0.31–0.46)	<LOD	0.38 (0.30–0.46)	1.4 (0.91–1.9)	1.8 ^E (0.99–2.6)
6–11 years							
2 (2009–2011)	511	20.6 (15.7–26.4)	—	<LOD	<LOD	1.0 ^E (<LOD–1.4)	1.8 ^E (1.1–2.4)
3 (2012–2013)	506	21.2 ^E (13.3–32.1)	—	<LOD	<LOD	1.1 (0.81–1.4)	1.6 ^E (0.82–2.5)
4 (2014–2015)	514	25.6 (19.0–33.6)	—	<LOD	<LOD	1.5 ^E (0.92–2.0)	2.6 ^E (1.2–4.0)
5 (2016–2017)	513	53.6 (44.3–62.6)	—	<LOD	0.26 ^E (<LOD–0.38)	1.3 (0.87–1.7)	1.7 (1.4–2.1)
6 (2018–2019)	499	71.3 (61.5–79.4)	0.45 (0.33–0.62)	<LOD	0.40 (0.31–0.49)	1.9 ^E (<LOD–6.3)	9.4 ^E (<LOD–19)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
2 (2009–2011)	510	29.2 (21.1–38.9)	—	<LOD	<LOD	1.9 ^E (1.2–2.7)	3.1 ^E (0.82–5.3)
3 (2012–2013)	510	28.2 (21.2–36.5)	—	<LOD	<LOD	1.5 ^E (<LOD–2.3)	2.6 ^E (1.1–4.0)
4 (2014–2015)	506	34.6 (26.6–43.5)	—	<LOD	<LOD	2.1 ^E (1.2–3.0)	3.2 (2.1–4.4)
5 (2016–2017)	517	64.4 (53.0–74.4)	0.40 (0.31–0.53)	<LOD	0.42 (0.29–0.55)	1.6 ^E (<LOD–3.3)	4.2 ^E (1.1–7.3)
6 (2018–2019)	505	78.7 (67.1–87.0)	0.55 (0.43–0.70)	<LOD	0.51 (0.37–0.64)	3.1 ^E (1.4–4.9)	3.7 (2.4–5.0)
20–39 years							
2 (2009–2011)	355	31.8 (21.8–43.8)	—	<LOD	<LOD	1.9 ^E (<LOD–3.1)	3.1 ^E (<LOD–5.7)
3 (2012–2013)	355	28.9 (22.1–36.9)	—	<LOD	<LOD	1.8 ^E (<LOD–4.2)	5.4 ^E (<LOD–11)
4 (2014–2015)	362	34.5 (28.5–41.1)	—	<LOD	<LOD	2.3 (1.7–2.8)	3.0 (2.3–3.8)
5 (2016–2017)	357	68.5 (53.6–80.4)	0.50 ^E (0.31–0.78)	<LOD	0.44 ^E (0.27–0.61)	3.0 ^E (0.53–5.5)	4.0 ^E (<LOD–9.5)
6 (2018–2019)	330	74.3 (63.9–82.5)	0.58 (0.42–0.80)	<LOD	0.54 (0.34–0.73)	2.8 ^E (<LOD–6.2)	6.5 ^E (<LOD–14)
40–59 years							
2 (2009–2011)	356	25.2 (17.6–34.8)	—	<LOD	<LOD	1.3 ^E (0.75–1.8)	2.0 ^E (1.0–2.9)
3 (2012–2013)	312	24.5 ^E (16.6–34.5)	—	<LOD	<LOD	1.7 ^E (<LOD–4.3)	4.4 ^E (<LOD–9.9)
4 (2014–2015)	312	29.4 (20.1–40.8)	—	<LOD	<LOD	1.6 ^E (1.0–2.3)	2.3 ^E (1.5–3.2)
5 (2016–2017)	345	63.2 (44.6–78.6)	0.43 ^E (0.29–0.65)	<LOD	0.37 ^E (<LOD–0.59)	2.5 ^E (1.2–3.7)	2.9 ^E (0.33–5.4)
6 (2018–2019)	342	66.9 (54.2–77.6)	0.39 (0.30–0.50)	<LOD	0.37 (0.27–0.47)	1.6 (1.0–2.1)	2.2 (1.6–2.7)
60–79 years							
2 (2009–2011)	289	28.1 (19.5–38.6)	—	<LOD	<LOD	1.9 ^E (1.1–2.7)	2.5 ^E (<LOD–5.9)
3 (2012–2013)	352	26.2 (18.9–35.1)	—	<LOD	<LOD	1.8 (1.1–2.4)	3.2 ^E (1.3–5.2)
4 (2014–2015)	361	35.2 (26.2–45.4)	—	<LOD	<LOD	1.8 (1.2–2.3)	2.7 ^E (<LOD–5.0)
5 (2016–2017)	348	49.5 (39.8–59.3)	—	<LOD	<LOD	1.6 ^E (0.77–2.4)	3.4 ^E (1.5–5.4)
6 (2018–2019)	342	56.5 (46.4–66.1)	0.36 (0.29–0.44)	<LOD	0.29 ^E (<LOD–0.45)	1.7 (1.1–2.2)	3.5 ^E (1.7–5.3)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 3, 4, 5 and 6 are 0.8, 0.75, 0.75, 0.25 and 0.25 µg As/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.4

Arsenite (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/g creatinine}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2527	27.4 (21.0–34.9)	—	<LOD	<LOD	2.0 (1.6–2.3)	2.9 (1.9–3.9)
3 (2012–2013)	2534	25.7 (22.7–29.0)	—	<LOD	<LOD	1.9 ^E (1.2–2.7)	3.6 ^E (<LOD–6.4)
4 (2014–2015)	2566	31.9 (27.0–37.2)	—	<LOD	<LOD	1.6 (1.3–1.9)	2.2 (1.5–2.9)
5 (2016–2017)	2605	60.9 (51.2–69.8)	—	<LOD	0.35 (0.28–0.42)	1.7 ^E (0.71–2.7)	3.3 ^E (1.7–5.0)
6 (2018–2019)	2530	68.3 (62.6–73.5)	0.49 (0.42–0.58)	<LOD	0.44 (0.36–0.51)	1.9 (1.3–2.4)	3.3 ^E (1.5–5.1)
Males, 3–79 years							
2 (2009–2011)	1267	31.7 (23.8–40.7)	—	<LOD	<LOD	1.4 ^E (0.85–1.9)	2.0 ^E (<LOD–3.5)
3 (2012–2013)	1250	29.1 (23.9–34.8)	—	<LOD	<LOD	1.2 (0.94–1.5)	2.1 ^E (<LOD–4.1)
4 (2014–2015)	1274	36.0 (29.3–43.4)	—	<LOD	<LOD	1.5 (1.0–1.9)	2.0 (1.4–2.6)
5 (2016–2017)	1296	62.2 (50.8–72.5)	—	<LOD	0.31 (0.25–0.38)	1.6 ^E (0.91–2.3)	2.9 ^E (1.6–4.1)
6 (2018–2019)	1255	71.4 (64.8–77.1)	0.47 (0.41–0.54)	<LOD	0.41 (0.35–0.48)	1.8 ^E (1.0–2.6)	3.2 ^E (<LOD–7.0)
Females, 3–79 years							
2 (2009–2011)	1260	23.0 (17.2–30.1)	—	<LOD	<LOD	2.2 (1.6–2.8)	3.0 (2.1–3.9)
3 (2012–2013)	1284	22.3 (16.4–29.7)	—	<LOD	<LOD	2.4 ^E (<LOD–3.9)	4.6 ^E (<LOD–15)
4 (2014–2015)	1292	27.8 (21.7–34.8)	—	<LOD	<LOD	1.7 (1.2–2.1)	2.6 ^E (1.4–3.9)
5 (2016–2017)	1309	59.5 (49.9–68.5)	—	<LOD	0.41 (<LOD–0.55)	1.8 ^E (0.37–3.3)	3.3 ^E (<LOD–7.4)
6 (2018–2019)	1275	65.2 (57.1–72.5)	0.51 (0.42–0.63)	<LOD	0.47 (0.36–0.59)	2.1 (1.4–2.7)	3.3 ^E (1.1–5.6)
3–5 years							
2 (2009–2011)	515	14.0 (9.7–19.6)	—	<LOD	<LOD	1.9 (<LOD–2.2)	2.9 (1.9–3.9)
3 (2012–2013)	499	13.9 (10.7–17.9)	—	<LOD	<LOD	2.5 ^E (<LOD–3.7)	4.3 ^E (2.6–6.1)
4 (2014–2015)	512	17.3 (13.1–22.5)	—	<LOD	<LOD	2.1 (1.8–2.5)	3.0 ^E (1.8–4.2)
5 (2016–2017)	532	49.1 (37.4–60.9)	—	<LOD	<LOD	1.7 (1.2–2.2)	2.3 ^E (1.3–3.3)
6 (2018–2019)	512	66.5 (54.2–77.0)	0.62 (0.53–0.73)	<LOD	0.60 (0.51–0.70)	1.6 (1.2–2.0)	2.6 (1.9–3.4)
6–11 years							
2 (2009–2011)	509	20.6 (15.7–26.4)	—	<LOD	<LOD	1.6 ^E (<LOD–2.2)	2.2 ^E (1.2–3.1)
3 (2012–2013)	506	21.2 ^E (13.3–32.1)	—	<LOD	<LOD	1.7 (1.1–2.2)	2.5 ^E (1.3–3.6)
4 (2014–2015)	513	25.6 (19.0–33.6)	—	<LOD	<LOD	1.6 (1.2–2.0)	2.2 ^E (0.77–3.7)
5 (2016–2017)	509	53.6 (44.3–62.6)	—	<LOD	0.34 (<LOD–0.44)	1.2 (0.92–1.4)	1.7 (1.1–2.3)
6 (2018–2019)	499	71.3 (61.5–79.4)	0.55 (0.41–0.73)	<LOD	0.44 (0.34–0.54)	2.3 ^E (<LOD–6.8)	9.4 ^E (<LOD–19)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
2 (2009–2011)	508	29.2 (21.1–38.9)	—	<LOD	<LOD	1.4 ^E (0.85–2.0)	2.9 ^E (1.4–4.5)
3 (2012–2013)	510	28.2 (21.2–36.5)	—	<LOD	<LOD	1.4 ^E (<LOD–2.0)	1.9 ^E (1.0–2.8)
4 (2014–2015)	506	34.6 (26.6–43.5)	—	<LOD	<LOD	1.4 (1.0–1.8)	2.0 ^E (1.2–2.8)
5 (2016–2017)	515	64.4 (53.0–74.4)	0.31 (0.24–0.40)	<LOD	0.30 (0.24–0.36)	1.0 (<LOD–1.4)	2.1 ^E (0.56–3.7)
6 (2018–2019)	505	78.7 (67.1–87.0)	0.46 (0.35–0.60)	<LOD	0.39 (0.27–0.51)	1.9 ^E (0.67–3.0)	3.2 ^E (1.5–5.0)
20–39 years							
2 (2009–2011)	353	31.8 (21.8–43.8)	—	<LOD	<LOD	1.9 ^E (<LOD–3.0)	2.6 ^E (<LOD–4.3)
3 (2012–2013)	355	28.9 (22.1–36.9)	—	<LOD	<LOD	2.1 ^E (<LOD–4.1)	5.2 ^E (<LOD–9.2)
4 (2014–2015)	362	34.5 (28.5–41.1)	—	<LOD	<LOD	1.6 (1.0–2.1)	2.1 ^E (1.2–3.0)
5 (2016–2017)	357	68.5 (53.6–80.4)	0.46 ^E (0.29–0.74)	<LOD	0.41 ^E (0.24–0.58)	2.6 ^E (0.43–4.8)	3.4 ^E (<LOD–6.1)
6 (2018–2019)	330	74.3 (63.9–82.5)	0.56 (0.42–0.74)	<LOD	0.48 (0.35–0.61)	2.4 ^E (<LOD–5.5)	6.5 ^E (<LOD–13)
40–59 years							
2 (2009–2011)	354	25.2 (17.6–34.8)	—	<LOD	<LOD	1.9 (1.3–2.6)	2.0 ^E (1.2–2.8)
3 (2012–2013)	312	24.5 ^E (16.6–34.5)	—	<LOD	<LOD	1.9 ^E (<LOD–3.9)	3.6 ^E (<LOD–16)
4 (2014–2015)	312	29.4 (20.1–40.8)	—	<LOD	<LOD	1.4 (0.93–1.9)	2.2 ^E (<LOD–4.6)
5 (2016–2017)	345	63.2 (44.6–78.6)	0.40 (0.29–0.56)	<LOD	0.35 (<LOD–0.46)	1.9 ^E (1.1–2.6)	2.8 ^E (1.3–4.3)
6 (2018–2019)	342	66.9 (54.2–77.6)	0.47 (0.38–0.58)	<LOD	0.44 (0.34–0.55)	1.6 (1.1–2.0)	2.6 ^E (1.5–3.7)
60–79 years							
2 (2009–2011)	288	28.1 (19.5–38.6)	—	<LOD	<LOD	2.3 ^E (1.2–3.3)	3.1 ^E (<LOD–6.7)
3 (2012–2013)	352	26.2 (18.9–35.1)	—	<LOD	<LOD	2.3 ^E (0.79–3.8)	3.7 ^E (1.7–5.6)
4 (2014–2015)	361	35.2 (26.2–45.4)	—	<LOD	<LOD	1.7 (1.3–2.0)	2.6 ^E (<LOD–4.0)
5 (2016–2017)	347	49.5 (39.8–59.3)	—	<LOD	<LOD	1.4 (0.98–1.8)	2.0 ^E (<LOD–3.9)
6 (2018–2019)	342	56.5 (46.4–66.1)	0.43 (0.35–0.53)	<LOD	0.38 (<LOD–0.46)	1.7 ^E (0.92–2.4)	3.2 ^E (1.5–5.0)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.5

Arsenate—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2538	0.10 ^E (0–0.40)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	2536	0.60 ^E (0.20–1.5)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	2567	0.60 ^E (0.10–2.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	2615	12.7 (10.0–15.9)	—	<LOD	<LOD	0.17 (<LOD–0.20)	0.23 (0.19–0.27)
6 (2018–2019)	2531	5.8 (4.1–8.3)	—	<LOD	<LOD	<LOD	0.15 (<LOD–0.18)
Males, 3–79 years							
2 (2009–2011)	1271	0.20 ^E (0.10–0.80)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	1251	0.60 ^E (0.20–1.8)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	1275	0.70 ^E (0.10–5.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1299	13.7 (9.6–19.1)	—	<LOD	<LOD	0.18 (<LOD–0.22)	0.25 (0.20–0.31)
6 (2018–2019)	1256	6.2 ^E (3.5–10.8)	—	<LOD	<LOD	<LOD	0.15 (<LOD–0.20)
Females, 3–79 years							
2 (2009–2011)	1267	0 ^E (0–0.10)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	1285	0.50 ^E (0.10–2.1)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	1292	0.50 ^E (0.20–1.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1316	11.7 (8.3–16.2)	—	<LOD	<LOD	0.15 (<LOD–0.21)	0.21 (0.18–0.24)
6 (2018–2019)	1275	5.5 ^E (3.7–8.0)	—	<LOD	<LOD	<LOD	<LOD (<LOD–0.18)
3–5 years							
2 (2009–2011)	516	0.80 ^E (0.30–2.0)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	500	3.0 ^E (1.1–7.8)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	512	1.4 ^E (0.50–3.6)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	535	25.1 (19.2–32.2)	—	<LOD	<LOD	0.29 (0.19–0.40)	0.38 (0.34–0.43)
6 (2018–2019)	513	10.6 ^E (6.4–17.1)	—	<LOD	<LOD	<LOD (<LOD–0.18)	0.17 (<LOD–0.21)
6–11 years							
2 (2009–2011)	511	0.30 ^E (0.10–1.7)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	507	0.80 ^E (0.20–4.1)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	514	0.90 ^E (0.40–2.0)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	513	15.0 ^E (8.2–26)	—	<LOD	<LOD	0.18 (<LOD–0.24)	0.24 ^E (<LOD–0.41)
6 (2018–2019)	499	8.8 ^E (5.9–12.9)	—	<LOD	<LOD	<LOD	0.17 (<LOD–0.20)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
2 (2009–2011)	510	0.30 ^E (0.10–1.0)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	510	1.3 ^E (0.30–4.5)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	506	0.70 ^E (0.20–2.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	517	18.0 (12.5–25.2)	—	<LOD	<LOD	0.20 (0.15–0.25)	0.27 (0.18–0.36)
6 (2018–2019)	505	10.9 ^E (6.4–18.1)	—	<LOD	<LOD	<LOD (<LOD–0.18)	0.18 (<LOD–0.25)
20–39 years							
2 (2009–2011)	355	0.20 ^E (0–1.7)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	355	0.40 ^E (0–3.9)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	362	0.60 ^E (0.10–3.2)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	357	14.7 ^E (8.8–23.5)	—	<LOD	<LOD	0.18 (<LOD–0.24)	0.21 ^E (<LOD–0.30)
6 (2018–2019)	330	7.3 ^E (3.9–13.2)	—	<LOD	<LOD	<LOD	0.16 (<LOD–0.19)
40–59 years							
2 (2009–2011)	357	0	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	312	0.50 ^E (0.10–3.3)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	312	0.70 ^E (0–19.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	345	10.6 ^E (6.1–17.8)	—	<LOD	<LOD	<LOD ^E (<LOD–0.26)	0.26 (0.18–0.34)
6 (2018–2019)	342	3.7 ^E (1.9–7.0)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
2 (2009–2011)	289	0	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	352	0	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	361	0.10 ^E (0–1.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	348	7.7 ^E (5.0–11.7)	—	<LOD	<LOD	<LOD	0.18 (<LOD–0.23)
6 (2018–2019)	342	2.7 ^E (1.2–6.1)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 3, 4, 5 and 6 are 0.8, 0.75, 0.75, 0.14 and 0.14 µg As/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.6

Arsenate (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/g creatinine}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2528	0.10 ^E (0–0.40)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	2535	0.60 ^E (0.20–1.5)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	2566	0.60 ^E (0.10–2.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	2605	12.7 (10.0–15.9)	—	<LOD	<LOD	0.25 (<LOD–0.30)	0.36 (0.33–0.39)
6 (2018–2019)	2530	5.8 (4.1–8.3)	—	<LOD	<LOD	<LOD	0.32 (<LOD–0.36)
Males, 3–79 years							
2 (2009–2011)	1267	0.20 ^E (0.10–0.80)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	1251	0.60 ^E (0.20–1.8)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	1274	0.70 ^E (0.10–5.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1296	13.7 (9.6–19.1)	—	<LOD	<LOD	0.20 (<LOD–0.23)	0.28 (0.19–0.38)
6 (2018–2019)	1255	6.2 ^E (3.5–10.8)	—	<LOD	<LOD	<LOD	0.29 (<LOD–0.35)
Females, 3–79 years							
2 (2009–2011)	1261	0 ^E (0–0.10)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	1284	0.50 ^E (0.10–2.1)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	1292	0.50 ^E (0.20–1.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1309	11.7 (8.3–16.2)	—	<LOD	<LOD	0.32 (<LOD–0.38)	0.37 (0.35–0.40)
6 (2018–2019)	1275	5.5 ^E (3.7–8.0)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
2 (2009–2011)	515	0.80 ^E (0.30–2.0)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	499	3.0 ^E (1.1–7.8)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	512	1.4 ^E (0.50–3.6)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	532	25.1 (19.2–32.2)	—	<LOD	<LOD	0.50 (0.41–0.58)	0.73 (0.51–0.94)
6 (2018–2019)	512	10.6 ^E (6.4–17.1)	—	<LOD	<LOD	<LOD	0.41 (<LOD–0.49)
6–11 years							
2 (2009–2011)	509	0.30 ^E (0.10–1.7)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	507	0.80 ^E (0.20–4.1)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	513	0.90 ^E (0.40–2.0)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	509	15.0 ^E (8.2–26)	—	<LOD	<LOD	0.26 ^E (<LOD–0.38)	0.37 (<LOD–0.43)
6 (2018–2019)	499	8.8 ^E (5.9–12.9)	—	<LOD	<LOD	<LOD	0.34 ^E (<LOD–0.52)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
2 (2009–2011)	508	0.30 ^E (0.10–1.0)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	510	1.3 ^E (0.30–4.5)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	506	0.70 ^E (0.20–2.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	515	18.0 (12.5–25.2)	—	<LOD	<LOD	0.19 (0.15–0.23)	0.28 (0.18–0.38)
6 (2018–2019)	505	10.9 ^E (6.4–18.1)	—	<LOD	<LOD	<LOD	0.32 ^E (<LOD–0.54)
20–39 years							
2 (2009–2011)	353	0.20 ^E (0–1.7)	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	355	0.40 ^E (0–3.9)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	362	0.60 ^E (0.10–3.2)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	357	14.7 ^E (8.8–23.5)	—	<LOD	<LOD	0.24 ^E (<LOD–0.37)	0.36 (<LOD–0.42)
6 (2018–2019)	330	7.3 ^E (3.9–13.2)	—	<LOD	<LOD	<LOD	0.31 (<LOD–0.42)
40–59 years							
2 (2009–2011)	355	0	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	312	0.50 ^E (0.10–3.3)	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	312	0.70 ^E (0–19.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	345	10.6 ^E (6.1–17.8)	—	<LOD	<LOD	<LOD	0.33 (0.27–0.38)
6 (2018–2019)	342	3.7 ^E (1.9–7.0)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
2 (2009–2011)	288	0	—	<LOD	<LOD	<LOD	<LOD
3 (2012–2013)	352	0	—	<LOD	<LOD	<LOD	<LOD
4 (2014–2015)	361	0.10 ^E (0–1.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	347	7.7 ^E (5.0–11.7)	—	<LOD	<LOD	<LOD	0.35 (<LOD–0.43)
6 (2018–2019)	342	2.7 ^E (1.2–6.1)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.7

Monomethylarsonic acid (MMA)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2538	28.5 (22.7–35.2)	—	<LOD	<LOD	1.2 (1.0–1.4)	1.6 (1.1–2.0)
3 (2012–2013)	2536	26.4 (23.9–29.1)	—	<LOD	<LOD	1.2 (1.1–1.4)	1.5 (1.3–1.7)
4 (2014–2015)	2567	30.6 (26.1–35.4)	—	<LOD	<LOD	1.2 (1.0–1.4)	1.6 (1.3–1.9)
5 (2016–2017)	2615	81.7 (68.3–90.2)	0.35 (0.27–0.45)	<LOD	0.40 (0.31–0.48)	1.1 (0.81–1.4)	1.7 (1.1–2.2)
6 (2018–2019)	2531	91.3 (87.7–93.9)	0.40 (0.35–0.45)	0.13 ^E (<LOD–0.18)	0.41 (0.34–0.48)	1.0 (0.87–1.2)	1.5 (1.2–1.7)
Males, 3–79 years							
2 (2009–2011)	1271	34.7 (27.4–42.8)	—	<LOD	<LOD	1.3 (0.92–1.6)	1.8 (1.3–2.4)
3 (2012–2013)	1251	31.8 (27.7–36.2)	—	<LOD	<LOD	1.2 (1.0–1.4)	1.5 (1.3–1.7)
4 (2014–2015)	1275	34.0 (28.1–40.6)	—	<LOD	<LOD	1.3 (1.1–1.6)	1.7 (1.3–2.1)
5 (2016–2017)	1299	83.9 (68.1–92.8)	0.37 (0.28–0.49)	<LOD	0.42 (0.33–0.52)	0.99 ^E (0.58–1.4)	1.7 (1.2–2.2)
6 (2018–2019)	1256	93.0 (89.8–95.2)	0.46 (0.39–0.52)	0.15 (<LOD–0.19)	0.49 (0.40–0.58)	1.2 (0.90–1.5)	1.5 (1.2–1.9)
Females, 3–79 years							
2 (2009–2011)	1267	22.3 (16.6–29.3)	—	<LOD	<LOD	1.1 (0.84–1.3)	1.3 (1.0–1.5)
3 (2012–2013)	1285	21.0 (16.2–26.7)	—	<LOD	<LOD	1.2 (0.88–1.5)	1.5 (1.3–1.8)
4 (2014–2015)	1292	27.1 (22.0–32.8)	—	<LOD	<LOD	1.1 (0.89–1.3)	1.5 (1.1–1.9)
5 (2016–2017)	1316	79.4 (64.9–88.9)	0.33 (0.26–0.43)	<LOD	0.38 (0.29–0.47)	1.2 (0.96–1.5)	1.6 ^E (0.95–2.3)
6 (2018–2019)	1275	89.6 (85.1–92.8)	0.35 (0.30–0.41)	<LOD	0.36 (0.29–0.43)	0.91 (0.81–1.0)	1.2 ^E (0.74–1.7)
3–5 years							
2 (2009–2011)	516	19.7 (14.2–26.5)	—	<LOD	<LOD	0.98 (0.79–1.2)	1.3 (1.1–1.5)
3 (2012–2013)	500	18.2 (14.2–23.1)	—	<LOD	<LOD	0.91 (<LOD–1.2)	1.5 (1.1–1.9)
4 (2014–2015)	512	21.6 ^E (14.4–31.2)	—	<LOD	<LOD	0.89 (0.81–0.98)	1.1 (0.94–1.3)
5 (2016–2017)	535	83.4 (70.1–91.5)	0.33 (0.25–0.44)	<LOD	0.37 (0.30–0.44)	0.92 ^E (0.49–1.3)	1.1 ^E (0.30–1.9)
6 (2018–2019)	513	90.5 (85.4–94.0)	0.38 (0.32–0.46)	<LOD	0.42 (0.32–0.52)	0.95 ^E (0.60–1.3)	1.2 (0.94–1.5)
6–11 years							
2 (2009–2011)	511	27.6 (21.9–34.1)	—	<LOD	<LOD	0.97 ^E (<LOD–1.3)	1.6 (1.1–2.1)
3 (2012–2013)	507	24.2 ^E (16.2–34.6)	—	<LOD	<LOD	1.0 (0.84–1.2)	1.3 (1.1–1.4)
4 (2014–2015)	514	27.6 (22.3–33.7)	—	<LOD	<LOD	1.2 (0.89–1.4)	1.5 (1.2–1.8)
5 (2016–2017)	513	87.4 (72.2–94.9)	0.34 (0.28–0.41)	<LOD	0.36 (0.30–0.43)	0.81 (0.74–0.88)	0.99 (0.90–1.1)
6 (2018–2019)	499	91.6 (82.5–96.2)	0.41 (0.34–0.50)	0.15 ^E (<LOD–0.21)	0.42 (0.35–0.49)	0.96 (0.83–1.1)	1.3 (0.99–1.6)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
2 (2009–2011)	510	33.6 (25.1–43.4)	—	<LOD	<LOD	1.3 (0.97–1.6)	1.7 (1.2–2.2)
3 (2012–2013)	510	40.7 (31.5–50.6)	—	<LOD	<LOD	1.3 (1.1–1.6)	1.6 (1.3–1.8)
4 (2014–2015)	506	37.3 (29.7–45.6)	—	<LOD	<LOD	1.3 (0.88–1.8)	1.8 (1.3–2.4)
5 (2016–2017)	517	88.7 (73.6–95.7)	0.43 (0.36–0.52)	<LOD	0.52 (0.45–0.60)	1.1 (0.80–1.4)	1.5 (1.2–1.7)
6 (2018–2019)	505	93.2 (84.4–97.2)	0.51 (0.42–0.61)	0.19 ^E (<LOD–0.28)	0.54 (0.44–0.63)	1.2 ^E (0.70–1.6)	1.7 (1.3–2.0)
20–39 years							
2 (2009–2011)	355	34.3 (25.2–44.6)	—	<LOD	<LOD	1.2 (0.89–1.6)	1.7 ^E (0.94–2.5)
3 (2012–2013)	355	32.1 (24.2–41.1)	—	<LOD	<LOD	1.3 (1.0–1.5)	1.5 (1.3–1.7)
4 (2014–2015)	362	38.1 (32.2–44.4)	—	<LOD	<LOD	1.3 (1.1–1.6)	1.6 (1.3–1.9)
5 (2016–2017)	357	77.1 (58.5–89.0)	0.36 ^E (0.24–0.54)	<LOD	0.42 ^E (0.27–0.58)	1.4 ^E (0.67–2.1)	2.0 ^E (1.2–2.7)
6 (2018–2019)	330	92.6 (87.2–95.8)	0.45 (0.38–0.54)	<LOD	0.54 (0.37–0.71)	1.4 (0.95–1.8)	1.6 (1.1–2.1)
40–59 years							
2 (2009–2011)	357	27.8 (20.7–36.3)	—	<LOD	<LOD	1.2 (0.92–1.5)	1.4 ^E (0.87–1.9)
3 (2012–2013)	312	20.9 (14.9–28.5)	—	<LOD	<LOD	1.1 (0.84–1.4)	1.6 (1.1–2.2)
4 (2014–2015)	312	28.4 (20.6–37.8)	—	<LOD	<LOD	1.2 ^E (<LOD–1.7)	1.9 ^E (<LOD–3.0)
5 (2016–2017)	345	85.4 (69.3–93.8)	0.38 (0.28–0.52)	<LOD	0.41 (0.28–0.53)	1.1 (0.84–1.3)	1.7 ^E (1.0–2.3)
6 (2018–2019)	342	92.1 (87.2–95.2)	0.36 (0.30–0.43)	<LOD	0.37 (0.29–0.45)	0.90 (0.75–1.0)	1.1 (0.84–1.4)
60–79 years							
2 (2009–2011)	289	19.2 ^E (11.8–29.7)	—	<LOD	<LOD	1.0 (0.70–1.3)	1.4 ^E (0.73–2.0)
3 (2012–2013)	352	23.9 (18.4–30.5)	—	<LOD	<LOD	1.1 (0.79–1.5)	1.4 (1.2–1.6)
4 (2014–2015)	361	21.7 (14.9–30.4)	—	<LOD	<LOD	1.1 (0.84–1.3)	1.3 (0.99–1.6)
5 (2016–2017)	348	77.2 (64.8–86.2)	0.28 (0.22–0.36)	<LOD	0.33 (0.27–0.39)	0.85 (0.67–1.0)	1.1 ^E (0.60–1.6)
6 (2018–2019)	342	87.5 (77.3–93.5)	0.34 (0.27–0.43)	<LOD	0.33 (0.27–0.39)	0.98 (0.70–1.3)	1.6 ^E (0.93–2.3)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 3, 4, 5 and 6 are 0.8, 0.75, 0.75, 0.13 and 0.13 µg As/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.8

Monomethylarsonic acid (MMA) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/g creatinine}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2528	28.5 (22.7–35.2)	—	<LOD	<LOD	1.3 ^E (0.75–1.8)	2.0 (1.8–2.1)
3 (2012–2013)	2535	26.4 (23.9–29.1)	—	<LOD	<LOD	1.2 (1.1–1.4)	1.7 (1.5–1.9)
4 (2014–2015)	2566	30.6 (26.1–35.4)	—	<LOD	<LOD	1.2 (0.97–1.3)	1.4 (1.2–1.7)
5 (2016–2017)	2605	81.7 (68.3–90.2)	0.35 (0.27–0.45)	<LOD	0.34 (0.29–0.39)	0.97 (0.73–1.2)	1.3 (0.97–1.7)
6 (2018–2019)	2530	91.3 (87.7–93.9)	0.43 (0.37–0.51)	0.20 (<LOD–0.24)	0.42 (0.34–0.49)	0.99 (0.90–1.1)	1.2 (1.1–1.4)
Males, 3–79 years							
2 (2009–2011)	1267	34.7 (27.4–42.8)	—	<LOD	<LOD	1.0 (0.87–1.1)	1.6 ^F (1.0–2.2)
3 (2012–2013)	1251	31.8 (27.7–36.2)	—	<LOD	<LOD	1.0 (0.87–1.1)	1.3 (1.0–1.6)
4 (2014–2015)	1274	34.0 (28.1–40.6)	—	<LOD	<LOD	1.0 (0.91–1.2)	1.3 (1.0–1.6)
5 (2016–2017)	1296	83.9 (68.1–92.8)	0.32 (0.24–0.43)	<LOD	0.32 (0.27–0.37)	0.77 (0.56–0.98)	1.0 (0.76–1.2)
6 (2018–2019)	1255	93.0 (89.8–95.2)	0.42 (0.36–0.50)	0.20 (<LOD–0.26)	0.41 (0.34–0.48)	0.93 (0.81–1.1)	1.2 (0.93–1.4)
Females, 3–79 years							
2 (2009–2011)	1261	22.3 (16.6–29.3)	—	<LOD	<LOD	1.9 (1.4–2.4)	2.0 (1.4–2.5)
3 (2012–2013)	1284	21.0 (16.2–26.7)	—	<LOD	<LOD	1.6 (1.3–1.9)	2.1 (1.8–2.5)
4 (2014–2015)	1292	27.1 (22.0–32.8)	—	<LOD	<LOD	1.3 (0.97–1.6)	1.7 (1.2–2.2)
5 (2016–2017)	1309	79.4 (64.9–88.9)	0.37 (0.29–0.48)	<LOD	0.37 (0.31–0.43)	1.1 (0.73–1.5)	1.4 (1.1–1.8)
6 (2018–2019)	1275	89.6 (85.1–92.8)	0.44 (0.38–0.52)	<LOD	0.44 (0.34–0.53)	1.0 (0.88–1.2)	1.3 (1.0–1.5)
3–5 years							
2 (2009–2011)	515	19.7 (14.2–26.5)	—	<LOD	<LOD	1.9 (1.8–2.0)	2.7 (1.8–3.6)
3 (2012–2013)	499	18.2 (14.2–23.1)	—	<LOD	<LOD	2.0 (<LOD–2.5)	3.0 (2.0–4.0)
4 (2014–2015)	512	21.6 ^F (14.4–31.2)	—	<LOD	<LOD	1.8 (1.3–2.2)	2.2 (1.9–2.5)
5 (2016–2017)	532	83.4 (70.1–91.5)	0.56 (0.47–0.68)	<LOD	0.60 (0.47–0.72)	1.3 (1.1–1.5)	1.5 (1.3–1.6)
6 (2018–2019)	512	90.5 (85.4–94.0)	0.62 (0.53–0.73)	<LOD	0.66 (0.55–0.77)	1.1 (0.97–1.3)	1.5 (1.3–1.7)
6–11 years							
2 (2009–2011)	509	27.6 (21.9–34.1)	—	<LOD	<LOD	1.2 (<LOD–1.6)	1.9 (1.7–2.1)
3 (2012–2013)	507	24.2 ^F (16.2–34.6)	—	<LOD	<LOD	1.3 (1.1–1.5)	1.8 (1.5–2.0)
4 (2014–2015)	513	27.6 (22.3–33.7)	—	<LOD	<LOD	1.2 (1.0–1.3)	1.4 (1.2–1.5)
5 (2016–2017)	509	87.4 (72.2–94.9)	0.39 (0.31–0.49)	<LOD	0.41 (0.35–0.47)	0.80 (0.65–0.95)	1.0 (0.88–1.2)
6 (2018–2019)	499	91.6 (82.5–96.2)	0.49 (0.43–0.56)	0.24 (<LOD–0.29)	0.48 (0.41–0.55)	0.98 (0.87–1.1)	1.2 (1.0–1.5)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
2 (2009–2011)	508	33.6 (25.1–43.4)	—	<LOD	<LOD	0.99 (0.84–1.1)	1.3 ^E (0.74–1.9)
3 (2012–2013)	510	40.7 (31.5–50.6)	—	<LOD	<LOD	0.99 (0.75–1.2)	1.5 (1.0–2.0)
4 (2014–2015)	506	37.3 (29.7–45.6)	—	<LOD	<LOD	0.98 (0.82–1.1)	1.1 (0.87–1.4)
5 (2016–2017)	515	88.7 (73.6–95.7)	0.33 (0.27–0.40)	<LOD	0.36 (0.31–0.40)	0.71 (0.59–0.82)	0.97 ^E (0.59–1.4)
6 (2018–2019)	505	93.2 (84.4–97.2)	0.42 (0.35–0.50)	0.20 (<LOD–0.27)	0.38 (0.35–0.41)	0.99 (0.73–1.3)	1.5 (1.0–2.0)
20–39 years							
2 (2009–2011)	353	34.3 (25.2–44.6)	—	<LOD	<LOD	1.1 ^E (<LOD–1.9)	1.8 ^E (0.89–2.8)
3 (2012–2013)	355	32.1 (24.2–41.1)	—	<LOD	<LOD	0.97 (0.73–1.2)	1.3 (0.87–1.8)
4 (2014–2015)	362	38.1 (32.2–44.4)	—	<LOD	<LOD	1.1 (0.96–1.2)	1.3 ^E (<LOD–2.4)
5 (2016–2017)	357	77.1 (58.5–89.0)	0.33 ^E (0.22–0.51)	<LOD	0.34 (0.26–0.42)	1.1 ^E (0.46–1.6)	1.5 ^E (0.83–2.1)
6 (2018–2019)	330	92.6 (87.2–95.8)	0.43 (0.37–0.50)	<LOD	0.40 (0.33–0.47)	1.0 (0.80–1.2)	1.3 (1.0–1.5)
40–59 years							
2 (2009–2011)	355	27.8 (20.7–36.3)	—	<LOD	<LOD	1.2 ^E (0.55–1.8)	1.9 (1.4–2.4)
3 (2012–2013)	312	20.9 (14.9–28.5)	—	<LOD	<LOD	1.3 (0.92–1.6)	1.7 (1.3–2.0)
4 (2014–2015)	312	28.4 (20.6–37.8)	—	<LOD	<LOD	1.3 (<LOD–1.7)	1.5 (<LOD–1.9)
5 (2016–2017)	345	85.4 (69.3–93.8)	0.35 (0.27–0.45)	<LOD	0.33 (0.26–0.40)	0.99 (0.71–1.3)	1.4 ^E (0.62–2.1)
6 (2018–2019)	342	92.1 (87.2–95.2)	0.43 (0.35–0.54)	<LOD	0.42 (0.28–0.56)	0.99 (0.81–1.2)	1.1 (1.0–1.3)
60–79 years							
2 (2009–2011)	288	19.2 ^E (11.8–29.7)	—	<LOD	<LOD	1.7 (1.3–2.2)	1.9 (1.6–2.2)
3 (2012–2013)	352	23.9 (18.4–30.5)	—	<LOD	<LOD	1.4 ^E (0.87–1.9)	2.1 ^E (1.3–2.9)
4 (2014–2015)	361	21.7 (14.9–30.4)	—	<LOD	<LOD	1.0 (0.75–1.3)	1.3 (1.1–1.6)
5 (2016–2017)	347	77.2 (64.8–86.2)	0.33 (0.26–0.41)	<LOD	0.32 (0.25–0.40)	0.75 (0.58–0.93)	1.1 (0.69–1.4)
6 (2018–2019)	342	87.5 (77.3–93.5)	0.40 (0.32–0.51)	<LOD	0.42 (0.33–0.51)	0.83 (0.67–1.0)	1.3 ^E (0.81–1.8)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.9

Dimethylarsinic acid (DMA)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2538	95.5 (93.4–96.9)	3.5 (3.0–4.0)	0.93 (0.89–0.97)	3.6 (3.1–4.1)	11 (8.3–13)	16 ^F (6.6–25)
3 (2012–2013)	2536	95.7 (93.7–97.1)	3.6 (3.2–4.0)	1.1 (0.89–1.4)	3.4 (3.0–3.8)	11 (7.8–13)	16 ^F (7.4–25)
4 (2014–2015)	2567	95.7 (93.5–97.2)	3.5 (3.1–3.9)	1.1 (1.0–1.3)	3.4 (3.0–3.8)	10 (8.2–12)	15 (11–20)
5 (2016–2017)	2615	99.6 (96.3–100)	3.2 (2.6–4.1)	0.98 (0.75–1.2)	3.1 (2.5–3.7)	10 (7.1–14)	15 ^F (7.6–22)
6 (2018–2019)	2531	100	3.7 (3.2–4.2)	0.98 (0.84–1.1)	3.5 (3.0–4.1)	13 (9.3–16)	21 ^F (13–30)
Males, 3–79 years							
2 (2009–2011)	1271	96.0 (92.7–97.8)	3.6 (3.1–4.3)	0.95 (<L00–1.3)	3.7 (2.8–4.5)	11 (7.9–14)	16 ^F (7.7–24)
3 (2012–2013)	1251	96.4 (92.2–98.3)	3.8 (3.3–4.4)	1.3 ^F (0.75–1.8)	3.8 (3.3–4.3)	9.8 (7.8–12)	14 ^F (4.8–23)
4 (2014–2015)	1275	94.7 (90.4–97.1)	3.6 (3.1–4.3)	1.1 (0.81–1.3)	3.6 (3.0–4.3)	11 (8.2–14)	19 ^F (9.8–28)
5 (2016–2017)	1299	99.8 (98.2–100)	3.2 (2.6–3.9)	0.94 (0.62–1.3)	3.1 (2.5–3.7)	11 (7.8–15)	15 ^F (8.6–22)
6 (2018–2019)	1256	100	4.1 (3.5–4.7)	1.0 (0.76–1.2)	3.8 (3.3–4.3)	16 (10–21)	25 ^F (8.8–42)
Females, 3–79 years							
2 (2009–2011)	1267	95.0 (91.5–97.1)	3.3 (2.8–3.9)	0.92 (0.75–1.1)	3.5 (3.0–3.9)	11 (7.5–14)	18 ^F (7.3–29)
3 (2012–2013)	1285	95.1 (92.3–96.9)	3.4 (2.9–4.1)	1.0 (0.85–1.2)	3.1 (2.7–3.5)	12 (8.4–16)	20 ^F (1.4–39)
4 (2014–2015)	1292	96.7 (94.2–98.2)	3.4 (3.0–3.9)	1.2 (1.1–1.4)	3.3 (2.9–3.7)	9.8 (7.7–12)	13 (9.0–17)
5 (2016–2017)	1316	99.4 (94.2–99.9)	3.3 (2.5–4.3)	0.98 (0.78–1.2)	3.2 (2.5–3.9)	9.9 ^E (5.5–14)	14 ^F (<L00–38)
6 (2018–2019)	1275	100	3.3 (2.8–3.8)	0.94 (0.80–1.1)	3.1 (2.6–3.6)	9.9 (7.9–12)	15 ^F (2.7–28)
3–5 years							
2 (2009–2011)	516	97.5 (95.7–98.6)	3.6 (3.1–4.3)	1.4 ^E (0.89–1.9)	3.5 (3.0–4.0)	9.4 (6.9–12)	13 ^F (8.5–18)
3 (2012–2013)	500	95.2 (91.4–97.4)	3.3 (3.0–3.8)	1.1 (0.83–1.4)	3.4 (2.8–3.9)	10 (7.9–12)	16 ^F (9.9–21)
4 (2014–2015)	512	97.9 (93.9–99.3)	3.4 (3.0–4.0)	1.2 (0.94–1.4)	3.4 (3.0–3.9)	9.2 (7.3–11)	13 (9.1–16)
5 (2016–2017)	535	97.6 (82.6–99.7)	3.4 (2.7–4.3)	1.0 ^E (0.58–1.5)	3.6 (3.2–4.0)	12 (9.0–14)	20 ^F (9.3–32)
6 (2018–2019)	513	100	4.0 (3.3–4.9)	1.3 (1.1–1.4)	4.0 (3.0–5.0)	12 (8.5–15)	16 ^F (8.5–23)
6–11 years							
2 (2009–2011)	511	98.4 (97.4–99.0)	3.9 (3.5–4.4)	1.5 (1.0–1.9)	4.1 (3.5–4.7)	9.8 (8.4–11)	14 ^F (7.7–20)
3 (2012–2013)	507	96.4 (91.1–98.6)	3.6 (3.1–4.1)	1.1 ^F (<L00–1.6)	3.7 (3.0–4.4)	9.1 (6.6–12)	14 ^F (6.9–22)
4 (2014–2015)	514	97.9 (95.1–99.1)	3.8 (3.2–4.5)	1.3 (0.89–1.7)	3.9 (3.3–4.5)	10 (6.4–14)	16 ^F (5.7–26)
5 (2016–2017)	513	99.7 (98.4–100)	3.5 (3.2–3.8)	1.3 (1.1–1.5)	3.5 (3.0–3.9)	7.6 (6.9–8.3)	10 (7.8–13)
6 (2018–2019)	499	100	4.5 (3.2–6.3)	1.1 ^F (0.48–1.7)	4.2 (3.3–5.0)	15 ^F (0.17–30)	44 ^F (<L00–120)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
2 (2009–2011)	510	97.2 (92.8–99.0)	3.6 (2.9–4.6)	0.94 ^E (<LOD–1.5)	3.5 (2.5–4.4)	11 (7.5–14)	17 ^E (9.3–25)
3 (2012–2013)	510	97.2 (93.1–98.9)	3.6 (3.0–4.3)	1.3 (0.88–1.7)	3.4 (2.6–4.2)	9.9 (6.6–13)	14 ^E (2.3–25)
4 (2014–2015)	506	98.0 (95.3–99.2)	3.6 (3.0–4.3)	1.2 ^E (0.77–1.7)	3.3 (2.8–3.9)	10 (7.9–13)	13 (8.6–18)
5 (2016–2017)	517	99.4 (94.1–99.9)	3.3 (2.8–3.9)	1.2 (0.77–1.5)	3.4 (2.8–3.9)	8.3 ^E (5.2–11)	14 (9.8–18)
6 (2018–2019)	505	100	4.0 (3.3–4.8)	1.2 (1.0–1.4)	3.8 (2.8–4.7)	15 (9.6–20)	25 ^E (6.3–43)
20–39 years							
2 (2009–2011)	355	94.9 (89.7–97.5)	3.6 (2.9–4.5)	0.92 (0.72–1.1)	3.9 (3.0–4.8)	12 ^E (2.6–21)	22 ^E (11–33)
3 (2012–2013)	355	94.0 (83.4–98.0)	3.8 (3.3–4.5)	1.2 ^E (<LOD–1.9)	3.5 (2.9–4.1)	12 ^E (4.4–20)	24 ^E (8.5–40)
4 (2014–2015)	362	94.3 (86.1–97.7)	3.6 (3.1–4.1)	1.1 (<LOD–1.4)	3.4 (2.7–4.0)	9.9 (8.4–11)	12 (9.3–15)
5 (2016–2017)	357	99.9 (99.2–100)	3.3 ^E (2.3–4.8)	1.0 ^E (0.44–1.6)	3.0 (2.2–3.9)	13 ^E (4.9–20)	19 ^E (<LOD–41)
6 (2018–2019)	330	100	4.1 (3.2–5.2)	1.0 (0.69–1.3)	3.9 (3.2–4.6)	18 ^E (3.9–31)	35 ^E (6.0–64)
40–59 years							
2 (2009–2011)	357	94.3 (88.0–97.3)	3.2 (2.6–3.8)	0.91 ^E (<LOD–1.2)	3.1 (2.5–3.8)	9.0 (7.4–11)	12 (8.8–15)
3 (2012–2013)	312	95.4 (90.9–97.8)	3.5 (2.8–4.4)	1.1 (0.77–1.5)	3.4 (2.7–4.1)	12 ^E (6.0–17)	13 ^E (<LOD–31)
4 (2014–2015)	312	94.8 (91.3–97.0)	3.3 (2.8–4.0)	1.1 (0.89–1.3)	3.1 (2.4–3.8)	10 ^E (4.7–16)	18 ^E (8.6–27)
5 (2016–2017)	345	99.6 (92.7–100)	3.4 (2.5–4.5)	0.88 (0.62–1.1)	3.7 (2.6–4.8)	11 (7.5–14)	14 ^E (1.5–26)
6 (2018–2019)	342	100	3.2 (2.6–4.0)	0.94 (0.63–1.2)	3.0 (2.3–3.7)	9.8 ^E (5.4–14)	16 ^E (8.4–23)
60–79 years							
2 (2009–2011)	289	96.1 (92.7–98.0)	3.6 (2.8–4.5)	0.92 (0.82–1.0)	3.6 (2.9–4.3)	13 ^E (5.8–20)	21 ^E (6.5–35)
3 (2012–2013)	352	97.4 (94.8–98.7)	3.5 (3.0–4.2)	1.0 (0.86–1.2)	3.4 (2.6–4.2)	10 (7.4–13)	18 ^E (10–26)
4 (2014–2015)	361	96.9 (93.9–98.4)	3.6 (2.9–4.5)	1.2 (0.87–1.5)	3.6 (2.7–4.6)	11 (7.5–14)	14 ^E (5.3–23)
5 (2016–2017)	348	99.6 (96.0–100)	2.9 (2.3–3.6)	0.84 (0.61–1.1)	2.5 (2.0–3.1)	10 (6.9–14)	15 (11–19)
6 (2018–2019)	342	100	3.3 (2.7–4.0)	0.89 (0.66–1.1)	2.8 (1.9–3.7)	12 (9.0–16)	17 (11–23)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 3, 4, 5 and 6 are 0.8, 0.75, 0.75, 0.14 and 0.14 µg As/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.10

Dimethylarsinic acid (DMA) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/g creatinine}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2528	95.5 (93.4–96.9)	3.5 (3.0–4.0)	1.4 (1.2–1.6)	3.0 (2.6–3.4)	9.5 (7.1–12)	15 ^F (9.1–21)
3 (2012–2013)	2535	95.7 (93.7–97.1)	3.7 (3.2–4.3)	1.4 (1.3–1.5)	3.4 (3.0–3.8)	11 ^E (5.6–16)	20 ^F (11–30)
4 (2014–2015)	2566	95.7 (93.5–97.2)	3.2 (2.8–3.6)	1.3 (1.1–1.4)	2.8 (2.5–3.2)	9.1 (6.7–12)	13 (10–16)
5 (2016–2017)	2605	99.6 (96.3–100)	3.2 (2.6–3.9)	1.2 (0.98–1.3)	2.6 (2.1–3.2)	9.6 (7.0–12)	15 (10–20)
6 (2018–2019)	2530	100	4.0 (3.5–4.6)	1.4 (1.2–1.7)	3.5 (3.1–4.0)	13 (9.5–16)	17 (12–23)
Males, 3–79 years							
2 (2009–2011)	1267	96.0 (92.7–97.8)	3.1 (2.7–3.6)	1.3 (<LOD–1.5)	2.9 (2.5–3.3)	7.7 (5.3–10)	10 ^F (4.4–16)
3 (2012–2013)	1251	96.4 (92.2–98.3)	3.1 (2.8–3.6)	1.3 (1.1–1.4)	3.0 (2.4–3.5)	7.2 (5.4–9.1)	13 ^F (7.1–19)
4 (2014–2015)	1274	94.7 (90.4–97.1)	2.9 (2.5–3.4)	1.1 (0.93–1.3)	2.5 (2.1–2.9)	8.4 (6.3–11)	12 (8.4–15)
5 (2016–2017)	1296	99.8 (98.2–100)	2.8 (2.3–3.3)	1.0 (0.85–1.2)	2.4 (2.1–2.7)	9.2 (6.8–12)	14 (11–17)
6 (2018–2019)	1255	100	3.8 (3.3–4.4)	1.3 (0.94–1.6)	3.3 (2.7–3.8)	14 (9.8–19)	18 ^F (5.3–30)
Females, 3–79 years							
2 (2009–2011)	1261	95.0 (91.5–97.1)	3.9 (3.3–4.5)	1.6 (1.3–1.8)	3.3 (2.8–3.9)	11 ^F (5.9–16)	18 ^F (11–24)
3 (2012–2013)	1284	95.1 (92.3–96.9)	4.3 (3.6–5.3)	1.5 (1.3–1.7)	3.8 (3.1–4.4)	15 ^F (5.2–25)	24 ^F (15–33)
4 (2014–2015)	1292	96.7 (94.2–98.2)	3.5 (3.0–4.1)	1.4 (1.1–1.7)	3.0 (2.4–3.5)	10 (7.4–13)	15 (11–19)
5 (2016–2017)	1309	99.4 (94.2–99.9)	3.7 (2.9–4.6)	1.4 (1.1–1.6)	3.3 (2.5–4.1)	9.9 ^E (5.7–14)	15 ^F (<LOD–38)
6 (2018–2019)	1275	100	4.2 (3.6–4.9)	1.6 (1.4–1.8)	3.9 (3.4–4.4)	12 (8.3–15)	16 ^F (4.9–27)
3–5 years							
2 (2009–2011)	515	97.5 (95.7–98.6)	6.4 (5.6–7.3)	3.0 (2.7–3.3)	5.6 (4.7–6.5)	16 (11–20)	23 ^F (10–36)
3 (2012–2013)	499	95.2 (91.4–97.4)	6.5 (5.9–7.1)	2.8 (2.1–3.4)	6.1 (5.5–6.8)	14 (11–17)	24 ^F (13–36)
4 (2014–2015)	512	97.9 (93.9–99.3)	6.0 (5.4–6.6)	2.7 (2.3–3.1)	5.3 (4.8–5.8)	15 (11–18)	21 ^F (12–30)
5 (2016–2017)	532	97.6 (82.6–99.7)	5.8 (4.5–7.4)	2.8 (2.2–3.4)	5.4 (4.2–6.6)	14 ^F (8.3–20)	23 (15–31)
6 (2018–2019)	512	100	6.6 (5.5–7.8)	2.9 (2.2–3.5)	6.3 (5.0–7.6)	14 ^E (8.0–20)	27 ^E (14–41)
6–11 years							
2 (2009–2011)	509	98.4 (97.4–99.0)	4.5 (4.1–5.0)	2.1 (1.9–2.3)	4.2 (3.8–4.7)	11 (7.9–13)	17 ^F (10–24)
3 (2012–2013)	507	96.4 (91.1–98.6)	4.5 (3.9–5.2)	2.2 (<LOD–2.4)	4.1 (3.7–4.4)	9.9 (6.7–13)	14 ^F (7.2–21)
4 (2014–2015)	513	97.9 (95.1–99.1)	4.2 (3.7–4.8)	1.9 (1.6–2.2)	3.7 (3.3–4.2)	11 (7.6–14)	14 ^F (7.7–21)
5 (2016–2017)	509	99.7 (98.4–100)	4.0 (3.6–4.5)	1.8 (1.5–2.2)	3.8 (3.4–4.1)	9.0 (7.4–11)	11 (7.6–15)
6 (2018–2019)	499	100	5.4 (4.0–7.2)	2.1 (1.7–2.5)	4.3 (3.3–5.3)	19 ^F (3.9–35)	50 ^F (<LOD–110)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
2 (2009–2011)	508	97.2 (92.8–99.0)	2.8 (2.3–3.5)	1.1 (<LOD–1.4)	2.4 (1.9–3.0)	8.5 ^E (4.5–13)	13 ^F (7.6–19)
3 (2012–2013)	510	97.2 (93.1–98.9)	2.7 (2.2–3.4)	1.2 (1.1–1.4)	2.3 (1.7–2.9)	7.4 ^E (2.9–12)	12 ^E (5.9–17)
4 (2014–2015)	506	98.0 (95.3–99.2)	2.6 (2.3–3.1)	1.1 (0.92–1.3)	2.4 (2.0–2.8)	7.3 (4.7–9.9)	10 (6.8–13)
5 (2016–2017)	515	99.4 (94.1–99.9)	2.5 (2.2–2.9)	1.1 (0.88–1.3)	2.2 (1.9–2.5)	6.2 (4.1–8.3)	10 ^E (5.6–15)
6 (2018–2019)	505	100	3.3 (2.7–4.1)	1.1 (0.79–1.4)	2.7 (2.0–3.4)	12 (8.0–16)	15 (10–20)
20–39 years							
2 (2009–2011)	353	94.9 (89.7–97.5)	3.1 (2.5–3.9)	1.3 (0.97–1.6)	2.6 (1.9–3.3)	9.1 ^E (5.8–12)	14 ^E (7.2–21)
3 (2012–2013)	355	94.0 (83.4–98.0)	2.9 (2.6–3.3)	1.1 ^F (<LOD–1.6)	2.7 (2.3–3.0)	7.8 ^E (<LOD–17)	17 ^E (4.7–29)
4 (2014–2015)	362	94.3 (86.1–97.7)	2.9 (2.5–3.4)	1.2 (<LOD–1.4)	2.5 (2.0–3.0)	8.4 (6.4–10)	11 ^E (6.4–15)
5 (2016–2017)	357	99.9 (99.2–100)	3.1 ^E (2.1–4.5)	1.0 (0.83–1.2)	2.5 ^E (1.5–3.4)	9.9 ^E (3.6–16)	16 ^F (<LOD–31)
6 (2018–2019)	330	100	3.9 (3.2–4.9)	1.4 (1.2–1.7)	3.2 (2.5–3.9)	11 ^E (<LOD–23)	27 ^E (<LOD–55)
40–59 years							
2 (2009–2011)	355	94.3 (88.0–97.3)	3.3 (2.9–3.7)	1.6 (<LOD–1.8)	3.0 (2.7–3.2)	7.7 (5.5–9.9)	11 ^E (6.1–15)
3 (2012–2013)	312	95.4 (90.9–97.8)	4.1 (3.3–5.2)	1.5 (1.2–1.7)	3.8 (3.1–4.5)	13 ^E (1.9–24)	24 ^E (<LOD–40)
4 (2014–2015)	312	94.8 (91.3–97.0)	3.1 (2.5–3.7)	1.2 (1.0–1.4)	2.9 (2.3–3.5)	8.5 ^E (3.3–14)	15 ^F (7.1–22)
5 (2016–2017)	345	99.6 (92.7–100)	3.1 (2.5–3.8)	1.2 (0.82–1.5)	2.4 (1.8–3.1)	9.4 (6.1–13)	15 (10–20)
6 (2018–2019)	342	100	3.8 (3.2–4.7)	1.4 (1.1–1.8)	3.6 (3.0–4.2)	13 ^F (8.3–18)	15 (11–19)
60–79 years							
2 (2009–2011)	288	96.1 (92.7–98.0)	4.2 (3.4–5.3)	1.5 ^F (0.88–2.1)	4.1 (3.1–5.0)	11 ^E (2.7–19)	20 ^F (5.0–34)
3 (2012–2013)	352	97.4 (94.8–98.7)	4.0 (3.2–4.9)	1.5 (1.2–1.9)	3.6 (2.9–4.3)	11 ^E (4.6–18)	20 ^F (10–30)
4 (2014–2015)	361	96.9 (93.9–98.4)	3.5 (2.9–4.2)	1.4 (1.1–1.7)	2.9 (2.0–3.8)	11 (7.2–14)	14 ^F (7.3–20)
5 (2016–2017)	347	99.6 (96.0–100)	3.4 (2.8–4.1)	1.3 (1.1–1.5)	3.0 (2.2–3.9)	9.4 (7.2–12)	12 (9.8–14)
6 (2018–2019)	342	100	3.9 (3.3–4.6)	1.4 ^F (0.85–1.9)	3.4 (2.8–4.0)	10 (7.2–13)	16 (11–20)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.11

Arsenocholine and arsenobetaine—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2538	59.6 (52.5–66.4)	—	<LOD	1.4 ^E (<LOD–2.2)	28 ^E (18–39)	48 ^E (30–67)
3 (2012–2013)	2536	60.0 (54.8–65.0)	—	<LOD	1.4 ^E (<LOD–2.1)	24 ^E (11–36)	56 (37–75)
4 (2014–2015)	2564	56.6 (51.8–61.3)	—	<LOD	1.2 ^E (<LOD–1.7)	28 ^E (13–44)	49 (33–65)
5 (2016–2017)	2615	82.8 (73.6–89.3)	1.3 ^E (0.80–2.1)	<LOD	1.3 ^E (0.58–1.9)	29 ^E (14–44)	56 ^E (27–86)
6 (2018–2019)	2531	84.3 (79.7–87.9)	1.3 (1.0–1.6)	<LOD	1.2 (0.90–1.5)	27 ^E (14–39)	63 ^E (37–88)
Males, 3–79 years							
2 (2009–2011)	1271	61.4 (53.2–69.0)	—	<LOD	1.5 ^E (<LOD–2.5)	29 ^E (14–43)	47 ^E (4.8–88)
3 (2012–2013)	1251	60.9 (53.1–68.2)	—	<LOD	1.4 ^E (<LOD–2.0)	21 ^E (13–29)	38 (25–51)
4 (2014–2015)	1273	60.1 (52.7–67.1)	—	<LOD	1.6 ^E (<LOD–2.6)	33 ^E (12–54)	44 (30–59)
5 (2016–2017)	1299	83.3 (74.0–89.8)	1.2 ^E (0.75–1.8)	<LOD	1.2 ^E (0.58–1.8)	18 ^E (11–25)	40 ^E (10–69)
6 (2018–2019)	1256	84.6 (80.5–88.0)	1.4 (1.1–1.8)	<LOD	1.2 (0.80–1.6)	28 (19–38)	64 ^E (36–92)
Females, 3–79 years							
2 (2009–2011)	1267	57.8 (48.9–66.3)	—	<LOD	<LOD	28 ^E (15–41)	49 ^E (29–69)
3 (2012–2013)	1285	59.1 (50.7–67.1)	—	<LOD	1.5 ^E (<LOD–2.6)	36 ^E (3.6–68)	58 ^E (33–83)
4 (2014–2015)	1291	53.1 (44.9–61.2)	—	<LOD	0.94 ^E (<LOD–1.6)	24 ^E (5.3–43)	52 ^E (18–86)
5 (2016–2017)	1316	82.3 (71.6–89.6)	1.4 ^E (0.83–2.5)	<LOD	1.3 ^E (0.53–2.2)	37 ^E (19–56)	65 ^E (23–110)
6 (2018–2019)	1275	83.9 (76.7–89.2)	1.2 (0.87–1.6)	<LOD	1.2 ^E (0.71–1.6)	26 ^E (2.0–51)	62 ^E (26–97)
3–5 years							
2 (2009–2011)	516	42.7 (34.7–51.0)	—	<LOD	<LOD	21 ^E (2.2–40)	34 ^E (19–49)
3 (2012–2013)	500	35.8 (30.2–41.8)	—	<LOD	<LOD	12 ^E (6.3–17)	22 ^E (<LOD–52)
4 (2014–2015)	512	35.8 (26.7–46.0)	—	<LOD	<LOD	16 ^E (5.4–26)	40 ^E (7.1–73)
5 (2016–2017)	535	66.6 (55.0–76.5)	0.41 ^E (0.25–0.69)	<LOD	0.18 ^E (<LOD–0.30)	9.4 ^E (<LOD–27)	37 ^E (<LOD–79)
6 (2018–2019)	513	73.5 (64.6–80.8)	0.56 ^E (0.38–0.82)	<LOD	0.42 ^E (0.18–0.66)	11 ^E (1.7–21)	34 ^E (11–57)
6–11 years							
2 (2009–2011)	511	40.7 (33.8–47.9)	—	<LOD	<LOD	10 ^E (1.3–19)	28 ^E (<LOD–70)
3 (2012–2013)	507	44.2 (34.1–54.8)	—	<LOD	<LOD	14 ^E (3.3–24)	27 ^E (14–39)
4 (2014–2015)	512	37.1 (30.1–44.8)	—	<LOD	<LOD	15 ^E (5.2–25)	39 ^E (13–64)
5 (2016–2017)	513	64.9 (53.6–74.8)	0.38 (0.27–0.52)	<LOD	0.18 ^E (<LOD–0.28)	13 ^E (7.3–19)	28 ^E (6.9–49)
6 (2018–2019)	499	74.9 (63.9–83.4)	0.91 ^E (0.55–1.5)	<LOD	0.56 ^E (<LOD–1.1)	33 ^E (8.6–58)	66 ^E (15–120)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
2 (2009–2011)	510	42.3 (34.1–51.0)	—	<LOD	<LOD	12 ^E (4.5–19)	38 ^E (16–59)
3 (2012–2013)	510	48.6 (39.0–58.3)	—	<LOD	<LOD	16 ^E (7.2–24)	37 ^E (17–56)
4 (2014–2015)	506	50.3 (41.1–59.5)	—	<LOD	0.75 ^E (<LOD–1.2)	16 ^E (9.4–22)	26 ^E (13–39)
5 (2016–2017)	517	72.2 (57.8–83.1)	0.50 ^E (0.31–0.80)	<LOD	0.23 ^E (<LOD–0.41)	10 ^E (6.1–14)	24 ^E (11–36)
6 (2018–2019)	505	82.7 (71.9–89.9)	0.99 ^E (0.57–1.7)	<LOD	0.73 ^E (0.16–1.3)	22 ^E (3.3–40)	42 ^E (9.0–75)
20–39 years							
2 (2009–2011)	355	62.6 (51.2–72.8)	2.3 ^E (1.5–3.6)	<LOD	1.5 ^E (<LOD–2.8)	33 ^E (15–52)	68 ^E (20–110)
3 (2012–2013)	355	59.3 (50.1–67.9)	—	<LOD	1.6 ^E (<LOD–3.0)	19 ^E (11–28)	35 ^E (12–58)
4 (2014–2015)	361	57.1 (47.3–66.4)	1.9 (1.5–2.5)	<LOD	1.5 ^E (<LOD–2.4)	32 ^E (17–47)	46 ^E (24–67)
5 (2016–2017)	357	81.8 (70.0–89.7)	1.4 ^E (0.72–2.8)	<LOD	1.5 ^E (0.55–2.5)	34 ^E (6.3–62)	57 ^E (<LOD–200)
6 (2018–2019)	330	84.4 (77.2–89.6)	1.3 ^E (0.81–2.0)	<LOD	1.2 ^E (0.56–1.7)	25 ^E (<LOD–50)	60 ^E (<LOD–130)
40–59 years							
2 (2009–2011)	357	62.1 (51.8–71.4)	1.8 (1.4–2.4)	<LOD	1.4 ^E (<LOD–2.5)	16 ^E (2.5–29)	35 ^E (19–52)
3 (2012–2013)	312	63.2 (52.9–72.5)	2.2 ^E (1.3–3.8)	<LOD	1.6 ^E (<LOD–2.8)	42 ^E (10–73)	57 ^E (30–84)
4 (2014–2015)	312	58.2 (48.7–67.2)	1.8 (1.3–2.6)	<LOD	1.3 ^E (<LOD–1.9)	27 ^E (4.8–50)	37 ^E (18–56)
5 (2016–2017)	345	88.2 (74.9–95.0)	2.0 ^E (1.1–3.7)	<LOD	1.7 ^E (<LOD–3.5)	37 (24–50)	59 ^E (30–87)
6 (2018–2019)	342	86.2 (76.9–92.1)	1.3 ^E (0.92–1.9)	<LOD	1.3 ^E (0.40–2.2)	21 ^E (<LOD–44)	56 ^E (18–95)
60–79 years							
2 (2009–2011)	289	71.1 (60.1–80.1)	3.6 ^E (2.2–5.9)	<LOD	3.6 ^E (1.4–5.8)	40 ^E (21–59)	74 ^E (33–120)
3 (2012–2013)	352	70.3 (60.8–78.3)	2.6 ^E (1.8–3.8)	<LOD	2.1 ^E (0.86–3.4)	29 ^E (<LOD–63)	67 ^E (29–100)
4 (2014–2015)	361	67.0 (57.8–75.1)	2.8 ^E (1.7–4.7)	<LOD	2.5 ^E (0.91–4.0)	50 ^E (12–88)	88 ^E (49–130)
5 (2016–2017)	348	89.7 (82.9–93.9)	1.7 ^E (1.1–2.8)	<LOD	1.7 ^E (0.59–2.8)	19 ^E (6.5–32)	59 ^E (13–110)
6 (2018–2019)	342	86.9 (79.5–92.0)	1.7 ^E (1.1–2.7)	<LOD	1.5 ^E (0.56–2.4)	35 ^E (13–58)	69 (46–91)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 3, 4, 5 and 6 are 0.8, 0.75, 0.75, 0.10 and 0.10 µg As/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.2.12

Arsenocholine and arsenobetaine (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g As/g creatinine}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2528	59.6 (52.5–66.4)	—	<LOD	1.5 ^E (<LOD–2.5)	22 (16–28)	44 ^E (18–71)
3 (2012–2013)	2535	60.0 (54.8–65.0)	—	<LOD	1.6 (<LOD–2.1)	25 ^E (12–39)	44 ^E (24–63)
4 (2014–2015)	2563	56.6 (51.8–61.3)	—	<LOD	1.2 (<LOD–1.5)	23 ^E (12–34)	46 ^E (27–65)
5 (2016–2017)	2605	82.8 (73.6–89.3)	1.3 ^E (0.79–2.1)	<LOD	1.1 ^E (0.43–1.8)	23 ^E (9.2–37)	62 ^E (21–100)
6 (2018–2019)	2530	84.3 (79.7–87.9)	1.4 (1.1–1.7)	<LOD	1.3 (0.97–1.6)	23 ^E (14–32)	51 (34–68)
Males, 3–79 years							
2 (2009–2011)	1267	61.4 (53.2–69.0)	—	<LOD	1.2 ^E (<LOD–2.1)	18 ^E (9.4–27)	40 ^E (7.8–72)
3 (2012–2013)	1251	60.9 (53.1–68.2)	—	<LOD	1.2 (<LOD–1.6)	16 ^E (7.3–24)	34 (25–43)
4 (2014–2015)	1272	60.1 (52.7–67.1)	—	<LOD	1.3 ^E (<LOD–1.8)	20 ^E (9.8–30)	37 ^E (19–55)
5 (2016–2017)	1296	83.3 (74.0–89.8)	1.0 ^E (0.65–1.6)	<LOD	1.0 ^E (0.50–1.5)	16 (12–21)	32 ^E (0.22–63)
6 (2018–2019)	1255	84.6 (80.5–88.0)	1.3 (1.0–1.6)	<LOD	1.2 (0.76–1.6)	21 (15–27)	51 ^E (30–71)
Females, 3–79 years							
2 (2009–2011)	1261	57.8 (48.9–66.3)	—	<LOD	<LOD	25 (19–32)	61 ^E (20–100)
3 (2012–2013)	1284	59.1 (50.7–67.1)	—	<LOD	2.1 ^E (<LOD–3.3)	33 ^E (9.5–56)	56 ^E (<LOD–130)
4 (2014–2015)	1291	53.1 (44.9–61.2)	—	<LOD	1.1 (<LOD–1.4)	26 ^E (3.7–48)	62 ^E (36–89)
5 (2016–2017)	1309	82.3 (71.6–89.6)	1.6 ^E (0.93–2.8)	<LOD	1.6 ^E (0.40–2.9)	31 ^E (<LOD–66)	92 ^E (35–150)
6 (2018–2019)	1275	83.9 (76.7–89.2)	1.5 (1.1–2.0)	<LOD	1.3 ^E (0.79–1.9)	24 ^E (2.9–46)	54 ^E (21–88)
3–5 years							
2 (2009–2011)	515	42.7 (34.7–51.0)	—	<LOD	<LOD	37 ^E (4.1–69)	74 ^E (4.3–140)
3 (2012–2013)	499	35.8 (30.2–41.8)	—	<LOD	<LOD	21 ^E (11–31)	43 ^E (<LOD–95)
4 (2014–2015)	512	35.8 (26.7–46.0)	—	<LOD	<LOD	26 ^E (14–38)	57 ^E (15–98)
5 (2016–2017)	532	66.6 (55.0–76.5)	0.69 ^F (0.40–1.2)	<LOD	0.33 ^E (<LOD–0.56)	15 ^E (<LOD–35)	43 ^E (<LOD–95)
6 (2018–2019)	512	73.5 (64.6–80.8)	0.92 ^E (0.61–1.4)	<LOD	0.61 ^E (0.18–1.0)	18 ^E (<LOD–36)	46 ^E (23–70)
6–11 years							
2 (2009–2011)	509	40.7 (33.8–47.9)	—	<LOD	<LOD	13 ^E (1.5–24)	32 ^E (<LOD–94)
3 (2012–2013)	507	44.2 (34.1–54.8)	—	<LOD	<LOD	13 ^E (<LOD–26)	40 ^E (12–69)
4 (2014–2015)	511	37.1 (30.1–44.8)	—	<LOD	<LOD	17 ^E (8.4–27)	35 ^E (<LOD–72)
5 (2016–2017)	509	64.9 (53.6–74.8)	0.44 (0.31–0.64)	<LOD	0.23 ^E (<LOD–0.36)	11 ^E (<LOD–23)	34 ^E (1.9–65)
6 (2018–2019)	499	74.9 (63.9–83.4)	1.1 ^E (0.70–1.7)	<LOD	0.54 ^E (<LOD–1.1)	58 ^E (<LOD–120)	96 ^E (52–140)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
2 (2009–2011)	508	42.3 (34.1–51.0)	—	<LOD	<LOD	9.3 ^E (4.0–15)	24 ^E (10–38)
3 (2012–2013)	510	48.6 (39.0–58.3)	—	<LOD	<LOD	10 ^E (3.8–17)	22 ^E (5.8–39)
4 (2014–2015)	506	50.3 (41.1–59.5)	—	<LOD	0.72 ^E (<LOD–1.0)	9.9 ^E (5.4–14)	16 ^E (1.6–31)
5 (2016–2017)	515	72.2 (57.8–83.1)	0.38 ^E (0.24–0.62)	<LOD	0.25 ^E (<LOD–0.40)	8.0 ^E (4.0–12)	17 ^E (5.6–28)
6 (2018–2019)	505	82.7 (71.9–89.9)	0.82 ^E (0.46–1.5)	<LOD	0.85 ^E (0.29–1.4)	15 ^E (7.7–22)	20 ^E (3.6–37)
20–39 years							
2 (2009–2011)	353	62.6 (51.2–72.8)	1.9 ^E (1.2–2.8)	<LOD	1.4 ^E (<LOD–2.8)	22 ^E (7.8–37)	44 ^E (<LOD–92)
3 (2012–2013)	355	59.3 (50.1–67.9)	—	<LOD	1.4 ^E (<LOD–1.9)	12 ^E (5.5–19)	21 ^E (9.8–32)
4 (2014–2015)	361	57.1 (47.3–66.4)	1.6 (1.2–2.1)	<LOD	1.1 ^E (<LOD–1.6)	20 (13–27)	29 ^E (7.7–50)
5 (2016–2017)	357	81.8 (70.0–89.7)	1.3 ^E (0.61–2.8)	<LOD	1.4 ^E (<LOD–3.1)	24 ^E (<LOD–51)	63 ^E (<LOD–160)
6 (2018–2019)	330	84.4 (77.2–89.6)	1.2 ^E (0.81–1.8)	<LOD	1.1 ^E (0.50–1.7)	17 ^E (<LOD–34)	42 ^E (<LOD–110)
40–59 years							
2 (2009–2011)	355	62.1 (51.8–71.4)	1.8 (1.3–2.5)	<LOD	1.9 ^E (<LOD–3.1)	17 ^E (10–24)	24 ^E (9.8–39)
3 (2012–2013)	312	63.2 (52.9–72.5)	2.6 ^E (1.6–4.4)	<LOD	2.2 ^E (<LOD–4.3)	33 ^E (14–52)	53 ^E (<LOD–130)
4 (2014–2015)	312	58.2 (48.7–67.2)	1.7 (1.2–2.4)	<LOD	1.1 ^E (<LOD–1.5)	23 ^E (3.1–43)	40 ^E (9.6–70)
5 (2016–2017)	345	88.2 (74.9–95.0)	1.8 ^E (1.0–3.2)	<LOD	1.7 ^E (<LOD–3.4)	26 ^E (<LOD–66)	76 ^E (38–110)
6 (2018–2019)	342	86.2 (76.9–92.1)	1.6 ^E (1.1–2.3)	<LOD	1.7 ^E (0.79–2.5)	26 ^E (<LOD–47)	68 ^E (15–120)
60–79 years							
2 (2009–2011)	288	71.1 (60.1–80.1)	4.2 ^E (2.6–6.8)	<LOD	4.6 ^E (1.7–7.5)	47 ^E (13–80)	84 ^E (43–120)
3 (2012–2013)	352	70.3 (60.8–78.3)	2.9 ^E (1.9–4.4)	<LOD	2.1 ^E (<LOD–3.6)	35 ^E (<LOD–57)	55 ^E (<LOD–120)
4 (2014–2015)	361	67.0 (57.8–75.1)	2.8 ^E (1.7–4.4)	<LOD	2.2 ^E (0.93–3.5)	43 ^E (8.8–77)	72 ^E (16–130)
5 (2016–2017)	347	89.7 (82.9–93.9)	2.0 ^E (1.3–3.1)	<LOD	2.5 ^E (1.5–3.5)	24 ^E (9.9–39)	54 ^E (10–97)
6 (2018–2019)	342	86.9 (79.5–92.0)	2.1 ^E (1.3–3.3)	<LOD	1.9 ^E (0.89–2.9)	31 ^E (16–45)	58 (43–73)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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8.3 BORON

Boron (CASRN 7440-42-8) is a naturally occurring element. It is a metalloid exhibiting properties intermediate between those of typical metals and nonmetals. Elemental boron exists in a crystalline or amorphous form; however, it is never found in nature in the free elemental form (Ince et al., 2017; WHO, 2009; ATSDR, 2010). Boron is always found in combination with oxygen as borate compounds, including boric acid, sodium tetraborate (or Borax) and boron oxide (ATSDR, 2010).

Boron is widely distributed in nature and can be released by both natural and anthropogenic processes. Volcanic emissions, sea salt aerosol, soil dust, plant aerosols and weathering of soil and rocks containing borates are important sources of natural borates released into the environment (Canada, 2016; HC, 2016; 2020). Anthropogenic sources include the manufacture, import and use of boric acid, its salts and its precursors in manufactured products and applications such as fibreglass insulation, oil and gas extraction, fertilizers,

cellulose insulation, gypsum boards, engineered wood products, pulp and paper manufacturing, rubber manufacturing, chemical manufacturing, metallurgical applications and cleaning products. Other anthropogenic sources include the incidental production and subsequent release of boric acid as a result of activities such as coal-fired power generation, metal mining, smelting and refining, coal mining, oil sands extraction and processing, oil and gas extraction, wastewater treatment and waste disposal (ECCC and HC, 2016).

Exposure to boron occurs primarily through the ingestion of food (mainly fruit and vegetables) and drinking water (ATSDR, 2010; Canada, 2016). The range of boron concentrations in these media varies widely across the world (WHO, 2009; Canada, 2016). Boron is generally not present at significant levels in air because of the low volatility of borate compounds (WHO, 2009). Exposure to borates can also occur through products available to consumers such as cosmetics, arts and craft materials, toys, natural health products, cleaning products and swimming pool products, as well as through the use of household pest control products (Canada, 2016; ECCC and HC, 2016; HC, 2016).

Inorganic borates are readily absorbed across mucous membranes; gastrointestinal absorption has been estimated at approximately 81% to 92% (ATSDR, 2010; Devirian and Volpe, 2003; Dourson et al., 1998). Significant absorption can also occur through inhalation (Ince et al., 2017). Dermal absorption is generally low in healthy skin (~0.5% to 10%), but can be significantly increased in damaged skin (ECCC and HC, 2016; Ince et al., 2017). Boron is mostly present in the body as boric acid; borates are rapidly converted to boric acid in the mucosal layer before rapid absorption and distribution (Devirian and Volpe, 2003). Animal studies show that absorbed boric acid is equally distributed to liver, kidneys, genital tissue, brain, adrenals, muscles and blood (Ince et al., 2017). Boron can also cross the placental barrier; some animal toxicology studies have reported accumulation in bone over long-term oral exposure (Ince et al., 2017). Boric acid is not further metabolized in the bodies of humans or animals because substantial energy is required to break the oxygen and boron bond (Ince et al., 2017). Consequently, orally absorbed boric acid is rapidly eliminated unchanged, mainly in urine, with a half-life of less than 24 hours (Ince et al., 2017). A small

amount is found in feces (2%) and a smaller amount in bile, sweat and breath (Devirian and Volpe, 2003). Measurement of inorganic borates in urine reflects boron intake, and is an indicator of human exposure (Devirian and Volpe, 2003). Boron in blood can also be used to estimate human exposure (ATSDR, 2010; ECCC and HC, 2016).

Although boron plays important roles in human health—being involved in functions such as bone growth, regulation of sex hormones and anti-inflammatory and anti-cancer effects—it is not considered an essential trace element in humans at this time (Devirian and Volpe, 2003; IOM, 2001; Pizzorno, 2015). The acute oral toxicity of boron is generally low (Hubbard, 1998). Acute toxicity is more likely in children, the elderly and people with kidney problems. Symptoms may include vomiting, nausea, digestive disorders, skin flushing, ataxia, headache, seizure, depression, vascular collapse and death (Devirian and Volpe, 2003; ECCC and HC, 2016; HC, 2020; Ince et al., 2017). Acute inhalation toxicity marked by irritation of the respiratory tract and eyes has been reported in boron production workers following occupational exposure to borate dusts (ATSDR, 2010).

Chronic exposure to boron has been associated with digestive problems (nausea, vomiting and loss of appetite) as well as nervous system irritation and convulsion. Subchronic and chronic experimental animal studies suggest that high-dose exposure to boron compounds leads to reproductive and developmental toxicity, particularly affecting the male reproductive system (Devirian and Volpe, 2003; ECCC and HC, 2016; HC, 2020; Hubbard, 1998; Ince et al., 2017). Evidence for the effects of boron on human reproduction and development is less clear (ECCC and HC, 2016; HC, 2020; Ince et al., 2017; Scialli et al., 2010). There is no conclusive evidence for mutagenic or genotoxic effects of boron (Hubbard, 1998; Ince et al., 2017); consequently, boron is not classified as a carcinogen by the International Agency for Research on Cancer or other agencies (ATSDR, 2010).

The Government of Canada has conducted a science-based screening assessment under the Chemicals Management Plan to determine whether boric acid, its salts and its precursors present or may present a risk to

the environment or human health as per the criteria set out in section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; ECCC and HC, 2016). The draft assessment proposed to conclude that boric acid, its salts and its precursors are toxic under CEPA 1999 because they are considered harmful to the environment and human health (ECCC and HC, 2016).

The sale and use of pesticides are regulated in Canada by the Pest Management Regulatory Agency (PMRA) under the *Pest Control Products Act* (Canada, 2002). Based on a re-evaluation by the PMRA in 2016, most pesticides containing boric acid and its salts continue to be approved, as they pose no unacceptable risk for humans or the environment when they are used according to revised label directions (HC, 2016). However, a number of pesticide products that contain boric acid for use in and around the home that are in powder form or in other formulations carrying a potential risk for overexposure will be phased out of the marketplace (HC, 2016). Boric acid and its salts are on the List of Ingredients that are Restricted for Use in Cosmetic Products (HC, 2019). Canada's Food and Drug Regulations specify that a cautionary statement must appear on the label of drug products containing boric acid or sodium borate to prevent administration to children under the age of 3 (Canada, 1985). Toy Regulations under the *Canada Consumer Product Safety Act* prohibit the presence of boron in children's toys (Canada, 2016).

Health Canada, in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water, has developed a Canadian drinking water quality guideline that proposed a maximum acceptable concentration for boron in drinking water (HC, 2020). The guideline was proposed based on the achievability of water treatment to reduce boron (HC, 2020).

Boron was analyzed in the urine of Canadian Health Measures Survey (CHMS) cycle 5 (2016–2017) and cycle 6 (2018–2019) participants aged 3–79. Data from this cycle are presented in urine as both µg/L and µg/g creatinine. Finding a measurable amount of boron in urine is an indicator of exposure to boron and does not necessarily mean that an adverse health effect will occur.

Table 8.3.1

Boron—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2715	98.2 (95.1–99.4)	960 (880–1000)	360 (310–410)	990 (940–1000)	2300 (2100–2400)	2900 (2500–3200)
6 (2018–2019)	2534	98.2 (96.5–99.0)	930 (860–1000)	370 (320–410)	970 (880–1100)	2400 (2200–2700)	3000 (2600–3500)
Males, 3–79 years							
5 (2016–2017)	1351	98.0 (93.4–99.4)	920 (840–1000)	360 (300–430)	960 (910–1000)	2300 (2000–2600)	2900 (2200–3600)
6 (2018–2019)	1256	98.4 (94.8–99.5)	1000 (890–1100)	390 (320–460)	1000 (930–1100)	2500 (2200–2900)	3100 (2300–3800)
Females, 3–79 years							
5 (2016–2017)	1364	98.5 (93.4–99.7)	990 (870–1100)	350 (290–410)	1100 (920–1200)	2200 (2100–2400)	2800 (2100–3500)
6 (2018–2019)	1278	98.0 (96.7–98.7)	870 (800–940)	350 (300–410)	880 (760–1000)	2100 (1700–2600)	2700 (2300–3100)
3–5 years							
5 (2016–2017)	553	99.8 (87.1–100)	1300 (1100–1500)	490 (310–670)	1200 (950–1500)	3000 (2700–3300)	3400 (3100–3700)
6 (2018–2019)	516	99.3 (95.9–99.9)	1500 (1400–1700)	710 (570–840)	1500 (1300–1600)	3100 (2200–4100)	5100 ^E (3100–7100)
6–11 years							
5 (2016–2017)	538	99.2 (97.8–99.7)	1100 (1000–1200)	380 (290–480)	1200 (970–1300)	2500 (2100–2800)	3000 (2200–3900)
6 (2018–2019)	499	97.5 (85.3–99.6)	1100 (940–1400)	410 (270–560)	1200 (990–1400)	3300 (2300–4200)	3700 (3000–4500)
12–19 years							
5 (2016–2017)	534	98.5 (94.9–99.6)	980 (890–1100)	350 (260–430)	1000 (970–1000)	2200 (1800–2500)	2600 (2400–2900)
6 (2018–2019)	505	96.6 (92.8–98.4)	870 (730–1000)	320 (220–420)	970 (830–1100)	2100 (1800–2500)	2500 (2100–2800)
20–39 years							
5 (2016–2017)	375	97.9 (87.2–99.7)	860 (680–1100)	330 (210–440)	860 (630–1100)	2200 (1800–2700)	2500 (1800–3200)
6 (2018–2019)	329	99.2 (97.3–99.8)	900 (800–1000)	350 (250–450)	940 (680–1200)	2400 (1900–2900)	2800 (2300–3400)
40–59 years							
5 (2016–2017)	360	97.8 (90.3–99.5)	930 (780–1100)	390 (260–520)	970 (760–1200)	1900 (1500–2300)	2600 ^E (1200–4000)
6 (2018–2019)	342	97.4 (91.8–99.2)	870 (740–1000)	360 (270–440)	930 (710–1200)	2200 (1800–2700)	2800 (2200–3400)
60–79 years							
5 (2016–2017)	355	98.5 (95.3–99.5)	1000 (960–1100)	370 (320–410)	1100 (920–1300)	2400 (1700–3100)	3500 (2800–4100)
6 (2018–2019)	343	98.6 (95.2–99.6)	940 (800–1100)	420 (320–520)	920 (770–1100)	2400 (2100–2700)	3300 ^E (1600–5000)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 160 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.3.2

Boron (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2691	98.2 (95.1–99.4)	930 (860–1000)	420 (360–480)	880 (800–960)	2300 (1900–2700)	2900 (2600–3300)
6 (2018–2019)	2533	98.2 (96.5–99.0)	1000 (900–1100)	420 (380–470)	990 (900–1100)	2300 (1900–2600)	2900 (2600–3300)
Males, 3–79 years							
5 (2016–2017)	1341	98.0 (93.4–99.4)	800 (740–860)	350 (280–430)	760 (700–830)	1800 (1500–2200)	2800 (2100–3500)
6 (2018–2019)	1255	98.4 (94.8–99.5)	930 (800–1100)	390 (300–470)	950 (830–1100)	2100 (1700–2500)	2700 (2100–3300)
Females, 3–79 years							
5 (2016–2017)	1350	98.5 (93.4–99.7)	1100 (960–1200)	510 (450–570)	1000 (890–1100)	2500 (2100–3000)	3000 (2100–3900)
6 (2018–2019)	1278	98.0 (96.7–98.7)	1100 (970–1200)	470 (410–530)	1000 (850–1200)	2600 (2100–3100)	3200 (2700–3700)
3–5 years							
5 (2016–2017)	545	99.8 (87.1–100)	2200 (1900–2400)	1000 (820–1200)	2200 (1900–2500)	4100 (3500–4700)	4800 (4200–5400)
6 (2018–2019)	515	99.3 (95.9–99.9)	2500 (2400–2600)	1200 (920–1500)	2500 (2300–2600)	4900 (4400–5300)	5800 (4800–6700)
6–11 years							
5 (2016–2017)	531	99.2 (97.8–99.7)	1300 (1200–1400)	630 (560–690)	1200 (1100–1400)	2500 (1900–3100)	3300 (2600–4000)
6 (2018–2019)	499	97.5 (85.3–99.6)	1400 (1200–1600)	600 (490–710)	1300 (1100–1400)	3000 (2600–3400)	3200 (2900–3600)
12–19 years							
5 (2016–2017)	530	98.5 (94.9–99.6)	750 (690–810)	370 (310–430)	760 (690–830)	1400 (1200–1500)	1700 (1500–1800)
6 (2018–2019)	505	96.6 (92.8–98.4)	720 (650–800)	350 (240–460)	690 (620–760)	1500 (1100–1900)	1900 (1300–2600)
20–39 years							
5 (2016–2017)	372	97.9 (87.2–99.7)	770 (690–870)	330 (230–430)	720 (600–840)	1800 (1300–2300)	2200 ^E (1400–3100)
6 (2018–2019)	329	99.2 (97.3–99.8)	850 (770–940)	400 (370–440)	810 (670–950)	2100 (1500–2700)	2300 (1900–2700)
40–59 years							
5 (2016–2017)	359	97.8 (90.3–99.5)	860 (740–990)	430 (340–520)	780 (660–910)	1700 ^E (870–2500)	2600 (1700–3500)
6 (2018–2019)	342	97.4 (91.8–99.2)	1000 (850–1300)	410 ^E (250–570)	1000 (800–1200)	2200 (1600–2900)	3100 (2300–4000)
60–79 years							
5 (2016–2017)	354	98.5 (95.3–99.5)	1200 (1100–1300)	540 (490–580)	1100 (980–1300)	2800 (2300–3400)	3400 (2800–4000)
6 (2018–2019)	343	98.6 (95.2–99.6)	1100 (940–1300)	490 (400–590)	1000 (810–1300)	2300 (1600–3000)	2900 (2300–3500)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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8.4 CADMIUM

Cadmium (CASRN 7440-43-9) is a naturally occurring, soft, silvery white, blue-tinged metal. Common forms include soluble species (e.g., cadmium chloride, cadmium sulfate) and insoluble species (e.g., cadmium metal and its oxides) that may also be found as particulate matter in the atmosphere (ATSDR, 2012; CCME, 1999).

Cadmium is released into the environment as a result of natural processes, including forest fires, volcanic emissions and weathering of soil and bedrock (Morrow, 2000). The main anthropogenic sources of atmospheric

cadmium are industrial base-metal smelting and refining processes and combustion processes (such as coal-fired electrical plants and waste incineration) where cadmium is released as a by-product (CCME, 1999).

Cadmium is primarily used in the manufacture of nickel-cadmium batteries. It is also used in industrial coatings and electroplating, in pigments and as a stabilizer in polyvinyl chloride plastics (ATSDR, 2012). Cadmium is present in metal alloy sheets, wires, rods, solders and shields for various industrial applications (EC and HC, 1994). It is also sometimes used in costume jewellery and as a pigment in ceramic glazes. Cadmium may also be present in fertilizers. It is frequently found as an impurity in galvanized pipes and well components, brass fittings and cement-mortar linings, and is a constituent of solders used in plumbing. Cadmium in drinking water results primarily from the deterioration of galvanized steel pipes and well components and, to a lesser extent, leaching from brass materials and cement-mortar linings (HC, 2020b; WHO, 2011).

In smokers, inhalation of cigarette smoke is a major source of cadmium exposure (EC and HC, 1994; IARC, 2012). For non-smoking adults and children, the largest source of cadmium exposure is food (EC and HC, 1994; IARC, 2012). Ambient air is usually a minor source of exposure, with intakes estimated to be 2 to 3 orders of magnitude lower than for food, although cadmium compounds are more readily absorbed following inhalation than through ingestion (Friberg, 1985). Other potential sources of exposure include ingestion of drinking water, soil or dust (ATSDR, 2012; HC, 2020b; Rasmussen et al., 2013).

Absorption of dietary cadmium into the bloodstream depends on one's nutritional status and the levels of other components of the diet, such as iron, calcium and protein. The majority of dietary cadmium is not absorbed; average gastrointestinal absorption is estimated at 5% in adult men and 10% or higher in adult women (CDC, 2009). About 25% to 60% of inhaled cadmium is absorbed through the lungs (ATSDR, 2012). Absorbed cadmium accumulates mainly in the kidneys and liver, with approximately one-third to one-half of the total body burden accumulating in the kidneys (CDC, 2009). The biological half-life of cadmium in the kidneys has been estimated to be approximately 10 to 12 years (Amzal et al., 2009; Lauwerys et al., 1994). Only a small

proportion of absorbed cadmium is eliminated, mainly in urine and feces, with small amounts also eliminated through hair, nails and sweat.

Cadmium can be measured in blood, urine, feces, liver, kidney, hair and other tissues. Cadmium concentrations in urine best reflect cumulative exposure and the concentration of cadmium in the kidneys, although slight fluctuations occur with recent exposures (Adams and Newcomb, 2014). Concentrations in blood reflect more recent exposures (Adams and Newcomb, 2014). Blood cadmium concentrations are about twice as high in smokers compared with non-smokers; concentrations can also be elevated following occupational exposures (ATSDR, 2012).

Oral exposure to high doses of cadmium may cause severe gastrointestinal irritation and kidney effects (ATSDR, 2012). Chronic exposure via inhalation has been associated with effects in the lungs (including emphysema) and kidneys (ATSDR, 2012). The kidney is considered the critical organ that exhibits the first adverse effects after either oral or inhalation exposure, based on observations in both human epidemiology and animal toxicity studies (EFSA, 2009; FAO/WHO, 2011; ATSDR, 2012).

Inhaled cadmium and its compounds have been classified as probably carcinogenic to humans by Environment Canada and Health Canada (EC and HC, 1994). More recently, the International Agency for Research on Cancer has classified cadmium and its compounds as carcinogenic to humans (Group 1) based on various data, including associations between occupational inhalation exposure and lung cancer (IARC, 2012). There is insufficient evidence to determine whether or not cadmium is carcinogenic in humans following oral exposure (ATSDR, 2012).

Health Canada and Environment Canada concluded that inorganic cadmium compounds may be harmful to the environment and may constitute a danger to human life or health in Canada (EC and HC, 1994). Inorganic cadmium compounds are listed on Schedule 1, List of Toxic Substances, under the *Canadian Environmental Protection Act, 1999* (CEPA 1999). The act allows the federal government to control the importation, manufacture, distribution and use of inorganic cadmium compounds in Canada (Canada, 1999; Canada, 2000). Risk management actions under CEPA 1999 have been developed to control releases

of cadmium from thermal electric power generation, base-metal smelting and steel manufacturing processes (EC, 2013).

Cadmium is included in the list of trace elements analyzed as part of Health Canada's ongoing Total Diet Study surveys (HC, 2020a). The food items analyzed represent those that are most typical of the Canadian diet, and these surveys are used to provide dietary exposure estimates for chemicals to which Canadians in different age-sex groups are exposed through the food supply. On the basis of data collected, Health Canada has concluded that dietary exposure to cadmium does not represent a health concern for the general Canadian population (HC, 2018). In Canada, the leachable cadmium content in a variety of consumer products is regulated under the *Canada Consumer Product Safety Act* (Canada, 2010a). Consumer products regulated for leachable cadmium content include glazed ceramics and glassware, as well as paints and other surface coatings on cribs, toys, and other products for use by a child in learning or play situations (Canada, 1998; 2010b; 2011; HC, 2009). In addition, because children's jewellery items containing high levels of cadmium have been found in the Canadian marketplace, a guideline limit for total cadmium in children's jewellery was finalized and published in 2018 as part of the Children's Jewellery Regulations under the *Canada Consumer Product Safety Act* (Canada, 2018). Cadmium and its compounds are on the List of Ingredients that are Prohibited for Use in

Cosmetic Products (HC, 2019). On the basis of health considerations, Health Canada, in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water, has developed a guideline for Canadian drinking water quality that establishes the maximum acceptable concentration for cadmium in drinking water (HC, 2020b).

Cadmium concentrations in blood and urine have been measured in a number of biomonitoring studies conducted in Canada, including the Maternal–Infant Research on Environmental Chemicals study (Arbuckle et al., 2016) and the First Nations Biomonitoring Initiative (AFN, 2013).

Cadmium was analyzed in the whole blood of Canadian Health Measures Survey (CHMS) participants aged 6–79 in cycle 1 (2007–2009), and aged 3–79 in cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented in blood as µg/L. Cadmium was analyzed in the urine of CHMS participants aged 6–79 in cycle 1, and aged 3–79 in cycles 2, 5 and 6. Data from these cycles are presented in urine as both µg/L and µg/g creatinine. Cadmium was also analyzed in hair from CHMS participants aged 20–59 in cycle 5. Finding a measurable amount of cadmium in blood, urine or hair is an indicator of exposure to cadmium, and does not necessarily mean that an adverse health effect will occur.

Table 8.4.1

Cadmium—Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	6070	97.1 (94.0–98.6)	0.29 (0.26–0.32)	0.083 (0.074–0.093)	0.26 (0.24–0.29)	1.7 (1.3–2.0)	2.6 (2.1–3.0)
3 (2012–2013)	5538	94.4 (92.4–95.9)	0.33 (0.30–0.36)	<LOD	0.27 (0.25–0.29)	2.0 (1.4–2.6)	3.4 (2.5–4.3)
4 (2014–2015)	5497	94.9 (93.6–96.0)	0.31 (0.29–0.32)	<LOD	0.25 (0.23–0.26)	1.9 (1.5–2.4)	3.3 (2.6–4.0)
5 (2016–2017)	4517	84.8 (80.8–88.2)	0.25 (0.23–0.27)	<LOD	0.21 (0.19–0.22)	1.6 (1.0–2.2)	2.8 (2.3–3.3)
6 (2018–2019)	4596	87.7 (84.6–90.2)	0.24 (0.22–0.26)	<LOD	0.21 (0.19–0.23)	0.96 (0.75–1.2)	1.7 (1.1–2.3)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2940	97.0 (93.8–98.5)	0.26 (0.24–0.29)	0.079 (0.070–0.089)	0.23 (0.20–0.26)	1.7 (1.5–2.0)	2.4 (2.0–2.9)
3 (2012–2013)	2769	92.6 (90.1–94.4)	0.29 (0.27–0.32)	<LOD	0.22 (0.19–0.25)	2.1 (1.5–2.7)	3.3 (2.5–4.2)
4 (2014–2015)	2753	93.7 (91.5–95.4)	0.28 (0.27–0.30)	<LOD	0.20 (0.19–0.21)	2.0 (1.4–2.6)	3.3 (2.5–4.2)
5 (2016–2017)	2257	81.9 (76.4–86.4)	0.24 (0.21–0.27)	<LOD	0.18 (0.17–0.19)	2.2 ^E (1.3–3.0)	3.1 (2.5–3.6)
6 (2018–2019)	2330	85.2 (81.2–88.4)	0.22 (0.19–0.24)	<LOD	0.18 (0.17–0.19)	1.0 ^E (0.52–1.6)	1.9 ^E (1.1–2.6)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	3130	97.2 (93.4–98.8)	0.32 (0.28–0.36)	0.089 (0.080–0.098)	0.30 (0.27–0.33)	1.5 ^E (0.92–2.1)	2.7 (2.1–3.4)
3 (2012–2013)	2769	96.3 (94.5–97.5)	0.37 (0.33–0.41)	<LOD	0.32 (0.28–0.37)	1.7 ^E (0.62–2.8)	3.4 ^E (1.8–5.0)
4 (2014–2015)	2744	96.2 (95.3–96.9)	0.33 (0.31–0.35)	0.099 (0.095–0.10)	0.28 (0.25–0.30)	1.8 ^E (1.1–2.5)	3.1 (2.3–4.0)
5 (2016–2017)	2260	87.7 (84.3–90.5)	0.26 (0.24–0.29)	<LOD	0.25 (0.22–0.27)	1.0 ^E (0.60–1.4)	2.1 ^E (1.2–3.1)
6 (2018–2019)	2266	90.2 (87.1–92.6)	0.27 (0.24–0.30)	<LOD	0.26 (0.22–0.29)	0.91 (0.74–1.1)	1.5 ^E (0.74–2.3)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	495	87.9 (78.4–93.6)	0.073 (0.065–0.081)	<LOD	0.078 (0.069–0.087)	0.099 (0.098–0.10)	0.14 ^E (<LOD–0.25)
3 (2012–2013)	471	60.0 (49.8–69.4)	—	<LOD	0.091 (<LOD–0.11)	0.16 (0.11–0.20)	0.18 ^E (<LOD–0.29)
4 (2014–2015)	479	65.9 (57.7–73.3)	0.082 (<LOD–0.091)	<LOD	0.093 (0.084–0.10)	0.16 (0.14–0.18)	0.19 (0.15–0.24)
5 (2016–2017)	473	32.0 (22.4–43.5)	—	<LOD	<LOD	0.13 (<LOD–0.16)	0.15 (0.12–0.18)
6 (2018–2019)	482	39.1 (26.7–53.1)	—	<LOD	<LOD	0.17 (0.13–0.21)	0.21 (0.16–0.26)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
6–11 years							
1 (2007–2009)	910	91.3 (87.6–94.0)	0.091 (0.082–0.10)	<LOD ^E (<LOD–0.053)	0.092 (0.090–0.094)	0.20 (0.18–0.21)	0.22 (0.19–0.26)
2 (2009–2011)	961	89.1 (82.9–93.3)	0.083 (0.076–0.090)	<LOD	0.090 (0.087–0.094)	0.17 ^E (0.088–0.25)	0.20 (0.18–0.23)
3 (2012–2013)	944	77.1 (67.6–84.5)	0.095 (0.085–0.11)	<LOD	0.10 (0.099–0.10)	0.18 (0.16–0.20)	0.21 (0.18–0.24)
4 (2014–2015)	925	76.7 (70.9–81.7)	0.094 (0.086–0.10)	<LOD	0.10 (0.096–0.10)	0.16 (0.14–0.19)	0.19 (0.17–0.21)
5 (2016–2017)	511	44.0 (32.5–56.2)	—	<LOD	<LOD	0.16 (0.12–0.19)	0.19 (0.14–0.25)
6 (2018–2019)	500	52.2 (40.7–63.5)	—	<LOD	0.099 (<LOD–0.12)	0.17 (0.15–0.19)	0.20 (0.18–0.23)
12–19 years							
1 (2007–2009)	945	97.0 (95.1–98.1)	0.16 (0.13–0.20)	0.066 (0.045–0.086)	0.099 ^E (<LOD–0.18)	0.52 ^E (0.088–0.95)	1.4 ^E (<LOD–3.0)
2 (2009–2011)	997	95.0 (89.1–97.8)	0.13 (0.12–0.15)	0.062 (0.040–0.084)	0.096 (0.095–0.097)	0.48 ^E (0.27–0.70)	0.82 ^E (0.45–1.2)
3 (2012–2013)	977	88.5 (81.6–93.0)	0.17 (0.15–0.20)	<LOD	0.12 ^E (<LOD–0.17)	0.82 ^E (0.31–1.3)	1.7 ^E (0.91–2.4)
4 (2014–2015)	974	88.8 (83.8–92.5)	0.14 (0.13–0.15)	<LOD	0.12 (0.12–0.13)	0.29 (0.25–0.33)	0.54 ^E (0.15–0.94)
5 (2016–2017)	521	62.5 (52.7–71.3)	0.11 (<LOD–0.12)	<LOD	0.11 (<LOD–0.12)	0.21 (0.15–0.28)	0.38 ^E (<LOD–0.84)
6 (2018–2019)	504	77.7 (67.2–85.6)	0.13 (0.11–0.15)	<LOD	0.13 (0.11–0.15)	0.26 (0.24–0.28)	0.32 (0.24–0.40)
20–39 years							
1 (2007–2009)	1165	98.3 (95.4–99.4)	0.34 (0.30–0.38)	0.091 (0.084–0.098)	0.24 (0.21–0.27)	2.6 (2.0–3.1)	3.4 (3.1–3.7)
2 (2009–2011)	1313	97.1 (89.8–99.2)	0.28 (0.24–0.34)	0.090 (0.066–0.11)	0.24 (0.20–0.29)	1.7 ^E (1.0–2.3)	2.7 (2.1–3.2)
3 (2012–2013)	1032	95.2 (91.9–97.2)	0.31 (0.24–0.41)	0.10 (0.084–0.12)	0.25 (0.20–0.29)	2.0 ^E (0.71–3.3)	3.4 ^E (0.26–6.6)
4 (2014–2015)	1074	96.7 (93.9–98.3)	0.33 (0.28–0.38)	0.10 (0.090–0.11)	0.22 (0.17–0.26)	2.9 (1.9–3.9)	4.2 ^E (2.5–5.9)
5 (2016–2017)	1038	88.1 (80.6–92.9)	0.27 (0.22–0.34)	<LOD	0.19 (0.16–0.22)	2.4 ^E (1.1–3.6)	3.1 (2.0–4.1)
6 (2018–2019)	1053	89.1 (85.5–91.8)	0.24 (0.21–0.27)	<LOD	0.21 (0.18–0.24)	1.1 ^E (0.55–1.7)	1.8 (1.2–2.5)
40–59 years							
1 (2007–2009)	1220	99.6 (98.0–99.9)	0.48 (0.43–0.54)	0.098 ^E (0.054–0.14)	0.36 (0.32–0.41)	3.1 (2.3–3.9)	4.2 (3.7–4.7)
2 (2009–2011)	1222	98.6 (94.5–99.6)	0.41 (0.37–0.46)	0.095 (0.090–0.10)	0.34 (0.31–0.37)	2.2 (1.5–2.8)	3.1 (2.3–3.8)
3 (2012–2013)	1071	99.1 (97.9–99.6)	0.50 (0.43–0.57)	0.11 (0.084–0.13)	0.39 (0.30–0.48)	3.0 (2.3–3.7)	4.6 (3.7–5.5)
4 (2014–2015)	1050	98.9 (97.8–99.4)	0.41 (0.37–0.45)	0.12 (0.097–0.15)	0.33 (0.26–0.39)	2.1 ^E (1.2–3.0)	3.4 (2.3–4.4)
5 (2016–2017)	990	95.3 (90.9–97.6)	0.35 (0.31–0.39)	0.11 (<LOD–0.14)	0.27 (0.24–0.29)	2.0 ^E (1.2–2.9)	2.8 (2.3–3.3)
6 (2018–2019)	1083	96.4 (94.4–97.7)	0.32 (0.27–0.38)	0.11 (<LOD–0.12)	0.26 (0.22–0.30)	1.2 ^E (0.44–2.0)	2.4 ^E (1.3–3.6)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
60–79 years							
1 (2007–2009)	1079	99.2 (95.5–99.9)	0.45 (0.42–0.49)	0.19 (0.18–0.20)	0.39 (0.37–0.41)	1.7 (1.2–2.2)	2.7 (2.2–3.2)
2 (2009–2011)	1082	99.7 (98.3–99.9)	0.45 (0.41–0.50)	0.18 (0.13–0.23)	0.40 (0.35–0.44)	1.6 (1.3–2.0)	2.4 (1.9–2.8)
3 (2012–2013)	1043	100	0.48 (0.43–0.54)	0.19 (0.17–0.20)	0.41 (0.35–0.46)	1.5 (1.3–1.8)	2.6 (1.9–3.3)
4 (2014–2015)	995	99.1 (97.4–99.7)	0.44 (0.41–0.48)	0.17 (0.16–0.18)	0.37 (0.34–0.40)	1.6 (1.1–2.2)	2.8 (2.0–3.6)
5 (2016–2017)	984	97.8 (93.3–99.3)	0.39 (0.35–0.43)	0.15 (0.13–0.17)	0.32 (0.28–0.36)	1.2 ^E (0.63–1.7)	2.7 (1.8–3.6)
6 (2018–2019)	974	97.5 (94.3–98.9)	0.36 (0.33–0.39)	0.14 (0.11–0.16)	0.34 (0.30–0.38)	1.0 (0.78–1.2)	1.8 (1.3–2.3)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 3, 4, 5 and 6 are 0.04, 0.04, 0.080, 0.080, 0.097 and 0.097 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 8.4.2

Cadmium—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	6311	94.4 (92.5–95.9)	0.38 (0.34–0.43)	0.092 (0.088–0.096)	0.41 (0.35–0.47)	1.2 (1.1–1.4)	1.8 (1.7–2.0)
5 (2016–2017)	2715	72.0 (65.3–77.9)	—	<LOD	0.16 (0.14–0.19)	0.91 (0.71–1.1)	1.4 (1.0–1.8)
6 (2018–2019)	2532	85.6 (81.7–88.8)	0.19 (0.17–0.21)	<LOD	0.21 (0.18–0.24)	0.76 (0.70–0.82)	1.1 (0.89–1.3)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	3036	94.2 (91.5–96.1)	0.38 (0.33–0.44)	0.092 (0.084–0.10)	0.41 (0.34–0.47)	1.2 (1.0–1.4)	1.6 (1.4–1.8)
5 (2016–2017)	1351	68.3 (58.9–76.4)	—	<LOD	0.15 (0.11–0.18)	0.67 (0.48–0.85)	0.99 (0.77–1.2)
6 (2018–2019)	1255	85.2 (79.6–89.5)	0.18 (0.15–0.21)	<LOD	0.21 (0.17–0.25)	0.68 (0.57–0.79)	0.89 (0.68–1.1)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	3275	94.6 (92.7–96.1)	0.39 (0.35–0.42)	0.092 (0.089–0.095)	0.41 (0.35–0.48)	1.3 (0.90–1.7)	2.0 (1.5–2.4)
5 (2016–2017)	1364	75.7 (70.3–80.3)	—	<LOD	0.19 (0.13–0.24)	1.1 (0.77–1.3)	1.5 (1.3–1.8)
6 (2018–2019)	1277	86.0 (82.2–89.1)	0.20 (0.18–0.22)	<LOD	0.20 (0.16–0.25)	0.86 (0.73–1.0)	1.5 (1.0–2.0)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	573	89.7 (82.1–94.3)	0.22 (0.18–0.28)	<LOD	0.26 (0.21–0.30)	0.62 (0.50–0.75)	0.76 ^E (<LOD–1.6)
5 (2016–2017)	553	19.6 ^E (10.5–33.6)	—	<LOD	<LOD	0.12 ^E (0.073–0.17)	0.17 ^E (0.070–0.28)
6 (2018–2019)	516	56.8 (41.4–71.0)	—	<LOD	<LOD	0.26 ^E (0.14–0.38)	0.29 (0.20–0.39)
6–11 years							
1 (2007–2009) ^c	1033	85.8 (80.3–90.0)	0.22 (0.18–0.25)	<LOD	0.25 (0.20–0.30)	0.58 (0.52–0.65)	0.72 (0.60–0.85)
2 (2009–2011) ^c	1062	91.8 (89.0–94.0)	0.24 (0.20–0.29)	0.077 (<LOD–0.095)	0.27 (0.22–0.32)	0.67 (0.48–0.86)	0.87 (0.65–1.1)
5 (2016–2017)	538	27.4 ^E (18.0–39.5)	—	<LOD	<LOD	0.16 (0.11–0.20)	0.19 (0.16–0.22)
6 (2018–2019)	498	62.3 (48.1–74.6)	—	<LOD	0.078 (0.053–0.10)	0.21 (0.17–0.26)	0.27 (0.21–0.34)
12–19 years							
1 (2007–2009) ^c	983	89.3 (85.2–92.4)	0.27 (0.23–0.31)	<LOD	0.32 (0.28–0.36)	0.68 (0.58–0.78)	0.89 (0.66–1.1)
2 (2009–2011) ^c	1041	94.2 (89.7–96.8)	0.26 (0.21–0.32)	0.090 (<LOD–0.11)	0.30 (0.24–0.36)	0.68 (0.56–0.79)	0.81 (0.67–0.94)
5 (2016–2017)	534	41.4 (27.7–56.6)	—	<LOD	<LOD	0.20 (0.16–0.23)	0.26 (0.20–0.32)
6 (2018–2019)	505	68.3 (57.4–77.6)	0.090 (0.071–0.11)	<LOD	0.10 (0.081–0.12)	0.37 (0.24–0.50)	0.47 (0.31–0.64)
20–39 years							
1 (2007–2009) ^c	1169	86.5 (82.0–90.0)	0.27 (0.25–0.31)	<LOD	0.31 (0.27–0.36)	0.92 (0.83–1.0)	1.1 (0.99–1.3)
2 (2009–2011) ^c	1321	92.8 (88.3–95.6)	0.33 (0.28–0.38)	0.088 ^E (<LOD–0.12)	0.36 (0.30–0.43)	0.99 (0.88–1.1)	1.2 (0.99–1.4)
5 (2016–2017)	375	67.9 (56.4–77.6)	0.13 (0.10–0.16)	<LOD	0.12 ^E (0.077–0.17)	0.64 (0.44–0.83)	0.84 ^E (0.32–1.4)
6 (2018–2019)	329	84.1 (75.9–89.9)	0.15 (0.12–0.20)	<LOD	0.16 ^E (0.087–0.24)	0.67 (0.52–0.81)	0.79 (0.57–1.0)
40–59 years							
1 (2007–2009) ^c	1223	92.4 (90.4–94.1)	0.42 (0.38–0.46)	0.093 (<LOD–0.10)	0.45 (0.40–0.51)	1.5 (1.3–1.6)	2.1 (1.7–2.4)
2 (2009–2011) ^c	1228	94.9 (92.2–96.7)	0.49 (0.43–0.56)	0.096 (0.084–0.11)	0.53 (0.44–0.62)	1.7 (1.5–2.0)	2.5 (2.0–3.0)
5 (2016–2017)	360	87.8 (82.1–91.9)	0.25 (0.22–0.29)	<LOD	0.28 (0.22–0.34)	1.0 (0.78–1.3)	1.5 (1.3–1.7)
6 (2018–2019)	341	92.2 (84.8–96.1)	0.25 (0.20–0.31)	<LOD	0.29 (0.23–0.35)	0.82 (0.59–1.0)	1.5 ^E (0.76–2.3)
60–79 years							
1 (2007–2009) ^c	1083	96.2 (93.2–97.9)	0.50 (0.44–0.56)	0.099 (<LOD–0.13)	0.51 (0.46–0.56)	1.6 (1.4–1.8)	2.2 (1.9–2.6)
2 (2009–2011) ^c	1086	98.5 (97.2–99.1)	0.53 (0.47–0.61)	0.098 (0.078–0.12)	0.57 (0.50–0.65)	1.7 (1.3–2.1)	2.5 (2.0–2.9)
5 (2016–2017)	355	92.2 (87.8–95.1)	0.36 (0.30–0.44)	0.090 (<LOD–0.12)	0.39 (0.27–0.51)	1.5 (1.2–1.8)	2.2 (1.4–2.9)
6 (2018–2019)	343	98.4 (96.5–99.2)	0.37 (0.33–0.42)	0.11 (0.093–0.13)	0.36 (0.29–0.42)	1.2 (0.81–1.6)	1.7 (1.3–2.0)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.09, 0.07, 0.066 and 0.047 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

c Urinary cadmium results from cycles 1 and 2 are not comparable with those from more recent cycles due to a change in analytical reporting based on molybdenum interference.

E Use data with caution.

Table 8.4.3

Cadmium (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	6291	94.4 (92.5–95.9)	0.37 (0.34–0.41)	0.14 (0.11–0.16)	0.36 (0.31–0.41)	0.99 (0.94–1.0)	1.4 (1.2–1.6)
5 (2016–2017)	2691	72.0 (65.3–77.9)	—	<LOD	0.16 (0.13–0.18)	0.77 (0.59–0.96)	1.2 (0.88–1.5)
6 (2018–2019)	2531	85.6 (81.7–88.8)	0.20 (0.18–0.23)	<LOD	0.21 (0.19–0.23)	0.71 (0.58–0.84)	1.0 (0.89–1.2)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	3028	94.2 (91.5–96.1)	0.31 (0.28–0.35)	0.12 (0.087–0.15)	0.31 (0.26–0.35)	0.83 (0.73–0.93)	1.1 (0.94–1.2)
5 (2016–2017)	1341	68.3 (58.9–76.4)	—	<LOD	0.11 (0.093–0.14)	0.48 ^F (0.30–0.66)	0.84 (0.62–1.1)
6 (2018–2019)	1254	85.2 (79.6–89.5)	0.17 (0.14–0.19)	<LOD	0.18 (0.15–0.21)	0.58 (0.43–0.74)	0.79 (0.58–1.0)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	3263	94.6 (92.7–96.1)	0.44 (0.40–0.47)	0.17 (0.14–0.20)	0.42 (0.38–0.46)	1.2 (0.94–1.4)	1.8 (1.4–2.3)
5 (2016–2017)	1350	75.7 (70.3–80.3)	—	<LOD	0.23 (0.20–0.25)	1.0 (0.69–1.3)	1.4 (1.1–1.7)
6 (2018–2019)	1277	86.0 (82.2–89.1)	0.25 (0.22–0.28)	<LOD	0.27 (0.22–0.31)	0.92 (0.74–1.1)	1.3 (1.1–1.5)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	572	89.7 (82.1–94.3)	0.39 (0.33–0.46)	<LOD	0.41 (0.35–0.47)	0.92 (0.78–1.0)	1.1 ^F (<LOD–2.1)
5 (2016–2017)	545	19.6 ^F (10.5–33.6)	—	<LOD	<LOD	0.21 ^F (0.13–0.29)	0.29 (0.21–0.38)
6 (2018–2019)	515	56.8 (41.4–71.0)	—	<LOD	<LOD	0.28 ^F (0.16–0.40)	0.40 (0.28–0.51)
6–11 years							
1 (2007–2009) ^c	1030	85.8 (80.3–90.0)	0.34 (0.30–0.38)	<LOD	0.32 (0.28–0.37)	0.69 (0.58–0.81)	0.89 (0.70–1.1)
2 (2009–2011) ^c	1058	91.8 (89.0–94.0)	0.28 (0.24–0.33)	0.096 (<LOD–0.12)	0.29 (0.24–0.33)	0.65 (0.50–0.80)	0.80 (0.67–0.93)
5 (2016–2017)	531	27.4 ^F (18.0–39.5)	—	<LOD	<LOD	0.17 (0.13–0.21)	0.22 (0.16–0.27)
6 (2018–2019)	498	62.3 (48.1–74.6)	—	<LOD	0.094 (0.066–0.12)	0.21 (0.17–0.25)	0.24 (0.21–0.27)
12–19 years							
1 (2007–2009) ^c	982	89.3 (85.2–92.4)	0.24 (0.22–0.26)	<LOD	0.23 (0.21–0.25)	0.41 (0.34–0.48)	0.53 (0.40–0.66)
2 (2009–2011) ^c	1039	94.2 (89.7–96.8)	0.20 (0.17–0.23)	0.099 (<LOD–0.12)	0.20 (0.18–0.21)	0.37 (0.31–0.44)	0.46 (0.33–0.58)
5 (2016–2017)	530	41.4 (27.7–56.6)	—	<LOD	<LOD	0.13 (0.11–0.15)	0.16 (0.13–0.19)
6 (2018–2019)	505	68.3 (57.4–77.6)	0.074 (0.060–0.093)	<LOD	0.082 (0.068–0.096)	0.23 ^F (0.14–0.32)	0.29 (0.21–0.37)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009) ^c	1165	86.5 (82.0–90.0)	0.31 (0.29–0.33)	<LOD	0.30 (0.29–0.30)	0.69 (0.61–0.77)	0.83 (0.69–0.97)
2 (2009–2011) ^c	1319	92.8 (88.3–95.6)	0.27 (0.24–0.31)	0.11 (<LOD–0.14)	0.27 (0.21–0.33)	0.63 (0.53–0.73)	0.79 (0.69–0.89)
5 (2016–2017)	372	67.9 (56.4–77.6)	0.12 (0.10–0.14)	<LOD	0.12 (0.095–0.15)	0.33 ^E (0.12–0.54)	0.59 ^E (0.24–0.95)
6 (2018–2019)	329	84.1 (75.9–89.9)	0.15 (0.12–0.18)	<LOD	0.16 (0.13–0.20)	0.36 (0.28–0.45)	0.46 (0.37–0.56)
40–59 years							
1 (2007–2009) ^c	1218	92.4 (90.4–94.1)	0.54 (0.51–0.57)	0.20 (<LOD–0.23)	0.51 (0.46–0.56)	1.4 (1.2–1.5)	1.9 (1.7–2.1)
2 (2009–2011) ^c	1223	94.9 (92.2–96.7)	0.47 (0.43–0.53)	0.19 (0.17–0.21)	0.45 (0.40–0.50)	1.2 (0.95–1.5)	1.8 (1.2–2.4)
5 (2016–2017)	359	87.8 (82.1–91.9)	0.23 (0.18–0.29)	<LOD	0.23 (0.18–0.28)	0.85 ^E (0.49–1.2)	1.2 (0.91–1.4)
6 (2018–2019)	341	92.2 (84.8–96.1)	0.30 (0.26–0.35)	<LOD	0.29 (0.24–0.35)	0.89 (0.67–1.1)	1.2 (0.93–1.5)
60–79 years							
1 (2007–2009) ^c	1083	96.2 (93.2–97.9)	0.70 (0.64–0.77)	0.30 (<LOD–0.31)	0.69 (0.62–0.76)	1.6 (1.5–1.7)	2.1 (1.8–2.4)
2 (2009–2011) ^c	1080	98.5 (97.2–99.1)	0.64 (0.58–0.70)	0.26 (0.20–0.31)	0.63 (0.57–0.68)	1.6 (1.4–1.7)	2.0 (1.7–2.3)
5 (2016–2017)	354	92.2 (87.8–95.1)	0.42 (0.36–0.49)	0.12 ^E (<LOD–0.17)	0.44 (0.39–0.49)	1.4 (1.1–1.8)	1.8 (1.4–2.1)
6 (2018–2019)	343	98.4 (96.5–99.2)	0.44 (0.41–0.48)	0.17 (0.14–0.20)	0.41 (0.37–0.46)	1.1 (1.0–1.3)	1.5 (1.0–1.9)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

c Urinary cadmium results from cycles 1 and 2 are not comparable with those from more recent cycles due to a change in analytical reporting based on molybdenum interference.

E Use data with caution.

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8.5 CHROMIUM

Chromium (CASRN 7440-47-3) is a naturally occurring element. It is a transition metal that exhibits different properties depending on its oxidation state. Chromium can exist in 9 different oxidation states, with the trivalent (chromium [III]) and the hexavalent (chromium [VI]) forms found most commonly in the environment (EC and HC, 1994; HC, 2018). In nature, chromium is not found in its elemental form, but rather in complexes with oxygen, iron or lead (HC, 2018).

Chromium is released into the environment by both natural and anthropogenic processes. Natural processes include weathering and erosion of soil and rocks as well as volcanic emissions (WHO, 2003; HC, 2018). More than 70% of chromium released into air, soil and water comes from anthropogenic sources, such as smelting and refining of nonferrous base metals, the production and combustion of fossil fuels, industrial manufacturing, and processing of chromium-based products (ATSDR, 2012; HC, 2018; ECCC, 2017). Chromium (VI) rarely occurs naturally. It is produced mainly during the reduction of chromite ore in the industrial production of chromium metal. This oxidation state represents one-third of the total anthropogenic chromium released into the atmosphere (ATSDR, 2012; IARC, 2012).

Chromium is primarily used in electrical applications, wood preservation, the automobile industry and the metallurgical industry, where it is used to produce stainless steel and high-chromium cast iron alloys (ATSDR, 2012; HC, 2018). It is also used in many other processes, such as the production of paint, textile dyes and mordants, catalysts, pulp and paper, as well as in leather tanning, electroplating, and clinical medicine (HC, 2018; WHO, 2003).

While exposure to chromium (III) occurs mainly through food, exposure to chromium (VI) occurs through drinking water and ambient air (HC, 2018; IARC, 2012). However, the majority of drinking water samples analyzed for total chromium across Canada were found to be below the detection limit (HC, 2018). Inhalation of chromium occurs mainly from cigarette smoke or from living near a contaminated area or an emission source, such as an industrial facility. Dermal exposure occurs through the use of consumer products containing chromium, including cleaning materials, textiles and leather (ATSDR, 2012).

Chromium (III) is an essential nutrient that plays a role in human metabolism, while chromium (VI) is the oxidation state that poses the greatest health risk (ATSDR, 2012; Dayan and Paine, 2001; IOM, 2001). As such, the summary of toxicokinetics and health effects will focus on chromium (VI).

Chromium (VI) can be absorbed after oral or inhalation exposure. Absorption from the gastrointestinal tract is low (~7%), and chromium (VI) is partially reduced to chromium (III) at the intragastric level, which lowers its absorption (HC, 2018; IARC, 2012; WHO, 2003). Chromium (VI) is readily absorbed via inhalation, but the fraction absorbed depends on several factors, such as the properties of the inhaled particles and the degree of reduction of chromium (VI) to chromium (III). Significant dermal absorption of chromium (VI) can occur, especially in damaged skin (ATSDR, 2012). After absorption into the bloodstream, chromium (VI) is taken up into red blood cells, where it is reduced to chromium (III), bound to hemoglobin and other intracellular proteins, and slowly lost from the cell (ATSDR, 2012; Dayan and Paine, 2001; IARC, 2012). Generally speaking, chromium (VI) is unstable in the body and is reduced to chromium (III), which can lead to the formation of reactive intermediates, chromium adducts with proteins and DNA, and secondary free radicals (ATSDR, 2012). Chromium is distributed to nearly all tissues, including blood, liver, lung, spleen and kidney, and has a half-life in blood of about 30 days (EPA, 1998; HC, 2018; WHO, 2003). Chromium can be transferred to infants via the placenta and breast milk (ATSDR, 2012). Elimination of chromium (VI) absorbed by inhalation occurs mainly in urine as the trivalent form (HC, 2018; WHO, 2003), whereas after oral exposure, excretion occurs mainly through feces (IARC, 2012).

Measured levels of chromium in urine, whole blood, plasma, red blood cells and lymphocytes can be used as biomarkers of exposure (ATSDR, 2012; Devoy et al., 2016). As chromium (III) is not able to cross the red blood cell membrane, chromium measured in red blood cells is a specific marker of chromium (VI) exposure, whereas the level of total chromium in urine may reflect either chromium (III) or chromium (VI) exposure (Devoy et al., 2016).

The toxicity of chromium depends upon its form and the route of exposure (HC, 2018). Acute toxicity resulting from ingestion of chromium (VI) can occur at high doses, leading to gastrointestinal, kidney, liver and respiratory disorders, hemorrhagic diathesis, convulsions and, at very high concentrations, death from cardiovascular shock (HC, 2018; WHO, 2003). There is a lack of clear evidence for chronic non-cancer toxicity from oral ingestion of chromium. However, chronic inhalation exposure of workers to chromium (VI) has been associated with respiratory tract effects, including nose bleeds, irritations or atrophy of the lining of the nose, bronchitis and pneumonia (ATSDR, 2012). Dermal disorders, such as chronic skin ulcers or acute irritative dermatitis, have been reported in workers dermally exposed to chromium-containing material (Dayan and Paine, 2001).

There is limited information on the reproductive toxicity of chromium (VI) in humans, but some studies suggest that occupational exposure in males may lead to abnormal sperm count, morphology and motility (ATSDR, 2012). Occupational exposure studies have also demonstrated genotoxic effects of chromium (VI) and its compounds (ATSDR, 2012). Several epidemiological studies in workers employed in chromate production, chromate pigment production or chromium electroplating have reported that inhalation of chromium (VI) is associated with lung cancer and possibly cancer of the nose and nasal sinuses (HC, 2018; IARC, 2012; WHO, 2003). The International Agency for Research on Cancer has classified chromium (VI) compounds as carcinogenic to humans (Group 1) based on sufficient evidence for carcinogenicity (lung cancer)

in both humans and experimental animals (IARC, 2012).

Health Canada and Environment Canada concluded that chromium (VI) compounds may be harmful to the environment and may constitute a danger to human life or health (EC and HC, 1994). Chromium (VI) and its compounds have been added to the List of Toxic Substances under Schedule 1 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999). The act allows the federal government to control the importation, manufacture, distribution and use of chromium (VI) compounds in Canada. Risk management actions, including regulations and emission guidelines, have been developed under CEPA 1999 to control the release of chromium (VI) from thermal electricity generation, wood preservation applications, electroplating, anodizing and reverse etching (ECCC, 2017). Chromium, chromic acid and its salts are on the List of Ingredients that are Prohibited for Use in Cosmetic Products (HC, 2019).

On the basis of health considerations, Health Canada, in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water, has developed a guideline for Canadian drinking water quality that establishes the maximum acceptable concentration for total chromium in drinking water (HC, 2018). The guideline also takes into account the ability of currently available treatment technologies to remove chromium from drinking water at or below the guideline level.

Chromium was measured in the red blood cells of Canadian Health Measures Survey (CHMS) participants aged 3–79 in cycle 5 (2016–2017) and cycle 6 (2018–2019). Data are presented as µg/L red blood cells. Chromium (VI) is the only form of inorganic chromium that substantially penetrates red blood cells. Thus, finding a measurable amount of chromium in red blood cells is an indicator of recent exposure. In addition, total chromium was analyzed in hair from CHMS participants aged 20–59 in cycle 5. The presence of chromium in red blood cells or hair does not necessarily mean that an adverse health effect will occur.

Table 8.5.1

Chromium (VI)^a—Geometric means and selected percentiles of red blood cell concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2567	43.4 (32.4–55.1)	—	<LOD	<LOD	0.24 (0.20–0.29)	0.33 (0.26–0.39)
6 (2018–2019)	2472	51.7 (38.5–64.6)	—	<LOD	0.12 (<LOD–0.17)	0.23 (0.20–0.25)	0.28 (0.26–0.31)
Males, 3–79 years							
5 (2016–2017)	1282	41.0 (31.7–50.9)	—	<LOD	<LOD	0.22 (0.17–0.27)	0.32 (0.21–0.42)
6 (2018–2019)	1229	50.9 (38.4–63.3)	—	<LOD	0.12 ^E (<LOD–0.17)	0.23 (0.20–0.26)	0.29 (0.26–0.33)
Females, 3–79 years							
5 (2016–2017)	1285	45.8 (31.9–60.4)	—	<LOD	<LOD	0.26 (0.22–0.31)	0.34 (0.27–0.41)
6 (2018–2019)	1243	52.5 (38.2–66.4)	—	<LOD	0.12 (<LOD–0.16)	0.22 (0.19–0.25)	0.27 (0.22–0.32)
3–5 years							
5 (2016–2017)	480	53.3 (39.0–67.0)	—	<LOD	<LOD	0.23 (0.19–0.27)	0.28 (0.27–0.29)
6 (2018–2019)	470	58.1 (43.8–71.1)	—	<LOD	0.13 (<LOD–0.17)	0.24 (0.20–0.28)	0.29 (0.23–0.34)
6–11 years							
5 (2016–2017)	520	46.1 (33.8–58.9)	—	<LOD	<LOD	0.23 (0.20–0.26)	0.27 (0.23–0.32)
6 (2018–2019)	496	50.5 ^E (32.7–68.3)	—	<LOD	<LOD ^E (<LOD–0.21)	0.25 (0.18–0.32)	0.30 (0.22–0.38)
12–19 years							
5 (2016–2017)	523	45.7 (33.0–59.0)	—	<LOD	<LOD	0.23 (0.19–0.28)	0.29 (0.22–0.36)
6 (2018–2019)	500	54.9 (41.1–68.0)	—	<LOD	0.13 (<LOD–0.17)	0.27 (0.21–0.33)	0.30 (0.27–0.33)
20–39 years							
5 (2016–2017)	358	35.0 ^E (23.4–48.7)	—	<LOD	<LOD	0.20 (0.14–0.26)	0.27 (0.19–0.35)
6 (2018–2019)	325	52.5 (37.4–67.3)	—	<LOD	0.13 ^E (<LOD–0.18)	0.21 (0.18–0.23)	0.23 (0.17–0.28)
40–59 years							
5 (2016–2017)	340	45.3 (30.9–60.5)	—	<LOD	<LOD	0.29 (0.19–0.39)	0.43 (0.31–0.55)
6 (2018–2019)	339	50.6 (34.2–66.8)	—	<LOD	<LOD ^E (<LOD–0.18)	0.24 (0.17–0.31)	0.31 (0.22–0.40)
60–79 years							
5 (2016–2017)	346	49.0 (36.6–61.5)	—	<LOD	<LOD	0.25 (0.18–0.32)	0.38 ^E (0.18–0.58)
6 (2018–2019)	342	50.0 (35.4–64.6)	—	<LOD	<LOD	0.22 (0.20–0.24)	0.26 (0.21–0.31)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.12 µg/L.

a Chromium (VI) was measured indirectly as total chromium in red blood cells.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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8.6 MERCURY

Mercury (CASRN 7439-97-6) is a naturally occurring, soft, silvery white metal that is liquid at room temperature. Mercury exists in elemental, inorganic and organic forms. Elemental and certain organic forms of mercury have sufficiently high vapour pressures to be present as vapour in ambient air (ATSDR, 1999; 2013). The most common organic mercury compounds in nature are methylmercury (monomethylmercury) and dimethylmercury. Mercury can be converted among its elemental, inorganic and organic forms by a variety of processes, including biological transformation (ECCC, 2017).

Mercury is found throughout the environment, including in remote Arctic regions, because of its persistence, mobility and tendency to accumulate in colder climates. Natural sources of inorganic mercury include volcanic activity and natural erosion of mercury-containing deposits (EC and HC, 2010). Anthropogenic sources of inorganic mercury include artisanal and small-scale gold mining; coal burning; the mining, smelting and production of iron and non-ferrous metals; cement production; industrial point sources such as power plants or factories; contaminated sites such as old mines, landfills, and waste disposal locations; and sewage sludge and wastewater (UNEP, 2013). Inorganic mercury may also be released to the environment following disposal of products containing mercury. Metabolism of inorganic mercury by microorganisms in the environment creates

organic mercury (e.g., methylmercury), which often bioaccumulates in terrestrial and aquatic food chains (ATSDR, 1999; 2013).

Mercury has unique properties that have made it useful in certain products, such as wiring devices, switches and scientific measuring devices, including vacuum gauges and thermometers (ATSDR, 1999; 2013). Today, the manufacture and import of most mercury-containing products is prohibited in Canada. Exemptions include certain essential products, such as certain medical and research applications, dental amalgams, and fluorescent and other types of lamps (Canada, 2014). Mercury is also used as an industrial catalyst and in laboratory reagents, disinfectants, embalming solutions and some pharmaceuticals. A significant use of inorganic mercury is in dental amalgam, which is composed of approximately 50% mercury (IMERC, 2010; SCENIHR, 2015). Based on data collected as part of the Canadian Health Measures Survey (CHMS) cycle 1 (2007–2009), it was estimated that approximately 64% of the Canadian population age 6 and over had 1 or more amalgam-restored tooth surfaces (Richardson, 2014). A review of these same data concluded that urinary mercury concentrations in the general Canadian population were significantly lower than the values considered to pose any health risks (Nicolae et al., 2013).

Mercury exposure in Canada's general population is primarily through the consumption of larger species of fish in which methylmercury is the predominant form (HC, 2007). To a lesser extent, the general population is exposed to inorganic mercury from sources such as dental amalgams (HC, 1996; 2004; SCENIHR 2015). The general population may also be exposed to elemental mercury via inhalation of vapours in ambient air, ingestion or dental and medical treatments (ATSDR, 1999). Methylmercury exposure can occur in utero via cord blood, and it can be transferred to infants through breast milk (ECCC, 2016).

Approximately 95% of methylmercury is absorbed from the gastrointestinal tract following oral ingestion (ATSDR, 1999; 2013). Following absorption, organic mercury is distributed to all tissues, including hair, with highest accumulation in the kidneys. Methylmercury readily passes through the blood-brain barrier and enters the brain, and in pregnant women, it can easily cross the placental barrier into the fetus (ECCC, 2016; HC, 2004). Absorbed organic mercury is demethylated

in the body to inorganic mercury that accumulates primarily in the liver and kidneys. The biological half-life of methylmercury in blood has been reported to range between 42 and 70 days in humans (ECCC, 2016). The majority of mercury in the body is excreted via feces, with a small amount excreted as inorganic mercury in urine (ATSDR, 1999; 2013; ECCC, 2016).

Generally, less than 10% of inorganic mercury is absorbed through the intestinal tract (HC, 2004). Absorbed inorganic mercury accumulates readily in the kidneys (IPCS, 2003). It also accumulates in placental tissues, but does not cross placental or blood-brain barriers as easily as elemental or methylmercury (HC, 2004). Excretion of elemental and inorganic mercury compounds occurs mainly in urine and feces, with an absorbed dose half-life of approximately 1 to 2 months (IPCS, 2003).

Elemental mercury is absorbed across the lungs and gastrointestinal tract, with absorption rates of about 80% and 0.01%, respectively (HC, 2004). Once absorbed, elemental mercury enters the bloodstream and is rapidly transported to other parts of the body, including the brain and kidneys. As with organic mercury, it readily crosses the blood-brain and placental barriers (HC, 2004). Once in the body, elemental mercury is oxidized in the tissues to inorganic forms and can remain for weeks or months, with an estimated half-life of approximately 60 days (Sandborgh-Englund et al., 1998).

Long-term exposure to elemental and inorganic mercury is commonly evaluated using mercury concentrations in urine (IPCS, 2003). Hair may also be used as a biomarker of chronic exposure, although inorganic forms of mercury are not excreted in any significant amount in scalp hair, making it an inappropriate biomarker of inorganic mercury exposure (ATSDR, 1999; 2013; IPCS, 2003). Total blood mercury concentrations primarily reflect recent dietary exposure to organic forms of mercury, particularly methylmercury (ATSDR, 1999; 2013; IPCS, 2003). The concentration of total mercury in blood is accepted as a reasonable measure of methylmercury exposure; however, methylmercury itself may also be measured directly in blood. Based on a review of existing data from a number of western countries, the World Health Organization (WHO) has estimated that the average total blood mercury concentration for the general population is approximately 8 µg/L (WHO, 1990).

In individuals who consume fish daily, methylmercury concentrations in blood can be as high as 200 µg/L (WHO, 1990).

Mercury is known to be toxic to humans, with the effects depending on the chemical form, the route of exposure, the timing and duration of exposure, and the absorbed concentration. Chronic exposure to low levels of methylmercury through ingestion may not result in any observable symptoms (HC, 2007). The primary effects associated with oral exposure to organic mercury compounds are neurological effects and developmental neurotoxicity (ATSDR, 2013; EFSA CONTAM Panel, 2012; FAO/WHO, 2011; HC, 2007). Symptoms of organic mercury toxicity include a tingling sensation in the extremities; impaired peripheral vision, hearing, taste and smell; slurred speech; muscle weakness and an unsteady gait; irritability; memory loss; depression; and sleeping difficulties. Exposure of a fetus or young child to organic mercury can affect the development of the nervous system, resulting in effects on fine-motor function, attention, verbal learning and memory (ATSDR, 2013; HC, 2007). Exposure to elemental mercury may be hazardous, depending upon the levels of exposure, because the vapour that can be released from this form is readily absorbed into the body through inhalation. Inhalation of mercury vapour may cause respiratory, cardiovascular, kidney and neurological effects. In 1996, Health Canada concluded that mercury exposure from dental amalgams does not pose a health impact for the general population (HC, 1996). Most published studies since this report have concurred that exposure to inorganic mercury from dental amalgams has not been associated with neurologic effects in children or adults (Bates et al., 2004; Bellinger et al., 2007; DeRouen et al., 2006; Factor-Litvak et al., 2003; SCENIHR, 2015).

The International Agency for Research on Cancer (IARC) determined that methylmercury compounds are possibly carcinogenic to humans (Group 2B), based on animal data showing a link to certain cancers, particularly renal cancer (IARC, 1993). IARC has determined that elemental mercury and inorganic mercury compounds are not classifiable as to their carcinogenicity to humans (Group 3) (IARC, 1993).

The United Nations Environment Programme (UNEP) Global Mercury Assessment has concluded that there is sufficient evidence of adverse impacts from mercury to warrant international action to reduce the risks to

human health and the environment (UNEP, 2013). International negotiations under UNEP resulted in the signing of the Minamata Convention on Mercury, a global legally binding agreement to prevent mercury emissions and releases (UNEP, 2019). The Minamata Convention is intended to reduce global atmospheric emissions, supply, trade and demand for mercury, and to find environmentally sound solutions for storage of mercury and mercury-containing wastes. It also supports a gradual phase-down of the use of dental amalgam in restorative treatment.

In Canada, mercury and its compounds are listed as toxic substances on Schedule 1 of the *Canadian Environmental Protection Act, 1999* (Canada, 1999; Canada, 2012). Existing and planned actions to manage the risks from mercury are summarized in the Government of Canada's Risk Management Strategy for Mercury (EC and HC, 2010). These risk management actions include several Canada-wide standards that have been established to reduce releases of mercury to the environment (Canada, 2013). The Products Containing Mercury Regulations came into force in 2015 and prohibit the manufacture and import of products containing mercury or any of its compounds, as well as provide content limits for exempted products (Canada, 2014). The Surface Coating Materials Regulations, in effect under the *Canada Consumer Product Safety Act*, restrict the level of mercury in all surface coating materials advertised, sold or imported into Canada (Canada, 2005). In addition, the Toys Regulations prohibit any compound of mercury in the surface coating material that is applied to a product used by a child in learning or play situations (Canada, 2011). Mercury and its compounds are on the List of Ingredients that are Prohibited for Use in Cosmetic Products (HC, 2019a). The Food and Drug Regulations prohibit the sale in Canada of drugs for human use containing mercury or any of its salts or derivatives except in some specific instances, including those where it is present as a preservative (Canada, 1978).

Health Canada has established a methylmercury blood guidance value of 20 µg/L for the general adult population; a methylmercury concentration in blood below this value is considered within the normal acceptable range (HC, 2004). For children (under 18 years), pregnant women, and women of child-bearing age (under 50 years), a provisional methylmercury blood guidance value of 8 µg/L has been proposed (Legrand et al., 2010). On the basis of health considerations,

Health Canada, in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water, has developed a guideline for Canadian drinking water quality that establishes the maximum acceptable concentration for mercury in drinking water (HC, 1986). Health Canada has also established maximum levels for mercury in retail fish (HC, 2020b) and provides consumption advice for consumers of certain types of fish (HC, 2019b). Mercury was analyzed as part of Health Canada's ongoing Total Diet Study surveys (Dabeka et al., 2003; HC, 2020a). The food items analyzed represent those that are most typical of the Canadian diet. These surveys are used to provide dietary exposure estimates for chemicals to which Canadians in different age-sex groups are exposed through the food supply.

Mercury concentrations in blood have been measured in a number of biomonitoring studies conducted in Canada, including the Maternal-Infant Research on Environmental Chemicals study (Arbuckle et al.,

2016) and the First Nations Biomonitoring Initiative (AFN, 2013).

Total mercury was analyzed in the whole blood of CHMS participants aged 6–79 in cycle 1 (2007–2009) and aged 3–79 in cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019). Methylmercury was analyzed in the whole blood of CHMS participants aged 20–79 in cycles 3 and 4, and aged 3–19 in cycles 5 and 6. Inorganic mercury was analyzed in the whole blood of CHMS participants aged 6–79 in cycle 1 and aged 3–19 in cycles 5 and 6. Data from these cycles are presented in blood as µg/L. In addition, inorganic mercury was analyzed in the urine of CHMS participants aged 6–79 in cycle 1 and aged 3–79 in cycles 3 and 4, and total mercury was analyzed in hair from CHMS participants aged 20–59 in cycle 5. Finding a measurable amount of mercury in blood, urine or hair is an indicator of exposure to mercury and does not necessarily mean that an adverse health effect will occur.

Table 8.6.1

Mercury (total)—Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	6070	88.6 (86.0–90.8)	0.69 (0.56–0.87)	<LOD	0.74 (0.55–0.93)	3.4 (2.4–4.5)	5.5 ^E (3.3–7.6)
3 (2012–2013)	5538	71.2 (66.4–75.6)	0.79 (0.64–0.97)	<LOD	0.79 (0.62–0.96)	3.2 ^E (1.5–4.9)	5.2 ^E (3.0–7.5)
4 (2014–2015)	5498	61.5 (55.5–67.2)	—	<LOD	0.59 (0.47–0.72)	2.5 (1.9–3.1)	3.5 (2.9–4.2)
5 (2016–2017)	4488	81.3 (78.2–84.0)	0.60 (0.51–0.71)	<LOD	0.65 (0.52–0.78)	2.4 (1.8–3.0)	3.7 (2.8–4.5)
6 (2018–2019)	4596	86.1 (81.9–89.4)	0.71 (0.60–0.85)	<LOD	0.77 (0.62–0.91)	2.8 (2.2–3.4)	3.8 (3.2–4.4)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2940	88.0 (84.9–90.5)	0.72 (0.56–0.91)	<LOD	0.76 (0.53–0.99)	3.9 (2.7–5.1)	6.1 ^E (2.7–9.5)
3 (2012–2013)	2769	69.5 (64.3–74.3)	0.76 (0.60–0.97)	<LOD	0.74 (0.54–0.94)	3.2 ^E (1.3–5.0)	5.6 ^E (3.4–7.8)
4 (2014–2015)	2754	60.7 (54.7–66.4)	—	<LOD	0.58 (0.45–0.71)	2.8 (2.0–3.6)	3.7 (2.6–4.8)
5 (2016–2017)	2241	81.7 (76.1–86.3)	0.59 (0.49–0.72)	<LOD	0.65 (0.50–0.79)	2.4 (1.8–3.0)	3.3 (2.8–3.8)
6 (2018–2019)	2330	85.5 (80.2–89.6)	0.72 (0.59–0.87)	<LOD	0.73 (0.59–0.86)	3.2 (2.4–4.0)	4.5 (3.6–5.5)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	3130	89.3 (86.6–91.5)	0.67 (0.54–0.83)	<LOD	0.71 (0.53–0.88)	3.0 (2.0–4.0)	5.1 ^E (3.0–7.1)
3 (2012–2013)	2769	73.0 (67.1–78.2)	0.81 (0.67–0.99)	<LOD	0.82 (0.67–0.97)	3.2 ^E (1.4–4.9)	5.1 ^E (2.4–7.8)
4 (2014–2015)	2744	62.4 (55.9–68.5)	—	<LOD	0.60 (0.47–0.74)	2.2 (1.6–2.8)	3.3 (2.7–4.0)
5 (2016–2017)	2247	80.9 (77.6–83.8)	0.61 (0.51–0.73)	<LOD	0.66 (0.52–0.80)	2.4 ^E (1.5–3.4)	4.5 (3.3–5.6)
6 (2018–2019)	2266	86.7 (82.5–90.0)	0.71 (0.59–0.85)	<LOD	0.80 (0.64–0.95)	2.5 (1.9–3.0)	3.2 (2.7–3.7)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	495	67.4 (58.2–75.4)	0.27 (0.20–0.36)	<LOD	0.19 ^E (<LOD–0.29)	1.4 ^E (0.44–2.3)	3.0 ^E (1.7–4.3)
3 (2012–2013)	471	37.3 (28.6–46.8)	—	<LOD	<LOD	1.3 (1.0–1.7)	1.7 ^E (0.88–2.5)
4 (2014–2015)	479	25.7 ^E (16.7–37.4)	—	<LOD	<LOD	0.85 ^E (<LOD–1.3)	1.3 ^E (0.54–2.1)
5 (2016–2017)	465	57.0 (46.5–66.9)	—	<LOD	0.23 (<LOD–0.29)	1.1 ^E (0.60–1.5)	1.6 ^E (1.0–2.3)
6 (2018–2019)	482	66.8 (51.8–79.0)	0.32 (0.24–0.44)	<LOD	0.29 (<LOD–0.40)	1.3 ^E (0.83–1.8)	1.9 ^E (0.52–3.2)
6–11 years							
1 (2007–2009)	910	74.3 (69.1–78.9)	0.26 (0.22–0.32)	<LOD	0.24 (0.18–0.29)	1.3 (1.0–1.6)	2.1 ^E (1.3–2.9)
2 (2009–2011)	961	72.9 (67.2–78.0)	0.28 (0.22–0.34)	<LOD	0.21 ^E (0.11–0.30)	1.2 (0.84–1.5)	2.0 (1.3–2.6)
3 (2012–2013)	944	47.0 (37.6–56.7)	—	<LOD	<LOD	1.2 (0.78–1.7)	1.9 ^E (0.91–2.9)
4 (2014–2015)	925	36.7 (29.4–44.6)	—	<LOD	<LOD	1.1 (0.84–1.3)	1.5 (0.96–2.0)
5 (2016–2017)	503	54.6 (45.0–63.8)	—	<LOD	0.23 ^E (<LOD–0.35)	1.1 (0.72–1.5)	1.6 (1.2–1.9)
6 (2018–2019)	500	69.0 (60.9–76.0)	0.36 (0.31–0.42)	<LOD	0.39 (0.27–0.50)	1.2 (1.0–1.3)	1.8 (1.4–2.1)
12–19 years							
1 (2007–2009)	945	79.5 (73.5–84.4)	0.30 (0.23–0.40)	<LOD	0.28 (0.20–0.37)	1.3 ^E (0.47–2.2)	2.2 ^E (0.88–3.5)
2 (2009–2011)	997	70.3 (60.8–78.3)	0.27 (0.21–0.35)	<LOD	0.19 ^E (<LOD–0.30)	1.3 (0.84–1.7)	2.4 ^E (1.3–3.5)
3 (2012–2013)	977	45.0 (35.5–54.8)	—	<LOD	<LOD	1.6 ^E (0.62–2.6)	2.8 ^E (1.3–4.4)
4 (2014–2015)	975	39.2 (31.8–47.1)	—	<LOD	<LOD	1.3 (0.92–1.7)	2.2 ^E (1.2–3.2)
5 (2016–2017)	512	67.3 (58.1–75.4)	0.33 (0.27–0.42)	<LOD	0.35 (0.26–0.44)	1.2 (1.0–1.4)	1.6 (1.1–2.1)
6 (2018–2019)	504	71.9 (57.5–82.8)	0.44 (0.31–0.63)	<LOD	0.42 ^E (0.26–0.57)	2.2 ^E (1.3–3.1)	3.6 ^E (1.4–5.8)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1165	90.6 (87.9–92.8)	0.65 (0.52–0.81)	<LOD	0.76 (0.61–0.91)	3.0 ^E (1.9–4.1)	4.9 ^E (2.4–7.4)
2 (2009–2011)	1313	88.0 (82.4–92.0)	0.64 (0.47–0.85)	<LOD	0.65 (0.43–0.86)	2.9 (2.0–3.9)	5.2 ^E (2.6–7.8)
3 (2012–2013)	1032	72.9 (65.6–79.1)	0.82 (0.65–1.0)	<LOD	0.77 (0.57–0.96)	4.1 ^E (1.5–6.6)	6.0 ^E (3.6–8.3)
4 (2014–2015)	1073	56.1 (47.9–64.0)	—	<LOD	0.48 (<LOD–0.65)	2.0 (1.6–2.4)	2.9 (2.0–3.8)
5 (2016–2017)	1037	78.7 (74.5–82.3)	0.55 (0.44–0.68)	<LOD	0.61 (0.45–0.77)	2.1 ^E (0.88–3.2)	3.4 ^E (2.1–4.8)
6 (2018–2019)	1053	86.6 (78.7–91.9)	0.74 (0.59–0.94)	<LOD	0.83 (0.60–1.1)	3.0 (2.1–3.8)	3.8 (3.0–4.7)
40–59 years							
1 (2007–2009)	1220	96.7 (95.0–97.8)	1.0 (0.80–1.3)	0.21 ^E (0.12–0.30)	1.1 (0.83–1.3)	3.6 (2.3–4.9)	6.4 ^E (3.0–9.8)
2 (2009–2011)	1222	96.1 (94.2–97.5)	1.0 (0.79–1.3)	0.15 (0.11–0.20)	1.0 (0.84–1.2)	4.1 ^E (2.4–5.8)	7.3 ^E (2.5–12)
3 (2012–2013)	1071	80.6 (73.9–86.0)	0.96 (0.74–1.2)	<LOD	0.99 (0.78–1.2)	3.4 ^E (1.5–5.4)	5.2 ^E (2.8–7.6)
4 (2014–2015)	1051	73.6 (66.4–79.7)	0.77 (0.65–0.92)	<LOD	0.80 (0.63–0.98)	3.1 (2.2–4.1)	3.7 (2.9–4.6)
5 (2016–2017)	987	89.7 (85.8–92.6)	0.85 (0.72–1.0)	<LOD	0.98 (0.78–1.2)	3.2 (2.4–4.0)	4.7 (3.5–5.9)
6 (2018–2019)	1083	94.0 (89.3–96.7)	0.84 (0.68–1.0)	0.21 (<LOD–0.28)	0.85 (0.65–1.1)	2.6 (1.9–3.3)	3.9 (2.8–5.0)
60–79 years							
1 (2007–2009)	1079	95.1 (91.4–97.3)	0.87 (0.64–1.2)	0.12 ^E (<LOD–0.22)	0.96 (0.75–1.2)	3.4 (2.4–4.4)	4.8 ^E (2.7–6.9)
2 (2009–2011)	1082	95.4 (92.0–97.4)	1.1 (0.86–1.5)	0.17 ^E (<LOD–0.28)	1.2 (0.89–1.5)	4.3 (3.1–5.5)	6.5 ^E (3.9–9.1)
3 (2012–2013)	1043	80.6 (73.4–86.3)	1.0 (0.82–1.3)	<LOD	0.99 (0.71–1.3)	3.8 ^E (2.2–5.3)	6.7 ^E (1.9–11)
4 (2014–2015)	995	74.9 (69.0–80.0)	0.88 (0.73–1.1)	<LOD	0.92 (0.76–1.1)	3.3 (2.6–4.0)	4.6 (3.1–6.1)
5 (2016–2017)	984	92.0 (89.4–94.0)	0.83 (0.70–0.97)	0.22 (<LOD–0.29)	0.85 (0.72–0.98)	2.9 (2.5–3.3)	3.8 (3.0–4.6)
6 (2018–2019)	974	89.5 (84.3–93.2)	0.94 (0.79–1.1)	<LOD	1.0 (0.81–1.2)	3.4 (2.6–4.1)	5.0 (3.4–6.6)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 3, 4, 5 and 6 are 0.1, 0.1, 0.42, 0.42, 0.20 µg/L and 0.20 respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 8.6.2

Methylmercury—Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–19 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–19 years							
5 (2016–2017)	1505	54.7 (47.3–61.9)	—	<LOD	0.23 ^E (<LOD–0.33)	1.3 (1.0–1.7)	1.9 (1.5–2.4)
6 (2018–2019)	1468	62.2 (50.6–72.5)	0.33 (0.26–0.43)	<LOD	0.30 (0.20–0.40)	1.8 (1.2–2.4)	2.6 (2.0–3.3)
Males, 3–19 years							
5 (2016–2017)	754	54.6 (47.6–61.5)	—	<LOD	0.24 ^E (<LOD–0.37)	1.5 (1.2–1.8)	2.2 (1.7–2.7)
6 (2018–2019)	738	63.1 (50.4–74.1)	—	<LOD	0.29 ^E (<LOD–0.40)	1.9 ^E (1.1–2.7)	2.8 ^E (1.7–3.9)
Females, 3–19 years							
5 (2016–2017)	751	54.8 (46.1–63.3)	—	<LOD	0.23 (<LOD–0.31)	1.1 (0.80–1.4)	1.7 ^E (1.1–2.4)
6 (2018–2019)	730	61.2 (49.3–72.0)	0.33 (0.26–0.43)	<LOD	0.31 ^E (<LOD–0.43)	1.7 (1.1–2.2)	2.3 (1.8–2.9)
3–5 years							
5 (2016–2017)	473	49.5 (39.3–59.7)	—	<LOD	<LOD	1.1 ^E (0.51–1.7)	1.8 (1.3–2.4)
6 (2018–2019)	477	60.7 (44.7–74.7)	—	<LOD	0.25 (<LOD–0.34)	1.3 ^E (0.75–1.9)	2.2 ^E (0.54–3.8)
6–11 years							
5 (2016–2017)	511	50.1 (40.3–59.8)	—	<LOD	<LOD ^E (<LOD–0.40)	1.3 ^E (0.77–1.9)	2.2 ^E (1.4–3.1)
6 (2018–2019)	492	58.3 (45.7–70.0)	0.29 (0.23–0.38)	<LOD	0.27 ^E (<LOD–0.37)	1.3 (1.1–1.5)	1.9 (1.5–2.3)
12–19 years							
5 (2016–2017)	521	60.1 (51.1–68.4)	—	<LOD	0.29 (0.19–0.40)	1.3 (1.1–1.6)	1.9 (1.4–2.5)
6 (2018–2019)	499	65.6 (51.2–77.6)	0.39 (0.27–0.55)	<LOD	0.36 ^E (0.20–0.53)	2.3 ^E (1.3–3.3)	2.8 (1.9–3.7)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.19 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.6.3

Methylmercury—Geometric means and selected percentiles of whole blood concentrations ($\mu\text{g/L}$) for the Canadian population aged 20–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013) and cycle 4 (2014–2015)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 20–79 years							
3 (2012–2013)	1032	81.6 (75.7–86.3)	0.69 (0.52–0.91)	<LOD	0.78 (0.54–1.0)	3.3 ^E (1.3–5.3)	5.6 ^E (2.9–8.2)
4 (2014–2015)	1043	81.6 (77.9–84.8)	0.59 (0.51–0.68)	<LOD	0.57 (0.45–0.68)	2.8 (1.9–3.7)	4.1 (3.5–4.6)
Males, 20–79 years							
3 (2012–2013)	502	81.2 (71.9–88.0)	0.68 ^E (0.41–1.1)	<LOD	0.68 ^E (0.26–1.1)	4.6 ^E (1.3–7.8)	8.1 ^E (4.2–12)
4 (2014–2015)	512	81.7 (76.2–86.2)	0.62 (0.53–0.71)	<LOD	0.56 (0.41–0.71)	2.9 (1.9–4.0)	4.0 (3.2–4.8)
Females, 20–79 years							
3 (2012–2013)	530	81.9 (72.4–88.6)	0.70 (0.58–0.85)	<LOD	0.89 (0.74–1.0)	2.8 ^E (1.4–4.1)	4.7 ^E (3.0–6.4)
4 (2014–2015)	531	81.5 (74.8–86.7)	0.57 (0.46–0.70)	<LOD	0.57 (0.43–0.72)	2.5 ^E (0.99–4.0)	4.4 (3.2–5.7)
20–39 years							
3 (2012–2013)	359	78.9 (68.5–86.6)	0.61 (0.45–0.82)	<LOD	0.65 (0.42–0.87)	2.9 ^E (<LOD–6.1)	5.0 ^E (1.9–8.1)
4 (2014–2015)	361	72.0 (63.8–78.9)	0.42 (0.34–0.52)	<LOD	0.48 (0.35–0.61)	1.8 (1.4–2.2)	2.2 (1.7–2.6)
40–59 years							
3 (2012–2013)	313	80.6 (71.8–87.2)	0.65 ^E (0.44–0.96)	<LOD	0.71 ^E (0.27–1.2)	3.2 ^E (0.85–5.5)	5.8 ^E (2.3–9.3)
4 (2014–2015)	316	86.8 (79.4–91.8)	0.66 (0.51–0.84)	<LOD	0.56 ^E (0.33–0.79)	3.7 (2.5–4.9)	4.3 (3.3–5.3)
60–79 years							
3 (2012–2013)	360	87.4 (79.0–92.8)	0.94 (0.67–1.3)	<LOD	1.0 ^E (0.65–1.4)	3.4 ^E (2.0–4.8)	5.4 ^E (<LOD–11)
4 (2014–2015)	366	87.9 (81.4–92.3)	0.83 (0.63–1.1)	<LOD	0.78 ^E (0.49–1.1)	3.8 (2.7–5.0)	5.1 (3.3–6.9)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 3 and 4 is 0.19 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 8.6.4

Mercury (inorganic)—Geometric means and selected percentiles of whole blood concentrations ($\mu\text{g/L}$) for the Canadian population aged 6–19^a, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 6–19 years							
1 (2007–2009)	425	1.6 ^E (0.50–4.6)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1032	2.2 ^E (1.3–3.8)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	991	4.2 ^E (1.3–12.3)	—	<LOD	<LOD	<LOD	<LOD
Males, 6–19 years							
1 (2007–2009)	227	1.9 ^E (0.40–8.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	514	1.6 ^E (0.70–3.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	498	4.3 ^E (1.1–14.9)	—	<LOD	<LOD	<LOD	<LOD
Females, 6–19 years							
1 (2007–2009)	198	1.3 ^E (0.30–5.8)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	518	2.8 ^E (1.4–5.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	493	4.1 ^E (1.5–10.8)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 5 and 6 are 0.4, 0.22 and 0.22 $\mu\text{g/L}$, respectively.

- a For the purpose of total population comparisons, only values from participants aged 6–19 years were included, as participants under the age of six years were not included in cycle 1 and participants over the age of 19 years were not included in cycles 5 and 6.
- b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
- E Use data with caution.

Table 8.6.5

Mercury (inorganic)—Geometric means and selected percentiles of whole blood concentrations (µg/L) for the Canadian population aged 3–19 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–19 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1505	2.2 ^E (1.2–3.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1468	3.7 ^E (1.3–10.3)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–19 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
5 (2016–2017)	754	1.7 ^E (0.70–3.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	738	4.0 ^E (1.2–12.4)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–19 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
5 (2016–2017)	751	2.7 ^E (1.2–5.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	730	3.5 ^E (1.3–9.0)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
5 (2016–2017)	473	2.0 ^E (0.80–5.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	477	1.6 ^E (0.20–9.2)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
1 (2007–2009)	221	2.4 ^E (0.80–7.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	511	4.1 ^E (2.2–7.4)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	492	5.8 ^E (1.7–18.1)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
1 (2007–2009)	204	1.1 ^E (0.20–6.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	521	0.80 ^E (0.30–2.3)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	499	3.0 ^E (1.0–8.4)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 5 and 6 are 0.4, 0.22 and 0.22 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1; the complete data set for cycle 1 participants aged 6–79 years is available in the *Report on Human Biomonitoring of Environmental Chemicals in Canada (2010)*.

E Use data with caution.

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8.7 SELENIUM

Selenium (CASRN 7782-49-2) is a naturally occurring trace mineral distributed widely in the environment (Schamberger, 1984). Selenium is present in the environment in the inorganic form as selenide, selenate and selenite, but rarely as elemental selenium. Selenium is an essential trace element required for the maintenance of good health in humans.

Selenium in its organic form is found in trace quantities in most plants and animal tissues (Schamberger, 1984). Elevated levels of selenium in the environment may occur naturally from weathering of base-metal deposits and soils (CCME, 2009). Selenium is also released into the environment as a result of anthropogenic activities, such as mining or metallurgical processes (CCME, 2009). Other sources of anthropogenic selenium emissions include incinerator stacks, burning coal and oil, and large-scale combustion processes.

Historically, selenium was primarily used in the electronics industry in the form of arsenic triselenide, a photoreceptor for photocopiers (USGS, 2001). Because selenium has various electrical and conductive properties, it is also used in light meters, photoelectric and solar cells, semiconductors and arc-light electrodes. It is also used as a colourizing and decolourizing agent for glass, and to reduce solar heat for architectural glass (USGS, 2004). Selenium is also present in stainless steel, enamels, inks, rubber, batteries, explosives, fertilizers, animal feed, pharmaceuticals and shampoos (ATSDR, 2003).

The Canadian population is exposed to selenium compounds in food, ambient air, drinking water, soil and natural health products. More than 99% of the total daily intake of selenium is estimated to occur through the diet for the general population and all age groups (CCME, 2009). Absorption of selenium depends on the chemical form; organic forms are absorbed more readily (>90%) than inorganic forms (>50%) (IOM, 2000). Absorption also depends on the overall exposure level; absorption increases when selenium levels in the body are low (IOM, 2000). Once inside the body, selenium generally concentrates in the liver and kidneys regardless of the initial chemical form. It can also be found in nails and hair (IOM, 2000). Selenium elimination is triphasic, with biological half-lives of approximately 1 day, 1 week and 3 months (ATSDR, 2003). Approximately 50% to 80% of absorbed selenium is eliminated in the urine (Marier and Jaworski, 1983). Selenium levels in the body following both short- and long-term exposure can be determined through blood and urine tests (IOM, 2000). Human breath can also be used as a biomarker for selenium exposure when large amounts of selenium are being excreted (IOM, 2000).

Selenium is an essential trace element and a component of several proteins and enzymes in the body (ATSDR, 2003; HC, 2010). Selenium aids in the defence of oxidative stress, the regulation of thyroid hormone action, and the regulation of the redox status of vitamin C and other molecules (IOM, 2000). Selenium deficiency seldom causes overt illness in isolation; however, it may lead to biochemical changes that predispose people to illness associated with other stresses (IOM, 2000). There is some evidence that suboptimal levels of selenium may lead to sperm abnormalities and effects on sperm motility (Ahsan et al., 2014). On account of its essentiality, Health Canada has established recommended dietary allowances for selenium (HC, 2010; IOM, 2000).

There is a narrow therapeutic window for selenium, and adverse health effects can occur when ingested at levels greater than the tolerable upper intake level (HC, 2010; IOM, 2000). The level at which selenium toxicity occurs can be difficult to determine because it is affected by the types of protein in the diet, levels of vitamin E, and the forms of selenium to which the individual is exposed (HC, 2014). Acute oral intake of excess selenium can result in nausea, vomiting and diarrhea. Selenosis, a disease that results in hair loss,

nail brittleness and neurological abnormalities, is the critical health effect associated with chronic exposure to elevated levels of selenium (i.e., 10 to 20 times more than the recommended dietary allowances) (ATSDR, 2003; IOM, 2000; WHO, 2011). The role of selenium in other chronic diseases, such as diabetes, hypertension and cardiovascular disease, is a subject of ongoing investigation (Benstoem et al., 2015; Boosalis, 2008; Ogawa-Wong et al., 2016). The International Agency for Research on Cancer has determined that selenium's carcinogenicity to humans is not classifiable (Group 3) (IARC, 1975).

The Government of Canada conducted a science-based screening assessment under the Chemicals Management Plan to determine whether selenium and its compounds (including 29 selenium-containing substances on the Domestic Substances List) present or may present a risk to the environment or human health as per the criteria set out in section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; ECCC and HC, 2017a). The assessment concluded that selenium and its compounds are toxic under CEPA 1999 as they are harmful to human health—based on the potential for elevated levels in certain Canadian subpopulations that have higher intake—as well as being harmful to the environment. Selenium and its compounds are proposed to be added to Schedule 1, List of Toxic Substances, under CEPA 1999 (Canada, 1999; HC, 2020b). Risk management actions for selenium and its compounds have been proposed that include measures to reduce the release of selenium into water and finalizing the revised maximum daily dose allowed for selenium in natural health products (ECCC and HC, 2017b). Selenium and its compounds (except selenium sulfide) are on the List of Ingredients that are Prohibited for Use in Cosmetic Products (HC, 2019).

In Canada, the leachable selenium content in a variety of consumer products is regulated under the *Canada Consumer Product Safety Act* (Canada, 2010a). Consumer products regulated for selenium content include paints and other surface coatings on cribs, toys and other products for use by a child in learning or play situations (Canada, 2010b; Canada, 2011). Health Canada has also set a maximum level for selenium in natural health products in Canada (HC, 2018). Health Canada has developed a Canadian drinking water quality guideline that sets out the maximum acceptable concentration of selenium on the basis of health considerations (HC, 2014). Tolerable upper intake levels for selenium, which account for its potential toxicity, have been developed by the Institute of Medicine and adopted by Health Canada (HC, 2010; IOM, 2000). Selenium is also included in the list of various chemicals analyzed as part of Health Canada's ongoing Total Diet Study surveys (HC, 2020a). These surveys provide estimates of the levels of chemicals to which Canadians in different age-sex groups are exposed through the food supply.

Selenium concentrations in blood have been measured in a limited number of biomonitoring studies conducted in Canada, including the First Nations Biomonitoring Initiative (AFN, 2013).

Selenium was measured in the whole blood of Canadian Health Measures Survey (CHMS) participants aged 6–79 in cycle 1 (2007–2009), and aged 3–79 in cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented in blood as µg/L. Selenium was also measured in the urine of all CHMS participants aged 6–79 in cycle 1 and aged 3–79 in cycle 2, and was analyzed in hair from participants aged 20–59 in cycle 5. Finding a measurable amount of selenium in blood, urine or hair is an indicator of exposure to selenium and does not necessarily mean that an adverse health effect will occur. Because selenium is an essential trace element, its presence in biological fluids is expected.

Table 8.7.1

Selenium—Geometric means and selected percentiles of whole blood concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	6070	100	190 (190–190)	160 (150–160)	180 (180–190)	220 (210–230)	240 (230–240)
5 (2016–2017)	4517	100	170 (170–170)	130 (130–140)	160 (160–170)	200 (190–210)	210 (210–210)
6 (2018–2019)	4596	100 (99.9–100)	170 (170–170)	130 (130–140)	160 (160–170)	200 (200–210)	210 (210–210)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2940	100	190 (190–200)	160 (160–160)	190 (180–190)	220 (210–230)	240 (230–250)
5 (2016–2017)	2257	100	170 (170–170)	130 (130–140)	160 (160–170)	200 (190–210)	210 (200–210)
6 (2018–2019)	2330	100 (99.9–100)	170 (170–170)	140 (130–140)	170 (160–170)	200 (200–210)	210 (200–220)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	3130	100	190 (180–190)	150 (150–160)	180 (180–180)	220 (210–230)	240 (230–240)
5 (2016–2017)	2260	100	170 (160–170)	130 (130–140)	160 (160–170)	200 (190–210)	210 (210–220)
6 (2018–2019)	2266	100	170 (170–170)	130 (130–130)	160 (160–170)	200 (200–210)	210 (200–220)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	495	100	170 (160–170)	140 (130–150)	160 (160–170)	190 (180–200)	210 (200–210)
5 (2016–2017)	473	100	150 (140–150)	120 (120–130)	140 (130–150)	170 (160–170)	170 (170–170)
6 (2018–2019)	482	100	150 (150–160)	120 (120–130)	150 (140–150)	180 (160–200)	190 (170–210)
6–11 years							
1 (2007–2009)	910	100	190 (180–190)	150 (150–160)	180 (180–180)	210 (210–220)	230 (220–240)
2 (2009–2011)	961	100	170 (170–180)	140 (140–150)	170 (160–170)	200 (200–210)	210 (200–220)
5 (2016–2017)	511	100	150 (150–160)	120 (120–130)	150 (150–150)	170 (160–180)	180 (170–190)
6 (2018–2019)	500	100	160 (150–160)	130 (120–130)	150 (150–150)	170 (160–180)	190 (170–210)
12–19 years							
1 (2007–2009)	945	100	200 (190–200)	160 (160–170)	190 (190–190)	230 (230–240)	250 (240–260)
2 (2009–2011)	997	100	190 (180–190)	160 (160–160)	180 (170–180)	210 (200–220)	230 (220–240)
5 (2016–2017)	521	100	160 (160–170)	130 (130–130)	160 (150–160)	190 (180–200)	200 (190–210)
6 (2018–2019)	504	99.9 (99.1–100)	170 (160–170)	130 (120–140)	160 (160–170)	200 (180–210)	210 (200–220)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1165	100	200 (200–210)	160 (160–170)	200 (190–200)	240 (230–240)	250 (240–260)
2 (2009–2011)	1313	100	190 (190–200)	160 (160–160)	190 (180–190)	220 (210–230)	240 (220–260)
5 (2016–2017)	1038	100	170 (170–180)	140 (130–140)	170 (160–170)	200 (190–220)	210 (200–220)
6 (2018–2019)	1053	100	170 (170–180)	140 (130–140)	170 (160–170)	200 (200–210)	210 (200–220)
40–59 years							
1 (2007–2009)	1220	100	200 (200–210)	170 (160–170)	200 (190–200)	240 (230–240)	250 (240–260)
2 (2009–2011)	1222	100	190 (190–200)	160 (160–160)	190 (180–200)	230 (220–240)	240 (230–250)
5 (2016–2017)	990	100	170 (170–180)	140 (140–150)	170 (160–170)	200 (200–210)	210 (200–230)
6 (2018–2019)	1083	100	170 (170–180)	140 (130–140)	170 (160–170)	210 (200–210)	210 (210–220)
60–79 years							
1 (2007–2009)	1079	100	200 (200–210)	170 (160–170)	200 (190–200)	240 (230–250)	250 (240–270)
2 (2009–2011)	1082	100	190 (190–190)	160 (160–160)	180 (180–190)	220 (210–230)	240 (230–240)
5 (2016–2017)	984	100	170 (170–180)	140 (130–140)	170 (160–170)	200 (200–210)	210 (210–220)
6 (2018–2019)	974	100 (99.9–100)	170 (170–180)	140 (130–140)	170 (160–170)	210 (200–210)	220 (210–220)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 8, 20, 32 and 32 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

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SUMMARIES AND RESULTS FOR SELF-CARE AND CONSUMER PRODUCT CHEMICALS

9

9.1 BISPHENOL A

Bisphenol A (BPA) (CASRN 80-05-7) is a synthetic chemical used as a monomer in the production of some polycarbonate plastics and as a precursor for monomers of certain epoxy-phenolic resins (EFSA, 2007). Polycarbonate plastics have wide application in consumer products, including storage containers for foods and beverages; they were also used in infant bottles in Canada prior to 2010. Epoxy resins are used as an interior protective lining for food and beverage cans. Additional end-use products containing polycarbonate plastics and resins include medical devices, some dental fillings and sealants, sporting and safety equipment, electronics and automotive parts (EFSA, 2007; NTP, 2007). BPA is also used in the paper industry to produce thermal paper for various products, including receipts, prescription labels, airline tickets and lottery tickets (Geens et al., 2011).

BPA does not occur naturally in the environment (EC and HC, 2008a). Entry into the environment may occur from industrial sources or from product leaching, disposal and use (CDC, 2009).

The primary route of exposure to BPA for the general public is through dietary intake from various sources, including migration from food packaging and repeat-use polycarbonate containers (HC, 2008). Health Canada updated its dietary exposure estimates for BPA after completing a number of surveys in which BPA concentrations were measured in various foods, including canned foods and beverages, liquid infant formula and samples from the Total Diet Study (HC,

2012). Dermal exposure through handling of thermal printing paper is considered an important secondary route of exposure (EFSA CEF Panel, 2015). Oral exposure can also result from leaching of BPA from dental materials; however, the contribution to total BPA exposure is likely negligible (Becher et al., 2018; SCENIHR, 2015). Exposure can also occur from contact with environmental media, including ambient and indoor air, drinking water, soil and dust, and from the use of consumer products (EC and HC, 2008a).

In humans, BPA is readily absorbed and undergoes extensive metabolism in the gut wall and liver (WHO, 2011). Studies have also suggested that it may be absorbed and metabolized by the skin following dermal exposure to free BPA in products such as those made from thermal printing papers (Mielke et al., 2011; Zalko et al., 2011). Glucuronidation has been recognized as a major metabolic pathway for BPA, occurring primarily in the liver and resulting in the BPA-glucuronide conjugate metabolite (EFSA, 2008; FDA, 2008). Conjugation of BPA to BPA-sulphate has been shown to be a minor metabolic pathway (Dekant and Völkel, 2008). There continues to be some uncertainty as to whether the BPA-glucuronide metabolite is biologically active. However, it is rapidly excreted in urine with a half-life of less than 2 hours (WHO, 2011). Urinary levels of total BPA, including both conjugated and free unconjugated forms, are commonly used as biomarkers to assess recent exposures (Arbuckle et al., 2015; Ye et al., 2005).

Characterization of the potential risk to human health from exposure to BPA includes key effects on the liver and kidneys as well as effects on reproduction, development, neurodevelopment and behaviour (EFSA CEF Panel, 2015; EC and HC, 2008a; EU, 2010). In 2018, the U.S. National Toxicology Program published the results of a comprehensive investigation of BPA toxicity and concluded that early-life and long-term exposures are unlikely to pose a health risk at low doses (NTP, 2018). The potential role of BPA and other environmental estrogens in the prevalence of obesity, related metabolic diseases and certain types of cancer continues to be investigated (Heindel et al., 2015; Seachrist et al., 2016).

The Government of Canada conducted a science-based screening assessment under phase 1 of the Chemicals Management Plan to determine whether BPA presents or may present a risk to the environment or human health as per the criteria set out in section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; EC and HC, 2008a). Based on information available at that time, the assessment concluded that BPA is toxic under CEPA 1999, as it is considered harmful to the environment and human health (EC and HC, 2008a). Because of the uncertainty raised by the results of some laboratory animal studies relating to the potential effects of low levels of BPA, a precautionary approach was applied when characterizing risk. Considering the highest potential exposure and subpopulations with potential vulnerability due to possible differences in the toxicokinetics and metabolism of BPA identified in the assessment, the risk management strategy for health focused on decreasing exposure to newborns and infants (EC and HC, 2008b).

Health 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 young children (HC, 2012). However, exposure to BPA should be as

low as reasonably achievable (ALARA) and efforts should continue to limit BPA exposure in infants and newborns from food packaging applications, specifically pre-packaged infant formula products as a sole-source food. As part of the ALARA approach, Health Canada committed to supporting industry to reduce levels of BPA in infant formula can linings (HC, 2014). Health Canada's findings confirm that alternative packaging materials for liquid infant formula products manufactured without BPA have been adopted by industry (HC, 2014). As of March 2010, under the *Canada Consumer Product Safety Act*, Health Canada has prohibited the manufacturing, advertisement, sale or import of polycarbonate baby bottles that contain BPA (Canada, 2010). The removal of BPA in polycarbonate baby bottles and liquid infant formula can linings has led Health Canada to conclude that there has been significant progress toward meeting the human health objective for BPA set out in 2008 (HC, 2018). BPA is on the List of Ingredients that are Prohibited for Use in Cosmetic Products (HC, 2019). Risk management actions also have been developed under CEPA 1999 with the objective of minimizing releases of BPA in industrial effluents (Canada, 2012).

BPA concentrations in urine have been measured in a number of biomonitoring studies conducted in Canada, including the Maternal–Infant Research on Environmental Chemicals study (Arbuckle et al., 2014) and the First Nations Biomonitoring Initiative (AFN, 2013).

Urinary total BPA (including both free and conjugated forms) was analyzed in the urine of Canadian Health Measures Survey (CHMS) participants aged 6–79 in cycle 1 (2007–2009) and aged 3–79 in cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented as both µg/L and µg/g creatinine. Finding a measurable amount of BPA in urine is an indicator of exposure to BPA and does not necessarily mean that an adverse health effect will occur.

Table 9.1.1

Bisphenol A (BPA)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2560	93.8 (91.2–95.7)	1.2 (1.1–1.3)	0.27 (0.22–0.31)	1.2 (1.1–1.3)	4.5 (4.0–5.0)	6.7 (4.8–8.6)
3 (2012–2013)	5670	91.7 (90.1–93.1)	1.1 (1.0–1.2)	0.29 (0.27–0.32)	1.1 (0.95–1.2)	4.2 (3.6–4.8)	6.6 (5.8–7.5)
4 (2014–2015)	2560	91.9 (88.5–94.4)	1.0 (0.95–1.1)	0.26 (<LOD–0.33)	1.0 (0.94–1.1)	4.0 (3.2–4.8)	6.0 (5.0–7.1)
5 (2016–2017)	2647	81.5 (74.7–86.7)	0.81 (0.71–0.93)	<LOD	0.85 (0.75–0.96)	2.9 (2.6–3.2)	4.2 (3.1–5.2)
6 (2018–2019)	2533	79.3 (76.3–82.1)	0.68 (0.59–0.79)	<LOD	0.68 (0.56–0.79)	2.3 (1.9–2.7)	3.6 (2.4–4.7)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1281	93.3 (89.1–96.0)	1.3 (1.1–1.5)	0.27 (<LOD–0.36)	1.3 (1.1–1.5)	4.6 (4.1–5.2)	7.9 ^E (4.3–11)
3 (2012–2013)	2826	93.0 (90.9–94.6)	1.2 (1.1–1.4)	0.35 (0.25–0.46)	1.2 (0.99–1.4)	4.4 (3.7–5.0)	6.4 (5.2–7.7)
4 (2014–2015)	1273	94.6 (91.3–96.7)	1.2 (1.0–1.3)	0.35 (0.28–0.43)	1.2 (0.97–1.3)	4.3 (3.0–5.6)	6.2 (4.3–8.0)
5 (2016–2017)	1315	80.7 (72.1–87.0)	0.84 (0.69–1.0)	<LOD	0.85 (0.69–1.0)	2.9 (2.5–3.4)	5.6 (3.7–7.5)
6 (2018–2019)	1254	79.6 (74.0–84.2)	0.77 (0.63–0.94)	<LOD	0.83 (0.68–0.97)	2.8 ^E (1.6–3.9)	4.7 ^E (1.3–8.1)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1279	94.3 (91.8–96.1)	1.2 (1.0–1.3)	0.26 (0.21–0.32)	1.1 (0.98–1.3)	4.1 (3.0–5.1)	6.6 (4.9–8.4)
3 (2012–2013)	2844	90.5 (88.1–92.5)	1.0 (0.88–1.2)	0.29 (<LOD–0.39)	1.0 (0.91–1.1)	4.1 (3.3–4.9)	6.9 (5.4–8.4)
4 (2014–2015)	1287	89.3 (82.8–93.5)	0.92 (0.79–1.1)	<LOD	0.98 (0.82–1.1)	3.4 (2.8–4.0)	5.4 (3.6–7.3)
5 (2016–2017)	1332	82.3 (74.7–88.0)	0.78 (0.69–0.89)	<LOD	0.85 (0.72–0.99)	2.6 (2.2–3.0)	3.3 (2.6–4.0)
6 (2018–2019)	1279	79.1 (74.8–82.8)	0.61 (0.52–0.70)	<LOD	0.61 (0.51–0.71)	2.0 (1.5–2.4)	2.8 (2.4–3.2)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	524	94.1 (89.3–96.8)	1.4 (1.1–1.8)	0.30 ^E (<LOD–0.46)	1.3 (1.1–1.5)	5.4 ^E (1.9–9.0)	9.9 ^E (5.5–14)
3 (2012–2013)	521	92.6 (82.9–97.0)	1.2 (0.87–1.6)	0.29 ^E (<LOD–0.47)	1.2 (0.95–1.5)	4.0 (2.6–5.4)	6.0 (4.3–7.7)
4 (2014–2015)	511	91.3 (84.2–95.4)	1.2 (1.0–1.4)	0.28 ^E (<LOD–0.44)	1.2 (1.0–1.3)	4.0 (3.5–4.5)	6.4 ^E (2.9–9.9)
5 (2016–2017)	547	86.2 (77.2–92.0)	0.94 (0.72–1.2)	<LOD	0.99 (0.78–1.2)	3.0 ^E (1.9–4.1)	4.4 ^E (2.4–6.3)
6 (2018–2019)	517	88.3 (81.0–93.0)	0.80 (0.65–0.99)	<LOD	0.78 (0.59–0.96)	2.4 ^E (0.78–3.9)	3.8 ^E (0.46–7.2)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
6–11 years							
1 (2007–2009)	1031	93.5 (89.1–96.2)	1.3 (1.2–1.4)	0.28 (<LOD–0.37)	1.3 (1.1–1.6)	4.5 (3.8–5.1)	7.1 (5.5–8.7)
2 (2009–2011)	516	93.4 (88.9–96.2)	1.4 (1.1–1.7)	0.25 ^E (<LOD–0.41)	1.3 (0.94–1.7)	4.6 ^E (2.6–6.6)	9.3 ^E (0.76–18)
3 (2012–2013)	1004	95.9 (94.6–96.9)	1.2 (1.1–1.4)	0.39 (0.30–0.49)	1.2 (1.0–1.3)	3.8 (2.8–4.8)	5.3 ^E (3.0–7.6)
4 (2014–2015)	511	94.4 (89.0–97.2)	1.1 (0.90–1.4)	0.29 (<LOD–0.40)	1.1 (0.83–1.4)	3.5 (2.6–4.4)	5.0 (4.0–6.0)
5 (2016–2017)	516	88.6 (83.8–92.1)	0.97 (0.83–1.1)	<LOD	0.94 (0.75–1.1)	2.9 ^E (1.8–4.0)	5.5 ^E (3.1–7.8)
6 (2018–2019)	496	85.5 (79.3–90.1)	0.80 (0.66–0.97)	<LOD	0.83 (0.64–1.0)	2.0 (1.3–2.8)	3.2 ^E (2.0–4.4)
12–19 years							
1 (2007–2009)	980	93.7 (90.2–96.0)	1.5 (1.3–1.8)	0.29 (0.22–0.36)	1.6 (1.3–1.9)	5.9 (4.8–7.0)	8.3 (6.2–10)
2 (2009–2011)	512	94.4 (88.9–97.2)	1.3 (1.1–1.6)	0.35 (0.23–0.47)	1.3 (0.99–1.6)	4.4 (2.9–5.9)	7.6 ^E (4.3–11)
3 (2012–2013)	992	92.3 (86.2–95.8)	1.3 (1.1–1.6)	0.30 ^E (<LOD–0.46)	1.4 (1.3–1.6)	4.8 (3.4–6.2)	8.0 ^E (4.1–12)
4 (2014–2015)	505	93.7 (88.7–96.6)	1.1 (1.1–1.2)	0.26 (<LOD–0.35)	1.2 (1.0–1.3)	3.8 (3.1–4.6)	5.5 (4.5–6.5)
5 (2016–2017)	524	86.8 (79.7–91.7)	0.96 (0.80–1.2)	<LOD	0.96 (0.83–1.1)	3.2 (2.6–3.8)	4.1 (2.9–5.3)
6 (2018–2019)	504	84.3 (75.9–90.2)	0.96 (0.74–1.2)	<LOD	0.85 (0.72–0.99)	4.7 ^E (2.0–7.4)	8.1 ^E (1.8–14)
20–39 years							
1 (2007–2009)	1165	92.1 (87.0–95.4)	1.3 (1.2–1.5)	0.22 ^E (<LOD–0.39)	1.4 (1.2–1.6)	4.8 (4.1–5.4)	7.3 (5.2–9.5)
2 (2009–2011)	357	96.1 (89.8–98.6)	1.3 (1.1–1.5)	0.32 (0.21–0.42)	1.3 (0.92–1.6)	4.6 (3.7–5.5)	5.6 ^E (0.50–11)
3 (2012–2013)	1040	91.1 (85.0–94.9)	1.1 (0.92–1.4)	0.29 (<LOD–0.39)	1.1 (0.81–1.3)	5.5 (3.9–7.0)	6.7 (5.1–8.3)
4 (2014–2015)	362	90.2 (82.7–94.7)	1.1 (0.93–1.4)	<LOD ^E (<LOD–0.35)	1.2 (0.97–1.4)	5.6 ^E (3.3–7.8)	7.4 (5.1–9.7)
5 (2016–2017)	362	75.2 (56.4–87.7)	0.84 ^E (0.57–1.2)	<LOD	1.0 (0.74–1.4)	2.9 (1.9–4.0)	5.4 ^E (1.9–8.8)
6 (2018–2019)	332	82.2 (73.3–88.5)	0.73 (0.58–0.91)	<LOD	0.68 (0.50–0.86)	2.2 ^E (1.3–3.1)	4.2 ^E (1.5–6.8)
40–59 years							
1 (2007–2009)	1219	87.5 (82.5–91.2)	1.0 (0.96–1.1)	<LOD	1.2 (1.1–1.4)	4.4 (3.5–5.3)	6.6 (4.8–8.4)
2 (2009–2011)	360	92.7 (86.4–96.2)	1.2 (0.97–1.5)	0.25 ^E (<LOD–0.37)	1.2 (0.98–1.4)	4.3 ^E (2.7–6.0)	6.7 ^E (2.6–11)
3 (2012–2013)	1075	93.1 (91.2–94.7)	1.1 (1.0–1.3)	0.30 (<LOD–0.36)	1.1 (0.94–1.2)	4.2 (3.1–5.3)	7.5 ^E (4.3–11)
4 (2014–2015)	311	92.5 (85.9–96.1)	0.86 (0.74–1.0)	0.28 (<LOD–0.38)	0.94 (0.77–1.1)	2.4 (1.9–2.9)	4.2 ^E (2.4–5.9)
5 (2016–2017)	348	82.4 (74.1–88.5)	0.73 (0.59–0.89)	<LOD	0.79 (0.61–0.96)	2.4 (1.9–3.0)	3.1 (2.6–3.7)
6 (2018–2019)	343	72.2 (65.2–78.2)	0.60 (0.50–0.71)	<LOD	0.59 (0.41–0.76)	2.5 (2.0–3.1)	3.1 ^E (0.85–5.3)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
60–79 years							
1 (2007–2009)	1081	88.1 (83.3–91.6)	0.90 (0.81–0.99)	<LOD	0.99 (0.87–1.1)	3.7 (3.3–4.2)	5.2 (3.8–6.6)
2 (2009–2011)	291	91.9 (86.5–95.2)	1.0 (0.84–1.3)	0.21 ^E (<LOD–0.31)	0.99 (0.76–1.2)	4.4 ^E (2.5–6.2)	6.3 (4.4–8.1)
3 (2012–2013)	1038	88.4 (83.9–91.7)	0.88 (0.77–1.0)	<LOD	0.88 (0.76–1.0)	3.3 (2.8–3.7)	5.5 (4.2–6.7)
4 (2014–2015)	360	92.0 (87.5–95.0)	1.1 (0.96–1.2)	<LOD	1.0 (0.84–1.2)	4.2 (3.1–5.3)	5.5 ^E (2.3–8.7)
5 (2016–2017)	350	83.3 (77.1–88.1)	0.77 (0.66–0.90)	<LOD	0.79 (0.66–0.92)	2.7 (1.9–3.4)	3.7 ^E (2.3–5.1)
6 (2018–2019)	341	79.5 (73.3–84.6)	0.61 (0.52–0.71)	<LOD	0.62 (0.46–0.78)	1.7 (1.4–2.0)	2.4 (1.7–3.1)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 3, 4, 5 and 6 are 0.2, 0.2, 0.23, 0.23, 0.32 and 0.31 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 9.1.2

Bisphenol A (BPA) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2550	93.8 (91.2–95.7)	1.2 (1.1–1.3)	0.39 (0.35–0.44)	1.0 (0.92–1.1)	4.1 (3.6–4.6)	6.9 (5.1–8.7)
3 (2012–2013)	5667	91.7 (90.1–93.1)	1.1 (1.0–1.2)	0.40 (0.36–0.45)	0.99 (0.94–1.0)	3.6 (3.0–4.2)	5.9 (4.4–7.5)
4 (2014–2015)	2559	91.9 (88.5–94.4)	0.93 (0.87–0.99)	0.32 (<LOD–0.36)	0.87 (0.80–0.94)	3.1 (2.6–3.5)	4.5 (3.9–5.2)
5 (2016–2017)	2620	81.5 (74.7–86.7)	0.79 (0.71–0.87)	<LOD	0.76 (0.65–0.86)	2.4 (1.8–2.9)	3.3 (2.8–3.8)
6 (2018–2019)	2532	79.3 (76.3–82.1)	0.74 (0.64–0.86)	<LOD	0.70 (0.60–0.81)	2.1 (1.7–2.6)	3.1 (2.2–4.0)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1277	93.3 (89.1–96.0)	1.1 (0.96–1.2)	0.36 (<LOD–0.48)	0.99 (0.93–1.1)	3.7 (2.7–4.8)	6.2 ^E (3.5–8.8)
3 (2012–2013)	2826	93.0 (90.9–94.6)	1.1 (0.96–1.2)	0.38 (0.32–0.45)	0.98 (0.90–1.1)	3.1 (2.8–3.4)	5.1 (3.9–6.4)
4 (2014–2015)	1272	94.6 (91.3–96.7)	0.92 (0.83–1.0)	0.30 (0.24–0.36)	0.87 (0.76–0.98)	2.8 (2.2–3.5)	4.1 (3.2–4.9)
5 (2016–2017)	1305	80.7 (72.1–87.0)	0.73 (0.64–0.83)	<LOD	0.70 (0.53–0.86)	2.4 (1.7–3.2)	3.2 (2.5–3.9)
6 (2018–2019)	1253	79.6 (74.0–84.2)	0.72 (0.58–0.88)	<LOD	0.69 (0.57–0.80)	2.3 (1.6–2.9)	3.7 ^E (1.1–6.3)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1273	94.3 (91.8–96.1)	1.3 (1.2–1.5)	0.48 (0.40–0.57)	1.1 (0.95–1.3)	4.5 (3.5–5.5)	6.9 (4.5–9.4)
3 (2012–2013)	2841	90.5 (88.1–92.5)	1.2 (1.1–1.4)	0.42 (<LOD–0.46)	1.0 (0.91–1.1)	4.0 (3.1–5.0)	7.1 ^E (4.4–9.9)
4 (2014–2015)	1287	89.3 (82.8–93.5)	0.94 (0.85–1.0)	<LOD	0.88 (0.78–0.97)	3.4 (2.5–4.3)	5.0 (4.2–5.8)
5 (2016–2017)	1315	82.3 (74.7–88.0)	0.85 (0.77–0.95)	<LOD	0.80 (0.70–0.90)	2.2 (1.5–2.9)	3.4 (2.3–4.4)
6 (2018–2019)	1279	79.1 (74.8–82.8)	0.77 (0.67–0.88)	<LOD	0.71 (0.58–0.83)	2.0 (1.5–2.4)	3.0 (2.3–3.7)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	523	94.1 (89.3–96.8)	2.4 (1.9–3.1)	0.88 ^E (<LOD–1.2)	2.0 (1.8–2.3)	10 ^E (4.6–15)	13 (8.6–17)
3 (2012–2013)	520	92.6 (82.9–97.0)	2.3 (1.8–2.9)	0.86 ^E (<LOD–1.2)	2.1 (1.4–2.7)	5.9 (4.1–7.8)	8.4 (6.7–10)
4 (2014–2015)	511	91.3 (84.2–95.4)	2.0 (1.7–2.4)	0.64 ^E (<LOD–0.90)	1.8 (1.5–2.2)	6.7 (4.7–8.7)	13 ^E (4.4–21)
5 (2016–2017)	538	86.2 (77.2–92.0)	1.6 (1.4–1.9)	<LOD	1.5 (1.2–1.8)	4.8 (3.7–5.9)	5.8 ^E (<LOD–11)
6 (2018–2019)	516	88.3 (81.0–93.0)	1.3 (1.0–1.7)	<LOD	1.2 (0.86–1.5)	3.8 ^E (0.91–6.7)	6.0 ^E (<LOD–16)
6–11 years							
1 (2007–2009)	1028	93.5 (89.1–96.2)	2.0 (1.8–2.2)	0.68 (<LOD–0.82)	2.0 (1.8–2.1)	5.8 (4.8–6.9)	9.8 (7.4–12)
2 (2009–2011)	514	93.4 (88.9–96.2)	1.5 (1.2–1.9)	0.44 ^E (<LOD–0.68)	1.4 (1.1–1.7)	5.0 ^E (1.4–8.6)	10 ^E (3.0–18)
3 (2012–2013)	1004	95.9 (94.6–96.9)	1.5 (1.3–1.7)	0.58 (0.46–0.69)	1.4 (1.1–1.6)	3.9 (2.6–5.2)	5.3 ^E (2.0–8.6)
4 (2014–2015)	510	94.4 (89.0–97.2)	1.2 (1.0–1.5)	0.41 (<LOD–0.54)	1.1 (0.94–1.3)	3.2 (2.6–3.8)	5.6 ^E (<LOD–12)
5 (2016–2017)	507	88.6 (83.8–92.1)	1.1 (0.99–1.3)	<LOD	1.0 (0.90–1.1)	3.1 (2.3–3.8)	5.0 ^E (2.9–7.0)
6 (2018–2019)	496	85.5 (79.3–90.1)	0.96 (0.85–1.1)	<LOD	0.96 (0.83–1.1)	2.1 (1.7–2.4)	2.9 ^E (1.5–4.4)
12–19 years							
1 (2007–2009)	978	93.7 (90.2–96.0)	1.3 (1.2–1.4)	0.40 (0.30–0.50)	1.2 (0.99–1.4)	4.2 (3.3–5.0)	6.4 ^E (4.0–8.8)
2 (2009–2011)	510	94.4 (88.9–97.2)	1.0 (0.83–1.2)	0.30 ^E (0.17–0.43)	0.94 (0.79–1.1)	3.4 ^E (1.5–5.2)	5.0 (3.8–6.3)
3 (2012–2013)	991	92.3 (86.2–95.8)	1.0 (0.85–1.2)	0.35 (<LOD–0.44)	0.95 (0.82–1.1)	3.0 (2.3–3.8)	5.4 ^E (2.6–8.2)
4 (2014–2015)	505	93.7 (88.7–96.6)	0.83 (0.74–0.93)	0.30 (<LOD–0.35)	0.74 (0.61–0.87)	2.7 (2.1–3.3)	3.9 (2.6–5.1)
5 (2016–2017)	520	86.8 (79.7–91.7)	0.74 (0.58–0.94)	<LOD	0.66 (0.52–0.80)	2.0 ^E (0.79–3.3)	3.2 ^E (2.1–4.4)
6 (2018–2019)	504	84.3 (75.9–90.2)	0.79 (0.63–1.0)	<LOD	0.71 (0.59–0.84)	2.6 (1.7–3.5)	4.3 ^E (<LOD–9.9)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1161	92.1 (87.0–95.4)	1.5 (1.4–1.6)	0.44 (<LOD–0.55)	1.4 (1.2–1.6)	4.4 (3.4–5.4)	6.8 (5.9–7.7)
2 (2009–2011)	355	96.1 (89.8–98.6)	1.1 (0.89–1.3)	0.39 (0.27–0.50)	0.99 (0.85–1.1)	2.8 (1.8–3.7)	4.5 ^E (0.73–8.2)
3 (2012–2013)	1040	91.1 (85.0–94.9)	1.0 (0.90–1.2)	0.36 (<LOD–0.43)	0.93 (0.80–1.1)	3.3 (2.6–3.9)	5.4 ^E (2.7–8.1)
4 (2014–2015)	362	90.2 (82.7–94.7)	0.91 (0.80–1.0)	<LOD	0.87 (0.75–0.99)	3.5 ^E (1.7–5.3)	4.6 ^E (2.0–7.1)
5 (2016–2017)	359	75.2 (56.4–87.7)	0.75 (0.60–0.94)	<LOD	0.84 (0.62–1.1)	2.4 ^E (1.5–3.3)	3.0 (2.0–4.1)
6 (2018–2019)	332	82.2 (73.3–88.5)	0.69 (0.56–0.84)	<LOD	0.62 (0.52–0.71)	1.8 ^E (1.0–2.5)	2.7 ^E (0.90–4.5)
40–59 years							
1 (2007–2009)	1214	87.5 (82.5–91.2)	1.3 (1.2–1.5)	<LOD	1.2 (1.0–1.4)	4.7 (3.8–5.7)	7.5 (6.1–8.8)
2 (2009–2011)	358	92.7 (86.4–96.2)	1.2 (0.99–1.4)	0.39 (<LOD–0.50)	1.1 (0.86–1.3)	4.2 ^E (2.3–6.2)	6.9 ^E (3.4–10)
3 (2012–2013)	1074	93.1 (91.2–94.7)	1.2 (1.1–1.3)	0.47 (<LOD–0.52)	0.99 (0.90–1.1)	3.8 (2.9–4.6)	6.1 ^E (3.7–8.5)
4 (2014–2015)	311	92.5 (85.9–96.1)	0.78 (0.70–0.86)	0.33 (<LOD–0.40)	0.71 (0.64–0.78)	1.9 ^E (0.95–2.9)	3.8 ^E (2.2–5.4)
5 (2016–2017)	347	82.4 (74.1–88.5)	0.66 (0.56–0.79)	<LOD	0.61 (0.53–0.69)	1.9 ^E (1.2–2.6)	2.8 (2.1–3.5)
6 (2018–2019)	343	72.2 (65.2–78.2)	0.71 (0.55–0.91)	<LOD	0.74 (0.59–0.89)	2.0 (1.5–2.6)	2.7 ^E (0.57–4.9)
60–79 years							
1 (2007–2009)	1081	88.1 (83.3–91.6)	1.2 (1.1–1.4)	<LOD	1.1 (0.94–1.3)	4.3 (3.0–5.6)	7.6 (5.4–9.8)
2 (2009–2011)	290	91.9 (86.5–95.2)	1.2 (0.99–1.4)	0.29 ^E (<LOD–0.45)	1.0 (0.89–1.1)	4.7 (3.3–6.0)	6.8 ^E (2.9–11)
3 (2012–2013)	1038	88.4 (83.9–91.7)	1.0 (0.97–1.1)	<LOD	0.99 (0.94–1.0)	3.0 (2.7–3.4)	4.7 ^E (2.7–6.7)
4 (2014–2015)	360	92.0 (87.5–95.0)	1.0 (0.92–1.2)	<LOD	0.99 (0.89–1.1)	3.5 (2.5–4.4)	4.8 ^E (2.1–7.4)
5 (2016–2017)	349	83.3 (77.1–88.1)	0.89 (0.80–0.99)	<LOD	0.84 (0.71–0.97)	2.2 ^E (0.85–3.5)	4.7 ^E (2.7–6.7)
6 (2018–2019)	341	79.5 (73.3–84.6)	0.71 (0.61–0.83)	<LOD	0.65 (0.55–0.75)	2.6 ^E (1.5–3.7)	3.7 (2.6–4.8)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

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9.2 PARABENS

Parabens are a group of *para*-hydroxybenzoic (*p*-hydroxybenzoic) acid esters, 4 of which were measured in cycles 3 through 6 of the Canadian Health Measures Survey (CHMS): methyl, ethyl, propyl and butyl paraben (Table 9.2.1).

Table 9.2.1
Parabens measured in the Canadian Health Measures Survey.

Paraben	CASRN
Methyl paraben	99-76-3
Ethyl paraben	120-47-8
Propyl paraben	94-13-3
Butyl paraben	94-26-8

Parabens are widely used as preservatives in personal care products owing to their antibacterial and antifungal properties, and are also used as fragrance ingredients (ECCC and HC, 2020; HC, 2020). These products include makeup, moisturizers, sunscreens, hair-care products, facial and skin cleansers, shaving products and toothpaste. Methyl, propyl, butyl and ethyl parabens are the most common ones used in cosmetic products (FDA, 2020). Concentrations of parabens in cosmetic products are typically 0.5% or less (HC, 2020). Methyl and propyl paraben are permitted for use as food additives (preservatives) in certain foods sold in Canada. Parabens are also used in food packaging materials, prescription and non-prescription drugs and pest control products (ECCC and HC, 2020). Methyl, ethyl, propyl and butyl paraben are listed as non-medicinal ingredients in natural health products (HC, 2021).

Some parabens may occur naturally in certain fruits and vegetables, such as blueberries and carrots (HC, 2020). The synthetic production and use of paraben-containing products can result in their release to the environment through various waste streams. Parabens are expected to degrade and not persist in water, air, sediment or soil (ECCC and HC, 2020).

A potential route of exposure for the general public is dermal contact with products that contain parabens, such as moisturizers and cosmetics. Approximately 50% of cosmetics in the United States contain parabens, with methyl paraben being the most commonly used and lipstick having the highest concentrations (Cosmetic

Ingredient Review Expert Panel, 2008; Yazar et al., 2011). Oral exposure to parabens can also occur through consumption of foods or pharmaceuticals containing parabens, ingestion of breast milk and ingestion of house dust (CDC, 2009; Fan et al., 2010; Ye et al., 2008).

Dermal exposure may result in small amounts of parabens being absorbed. Following oral exposure, parabens are rapidly absorbed from the gastrointestinal tract (NTP, 2005). Once absorbed, parabens are mainly hydrolyzed to *p*-hydroxybenzoic acid that can then be conjugated with glycine, glucuronide and sulphate for excretion in urine (Soni et al., 2005). There is no evidence of bioaccumulation potential in humans. In laboratory animals, complete elimination of orally ingested ethyl and propyl paraben was observed within 72 hours (Soni et al., 2005). In humans, parabens are eliminated rapidly in urine and are recovered predominantly as hydrolyzed and conjugated isoforms (ECCC and HC, 2020). In a study of orally dosed volunteers, Moos et al. (2016) found that the fraction of parent paraben excreted in urine generally decreased with increasing molecular weight (i.e., increasing length of the alkyl side chain). The concentration of parabens in urine (parent and metabolites) can be used as a biomarker of exposure to parabens. Certain metabolites, such as *p*-hydroxybenzoic acid and *p*-hydroxyhippuric acid, are common to all parabens; as such, they may not be optimal biomarkers of exposure for specific parabens. Conversely, parent parabens are specific biomarkers in urine. It should be noted that because parent parabens are widely used as preservatives, their use as biomarkers may be susceptible to contamination during sample collection and analysis (Aylward et al., 2017).

Health effects have not been observed as a result of exposures to parabens at concentrations found in cosmetics, with acute, subchronic and chronic experimental animal studies demonstrating low toxicity of parabens (Cosmetic Ingredient Review Expert Panel, 2008). Animal studies have reported various health effects depending on the specific paraben, route of exposure and dose. These include depression and decreased motor activity after ethyl paraben exposure, and delayed onset of puberty, altered morphology of reproductive organs and reduced sperm count and motility in offspring following gestational exposure to butyl paraben (ECCC and HC, 2020). Animal studies have found parabens to be non-allergenic; however, sporadic human cases of allergic reactions have

been reported following paraben exposure (Cosmetic Ingredient Review Expert Panel, 2008). Parabens have been found to weakly mimic estrogens in vitro, but well-conducted animal studies do not demonstrate estrogenic effects (Sivaraman et al., 2018); human data do not support a link to estrogenic effects because exposure to parabens has not been observed to affect hormone levels or sperm quality (Adoamnei et al., 2018; Meeker et al., 2011). It should be noted that most of the available toxicity data are from single paraben exposure studies, and that the additive and cumulative risks of exposures to multiple parabens are not well studied (Karpuzoglu et al., 2013). Parabens have not been found to be carcinogenic in chronic animal studies. The International Agency for Research on Cancer has not evaluated parabens with respect to human carcinogenicity.

The Government of Canada has conducted a screening assessment to determine whether 7 substances referred to collectively as the Parabens Group present or may present a risk to the environment or human health as per the criteria set out in section 64 of the *Canadian*

Environmental Protection Act, 1999 (CEPA 1999) (Canada, 1999; ECCC and HC, 2020). The draft assessment released in 2020 proposed to conclude that methyl paraben, propyl paraben and butyl paraben are toxic under CEPA 1999, given that they are considered harmful to human health, but that ethyl paraben does not meet the criteria to be considered toxic (ECCC and HC, 2020).

A limited number of biomonitoring studies conducted in Canada have measured the concentrations of parabens in urine (e.g. Genuis et al., 2013; Fisher et al., 2017).

Methyl, ethyl, propyl and butyl paraben were analyzed in the urine of CHMS participants aged 3–79 in cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019). Data are presented as µg/L and µg/g creatinine. Finding a measurable quantity of parabens in urine is an indicator of exposure to parabens and does not necessarily mean that an adverse health effect will occur.

Table 9.2.2

Methyl paraben—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
3 (2012–2013)	2339	91.0 (87.4–93.7)	21 (17–25)	<LOD ^E (<LOD–1.8)	19 (16–23)	320 ^E (200–450)	470 ^E (210–730)
4 (2014–2015)	2564	89.6 (85.4–92.7)	17 (13–22)	<LOD	15 (9.8–20)	270 (190–340)	490 (340–640)
5 (2016–2017)	2720	87.9 (84.2–90.8)	14 (11–18)	<LOD	11 (7.3–15)	230 ^E (100–350)	550 ^E (260–830)
6 (2018–2019)	2531	85.3 (80.5–89.0)	11 (9.5–13)	<LOD	7.8 (6.5–9.1)	190 (170–210)	360 (250–460)
Males, 3–79 years							
3 (2012–2013)	1171	85.1 (78.3–90.0)	9.6 (7.2–13)	<LOD	5.9 ^E (3.5–8.3)	130 ^E (13–240)	310 ^E (<LOD–1000)
4 (2014–2015)	1275	85.5 (78.2–90.7)	9.4 (6.9–13)	<LOD	6.8 ^E (4.2–9.4)	130 ^E (<LOD–270)	450 ^E (110–790)
5 (2016–2017)	1356	84.4 (79.8–88.2)	7.2 (5.8–8.9)	<LOD	5.0 (3.9–6.1)	110 (73–140)	190 ^E (78–290)
6 (2018–2019)	1256	82.5 (78.9–85.7)	6.9 (5.6–8.6)	<LOD	4.8 (3.9–5.7)	86 ^E (50–120)	230 ^E (<LOD–490)
Females, 3–79 years							
3 (2012–2013)	1168	97.1 (95.2–98.3)	45 (33–63)	3.7 (2.4–4.9)	53 ^E (21–85)	410 (330–480)	480 ^E (220–740)
4 (2014–2015)	1289	93.7 (91.4–95.4)	30 (21–43)	1.8 (1.3–2.4)	31 ^E (4.2–59)	310 ^E (170–440)	510 ^E (170–850)
5 (2016–2017)	1364	91.4 (87.7–94.0)	28 (19–39)	1.6 ^E (<LOD–2.3)	26 ^E (8.4–43)	480 ^E (210–750)	860 ^E (510–1200)
6 (2018–2019)	1275	88.0 (80.9–92.7)	18 (14–22)	<LOD	17 ^E (7.2–27)	230 (180–280)	450 (290–610)
3–5 years							
3 (2012–2013)	463	91.7 (86.8–94.8)	20 ^E (14–28)	1.5 ^E (<LOD–2.2)	16 (11–21)	270 ^E (85–450)	660 ^E (340–980)
4 (2014–2015)	511	94.3 (91.4–96.3)	12 (9.3–15)	1.9 ^E (<LOD–2.7)	8.0 (5.9–10)	110 ^E (50–170)	330 ^E (110–560)
5 (2016–2017)	552	88.9 (81.9–93.4)	9.9 ^E (6.8–14)	<LOD	6.9 (4.4–9.4)	130 ^E (26–230)	390 ^E (<LOD–790)
6 (2018–2019)	512	86.0 (78.1–91.4)	6.3 ^E (4.3–9.3)	<LOD	5.6 ^E (2.6–8.6)	30 ^E (5.2–55)	120 ^E (<LOD–310)
6–11 years							
3 (2012–2013)	481	87.9 (82.5–91.8)	7.7 (5.7–10)	<LOD	6.0 (4.4–7.7)	80 ^E (30–130)	150 ^E (55–240)
4 (2014–2015)	514	91.9 (89.5–93.8)	7.6 (6.4–9.1)	1.4 (<LOD–1.8)	6.1 (4.0–8.2)	43 (30–57)	96 ^E (14–180)
5 (2016–2017)	540	88.4 (84.2–91.6)	7.5 (5.6–9.9)	<LOD	4.9 (3.8–6.0)	140 ^E (62–230)	370 ^E (20–710)
6 (2018–2019)	498	76 (63.5–85.2)	4.7 (3.3–6.5)	<LOD	3.5 ^E (2.0–5.1)	72 ^E (2.1–140)	190 ^E (90–280)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
3 (2012–2013)	469	93.7 (89.3–96.4)	15 ^E (10–22)	1.5 ^E (<LOD–2.3)	10 ^E (3.1–18)	260 ^E (<LOD–520)	540 ^E (<LOD–1200)
4 (2014–2015)	505	89.4 (84.3–92.9)	14 ^E (9.1–21)	<LOD	9.7 (6.4–13)	300 ^E (130–470)	520 ^E (250–780)
5 (2016–2017)	538	87.5 (82.6–91.2)	9.5 (6.7–13)	<LOD	6.0 ^E (1.6–10)	130 (100–160)	280 ^E (150–400)
6 (2018–2019)	504	85.6 (81.4–89.0)	8.0 (6.6–9.8)	<LOD	5.9 (4.6–7.2)	130 ^E (43–230)	450 ^E (66–830)
20–39 years							
3 (2012–2013)	328	91.3 (77.9–96.9)	21 ^E (13–34)	<LOD ^E (<LOD–2.7)	21 ^E (6.4–36)	290 ^E (<LOD–880)	950 ^E (130–1800)
4 (2014–2015)	362	90.8 (82.9–95.3)	16 ^E (9.3–28)	1.3 ^E (<LOD–1.9)	15 ^E (3.6–25)	300 ^E (170–430)	390 ^E (180–610)
5 (2016–2017)	376	85.6 (75.8–91.9)	15 ^E (9.8–22)	<LOD	16 ^E (7.0–24)	190 ^E (<LOD–400)	500 ^E (91–910)
6 (2018–2019)	332	86.7 (81.4–90.6)	11 (8.1–16)	<LOD	7.2 (5.2–9.3)	200 ^E (29–380)	580 ^E (130–1000)
40–59 years							
3 (2012–2013)	284	90.3 (79.6–95.7)	25 ^E (14–43)	1.3 ^E (<LOD–2.1)	26 ^E (8.0–44)	400 ^E (180–620)	430 ^E (190–670)
4 (2014–2015)	312	86.3 (77.7–91.9)	21 ^E (11–38)	<LOD	23 ^E (<LOD–48)	270 ^E (93–440)	550 ^E (250–860)
5 (2016–2017)	360	89.8 (83.1–94.0)	14 ^E (9.6–21)	<LOD	12 ^E (5.0–18)	200 ^E (<LOD–400)	530 ^E (<LOD–1100)
6 (2018–2019)	343	83.3 (75.3–89.1)	11 ^E (7.3–17)	<LOD	8.7 ^E (<LOD–20)	170 ^E (100–240)	240 (180–290)
60–79 years							
3 (2012–2013)	314	91.6 (84.7–95.5)	25 ^E (16–37)	1.7 ^E (<LOD–2.7)	30 ^E (8.1–51)	360 (230–480)	460 (330–600)
4 (2014–2015)	360	91.6 (87.3–94.5)	20 (16–26)	1.4 ^E (<LOD–2.0)	22 ^E (8.2–36)	270 ^E (<LOD–550)	680 ^E (210–1200)
5 (2016–2017)	354	88.4 (79.3–93.8)	20 (15–28)	<LOD	17 ^E (9.9–24)	430 ^E (190–660)	680 ^E (<LOD–1500)
6 (2018–2019)	342	88.7 (81.6–93.3)	18 (13–25)	<LOD	19 ^E (9.0–29)	250 ^E (120–380)	570 ^E (230–920)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 3, 4, 5 and 6 is 1.3 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 9.2.3

Methyl paraben (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
3 (2012–2013)	2338	91.0 (87.4–93.7)	21 (18–26)	<LOD	23 (15–31)	320 ^E (190–450)	620 (410–840)
4 (2014–2015)	2563	89.6 (85.4–92.7)	15 (11–21)	<LOD	13 ^E (6.5–19)	230 (180–290)	340 (230–440)
5 (2016–2017)	2688	87.9 (84.2–90.8)	14 (11–18)	<LOD	9.6 (6.5–13)	250 ^E (150–360)	500 ^E (300–710)
6 (2018–2019)	2530	85.3 (80.5–89.0)	12 (10–14)	<LOD	7.3 (5.4–9.3)	240 (210–270)	390 (310–480)
Males, 3–79 years							
3 (2012–2013)	1171	85.1 (78.3–90.0)	8.1 (6.2–11)	<LOD	5.9 (3.9–7.9)	120 ^E (24–220)	260 ^E (<LOD–470)
4 (2014–2015)	1274	85.5 (78.2–90.7)	7.4 (5.4–10)	<LOD	5.3 ^E (3.3–7.2)	99 ^E (<LOD–150)	230 ^E (130–340)
5 (2016–2017)	1341	84.4 (79.8–88.2)	6.2 (5.1–7.6)	<LOD	4.0 (2.9–5.1)	110 (81–130)	200 (140–250)
6 (2018–2019)	1255	82.5 (78.9–85.7)	6.4 (5.0–8.3)	<LOD	3.9 (3.0–4.8)	95 ^E (28–160)	220 ^E (<LOD–330)
Females, 3–79 years							
3 (2012–2013)	1167	97.1 (95.2–98.3)	58 (43–79)	4.5 ^E (2.8–6.2)	60 ^E (28–93)	460 ^E (200–710)	760 (630–890)
4 (2014–2015)	1289	93.7 (91.4–95.4)	31 ^E (21–46)	2.1 (1.5–2.7)	37 ^E (17–56)	290 ^E (180–400)	480 ^E (250–700)
5 (2016–2017)	1347	91.4 (87.7–94.0)	30 (21–43)	2.0 (<LOD–2.6)	33 ^E (15–51)	470 ^E (290–640)	780 ^E (470–1100)
6 (2018–2019)	1275	88.0 (80.9–92.7)	22 (17–29)	<LOD	22 ^E (11–32)	330 (230–430)	490 (370–620)
3–5 years							
3 (2012–2013)	462	91.7 (86.8–94.8)	38 ^E (25–58)	3.9 ^E (<LOD–6.2)	27 ^E (16–38)	540 ^E (180–910)	1000 ^E (260–1800)
4 (2014–2015)	511	94.3 (91.4–96.3)	21 (16–27)	3.7 (<LOD–4.6)	13 ^E (8.2–19)	210 ^E (72–360)	430 ^E (200–660)
5 (2016–2017)	542	88.9 (81.9–93.4)	17 ^E (11–26)	<LOD	13 ^E (7.2–18)	260 ^E (86–430)	640 ^E (<LOD–1200)
6 (2018–2019)	511	86.0 (78.1–91.4)	10 ^E (6.8–15)	<LOD	8.2 ^E (5.1–11)	53 ^E (<LOD–110)	160 ^E (<LOD–420)
6–11 years							
3 (2012–2013)	481	87.9 (82.5–91.8)	9.8 (6.9–14)	<LOD	7.5 (4.9–10)	71 ^E (<LOD–200)	250 ^E (98–390)
4 (2014–2015)	513	91.9 (89.5–93.8)	8.4 (7.1–9.8)	1.8 (<LOD–2.2)	7.1 (5.3–8.8)	41 (30–52)	120 ^E (19–230)
5 (2016–2017)	531	88.4 (84.2–91.6)	8.7 (6.6–11)	<LOD	5.3 (4.0–6.6)	160 ^E (49–280)	290 ^E (<LOD–710)
6 (2018–2019)	498	76 (63.5–85.2)	5.6 (4.2–7.4)	<LOD	4.7 (3.5–5.8)	59 ^E (<LOD–120)	150 ^E (13–290)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
3 (2012–2013)	469	93.7 (89.3–96.4)	11 (8.0–16)	0.97 (<LOD–1.2)	9.7 ^E (5.7–14)	200 ^E (<LOD–360)	440 ^E (<LOD–770)
4 (2014–2015)	505	89.4 (84.3–92.9)	9.9 ^E (6.7–15)	<LOD	7.2 (4.9–9.5)	180 ^E (66–290)	370 ^E (100–640)
5 (2016–2017)	531	87.5 (82.6–91.2)	7.2 (5.4–9.6)	<LOD	4.9 ^E (2.4–7.4)	110 ^E (50–180)	190 ^E (120–270)
6 (2018–2019)	504	85.6 (81.4–89.0)	6.6 (5.3–8.4)	<LOD	4.5 (2.9–6.0)	120 ^E (58–180)	230 ^E (85–380)
20–39 years							
3 (2012–2013)	328	91.3 (77.9–96.9)	17 ^E (12–25)	<LOD	18 ^E (6.0–30)	320 ^E (<LOD–530)	630 ^E (340–920)
4 (2014–2015)	362	90.8 (82.9–95.3)	13 ^E (6.9–25)	0.90 ^E (<LOD–1.4)	10 ^E (<LOD–23)	230 (150–310)	280 ^E (94–460)
5 (2016–2017)	372	85.6 (75.8–91.9)	13 ^E (8.7–20)	<LOD	10 ^E (<LOD–22)	220 ^E (<LOD–420)	400 ^E (51–750)
6 (2018–2019)	332	86.7 (81.4–90.6)	11 (8.1–14)	<LOD	5.1 (3.3–6.9)	250 (180–320)	330 (210–440)
40–59 years							
3 (2012–2013)	284	90.3 (79.6–95.7)	29 ^E (17–49)	<LOD ^E (<LOD–2.7)	34 ^E (14–55)	390 ^E (140–630)	610 ^E (230–990)
4 (2014–2015)	312	86.3 (77.7–91.9)	19 ^E (10–35)	<LOD	20 ^E (<LOD–44)	250 ^E (140–370)	310 ^E (130–490)
5 (2016–2017)	359	89.8 (83.1–94.0)	13 ^E (8.7–20)	<LOD	8.4 ^E (1.5–15)	230 ^E (<LOD–370)	470 ^E (<LOD–690)
6 (2018–2019)	343	83.3 (75.3–89.1)	13 (9.3–19)	<LOD	11 ^E (<LOD–22)	230 ^E (83–380)	360 ^E (230–500)
60–79 years							
3 (2012–2013)	314	91.6 (84.7–95.5)	28 ^E (19–41)	1.6 ^E (<LOD–2.5)	36 ^E (13–59)	340 ^E (98–590)	710 ^E (310–1100)
4 (2014–2015)	360	91.6 (87.3–94.5)	20 (16–23)	1.2 ^E (<LOD–1.7)	22 ^E (13–31)	320 ^E (<LOD–510)	620 ^E (340–890)
5 (2016–2017)	353	88.4 (79.3–93.8)	23 (17–31)	<LOD	20 ^E (13–28)	470 ^E (120–810)	790 ^E (<LOD–1100)
6 (2018–2019)	342	88.7 (81.6–93.3)	21 (15–30)	<LOD	24 ^E (14–35)	340 ^E (190–500)	600 ^E (340–870)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 9.2.4

Ethyl paraben—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
3 (2012–2013)	2339	41.9 (38.8–45.0)	—	<LOD	<LOD	18 ^E (3.1–33)	52 ^E (13–91)
4 (2014–2015)	2564	42.1 (36.7–47.6)	—	<LOD	<LOD	27 ^E (14–39)	73 ^E (33–110)
5 (2016–2017)	2720	39.6 (34.6–44.9)	—	<LOD	<LOD	17 (11–23)	65 ^E (38–93)
6 (2018–2019)	2531	35.1 (31.2–39.1)	—	<LOD	<LOD	17 ^E (5.2–28)	47 (33–62)
Males, 3–79 years							
3 (2012–2013)	1171	30.8 (24.3–38.0)	—	<LOD	<LOD	6.9 ^E (2.9–11)	14 ^E (6.2–22)
4 (2014–2015)	1275	32.5 (28.4–36.9)	—	<LOD	<LOD	11 (6.9–14)	29 ^E (<LOD–60)
5 (2016–2017)	1356	29.8 (22.7–38.1)	—	<LOD	<LOD	6.5 ^E (2.2–11)	17 ^E (<LOD–43)
6 (2018–2019)	1256	30.1 (26.1–34.4)	—	<LOD	<LOD	4.9 ^E (<LOD–13)	18 ^E (<LOD–44)
Females, 3–79 years							
3 (2012–2013)	1168	53.3 (48.3–58.2)	—	<LOD	<LOD	49 ^E (16–83)	120 ^E (53–190)
4 (2014–2015)	1289	51.7 (43.9–59.4)	—	<LOD	<LOD	39 ^E (14–64)	100 ^E (9.8–190)
5 (2016–2017)	1364	49.3 (43.3–55.4)	—	<LOD	<LOD	33 ^E (7.6–58)	81 ^E (17–150)
6 (2018–2019)	1275	40.0 (34.3–46.0)	—	<LOD	<LOD	39 ^E (18–59)	68 ^E (36–100)
3–5 years							
3 (2012–2013)	463	30.6 (21.3–41.8)	—	<LOD	<LOD	4.2 ^E (<LOD–9.7)	14 ^E (2.8–25)
4 (2014–2015)	511	32.3 (24.8–40.9)	—	<LOD	<LOD	5.4 ^E (<LOD–10)	17 ^E (<LOD–41)
5 (2016–2017)	552	35.8 (27.3–45.4)	—	<LOD	<LOD	6.6 ^E (<LOD–12)	18 ^E (3.1–32)
6 (2018–2019)	512	30.1 (20.4–42.0)	—	<LOD	<LOD	1.9 (1.4–2.4)	3.2 (2.2–4.1)
6–11 years							
3 (2012–2013)	481	20.5 ^E (13.2–30.5)	—	<LOD	<LOD	2.2 ^E (<LOD–4.3)	6.8 ^E (2.2–11)
4 (2014–2015)	514	21.2 ^E (14.2–30.6)	—	<LOD	<LOD	2.0 ^E (1.1–2.9)	3.4 ^E (1.3–5.5)
5 (2016–2017)	540	26.3 (20.2–33.5)	—	<LOD	<LOD	3.9 ^E (<LOD–8.9)	20 ^E (<LOD–51)
6 (2018–2019)	498	20.3 ^E (12.6–30.9)	—	<LOD	<LOD	2.6 ^E (<LOD–5.1)	4.9 ^E (2.2–7.5)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
3 (2012–2013)	469	29.8 (21.8–39.2)	—	<LOD	<LOD	11 ^E (3.8–18)	20 ^E (8.3–32)
4 (2014–2015)	505	29.6 (22.2–38.2)	—	<LOD	<LOD	10 ^E (2.5–17)	28 ^E (11–45)
5 (2016–2017)	538	28.2 (22.6–34.5)	—	<LOD	<LOD	14 ^E (<LOD–27)	31 ^E (<LOD–68)
6 (2018–2019)	504	27.4 (19.3–37.3)	—	<LOD	<LOD	6.7 ^E (<LOD–14)	36 ^E (<LOD–85)
20–39 years							
3 (2012–2013)	328	44.6 (35.6–54.0)	—	<LOD	<LOD	13 ^E (<LOD–28)	40 ^E (2.4–77)
4 (2014–2015)	362	44.5 (35.3–54.1)	—	<LOD	<LOD	13 ^E (<LOD–28)	46 ^E (<LOD–200)
5 (2016–2017)	376	43.4 (33.4–53.9)	—	<LOD	<LOD	11 ^E (<LOD–21)	24 ^E (<LOD–76)
6 (2018–2019)	332	33.8 (25.4–43.3)	—	<LOD	<LOD	39 ^E (<LOD–79)	47 ^E (2.3–92)
40–59 years							
3 (2012–2013)	284	46.4 (38.8–54.2)	—	<LOD	<LOD	44 ^E (<LOD–88)	81 ^E (2.7–160)
4 (2014–2015)	312	49.6 (38.2–61.1)	—	<LOD	<LOD	41 ^E (<LOD–81)	98 ^E (44–150)
5 (2016–2017)	360	34.6 (29.8–39.8)	—	<LOD	<LOD	15 ^E (<LOD–30)	45 ^E (<LOD–120)
6 (2018–2019)	343	39.1 (28.8–50.5)	—	<LOD	<LOD	18 ^E (<LOD–50)	58 ^E (16–100)
60–79 years							
3 (2012–2013)	314	46.5 (38.2–55.1)	—	<LOD	<LOD	34 ^E (<LOD–73)	73 ^E (33–110)
4 (2014–2015)	360	41.7 (36.7–47.0)	—	<LOD	<LOD	38 ^E (22–55)	78 ^E (44–110)
5 (2016–2017)	354	51.7 (43.7–59.7)	—	<LOD	1.1 ^E (<LOD–2.3)	57 ^E (16–98)	160 ^E (46–270)
6 (2018–2019)	342	40.2 (32.4–48.6)	—	<LOD	<LOD	27 ^E (11–44)	50 ^E (22–78)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 3, 4, 5 and 6 is 0.90 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 9.2.5

Ethyl paraben (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
3 (2012–2013)	2338	41.9 (38.8–45.0)	—	<LOD	<LOD	24 ^E (6.0–43)	72 ^E (23–120)
4 (2014–2015)	2563	42.1 (36.7–47.6)	—	<LOD	<LOD	25 ^E (8.9–42)	59 ^E (23–95)
5 (2016–2017)	2688	39.6 (34.6–44.9)	—	<LOD	<LOD	18 ^E (5.0–31)	54 ^E (17–91)
6 (2018–2019)	2530	35.1 (31.2–39.1)	—	<LOD	<LOD	17 ^E (6.7–27)	62 ^E (26–98)
Males, 3–79 years							
3 (2012–2013)	1171	30.8 (24.3–38.0)	—	<LOD	<LOD	5.1 ^E (3.0–7.2)	8.7 ^E (3.5–14)
4 (2014–2015)	1274	32.5 (28.4–36.9)	—	<LOD	<LOD	6.5 (4.4–8.6)	17 ^E (<LOD–41)
5 (2016–2017)	1341	29.8 (22.7–38.1)	—	<LOD	<LOD	5.9 ^E (3.0–8.7)	19 ^E (<LOD–43)
6 (2018–2019)	1255	30.1 (26.1–34.4)	—	<LOD	<LOD	4.9 ^E (<LOD–8.7)	13 ^E (<LOD–32)
Females, 3–79 years							
3 (2012–2013)	1167	53.3 (48.3–58.2)	—	<LOD	<LOD	70 ^E (14–130)	130 ^E (68–180)
4 (2014–2015)	1289	51.7 (43.9–59.4)	—	<LOD	<LOD	54 ^E (22–86)	120 ^E (54–190)
5 (2016–2017)	1347	49.3 (43.3–55.4)	—	<LOD	<LOD	36 ^E (11–61)	140 ^E (80–200)
6 (2018–2019)	1275	40.0 (34.3–46.0)	—	<LOD	<LOD	43 ^E (13–74)	86 (63–110)
3–5 years							
3 (2012–2013)	462	30.6 (21.3–41.8)	—	<LOD	<LOD	7.0 ^E (<LOD–18)	23 ^E (4.3–41)
4 (2014–2015)	511	32.3 (24.8–40.9)	—	<LOD	<LOD	9.2 ^E (<LOD–17)	23 ^E (<LOD–51)
5 (2016–2017)	542	35.8 (27.3–45.4)	—	<LOD	<LOD	11 ^E (<LOD–22)	30 ^E (<LOD–59)
6 (2018–2019)	511	30.1 (20.4–42.0)	—	<LOD	<LOD	3.1 (2.2–4.0)	4.9 (3.2–6.7)
6–11 years							
3 (2012–2013)	481	20.5 ^E (13.2–30.5)	—	<LOD	<LOD	3.3 ^E (<LOD–5.0)	6.3 ^E (3.2–9.3)
4 (2014–2015)	513	21.2 ^E (14.2–30.6)	—	<LOD	<LOD	2.0 ^E (1.2–2.8)	4.6 ^E (2.2–7.1)
5 (2016–2017)	531	26.3 (20.2–33.5)	—	<LOD	<LOD	5.2 ^E (<LOD–9.6)	13 ^E (<LOD–50)
6 (2018–2019)	498	20.3 ^E (12.6–30.9)	—	<LOD	<LOD	3.1 ^E (<LOD–5.2)	4.8 (3.5–6.1)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
3 (2012–2013)	469	29.8 (21.8–39.2)	—	<LOD	<LOD	7.7 ^E (1.9–14)	23 ^E (<LOD–48)
4 (2014–2015)	505	29.6 (22.2–38.2)	—	<LOD	<LOD	6.1 ^E (<LOD–14)	44 ^E (4.8–83)
5 (2016–2017)	531	28.2 (22.6–34.5)	—	<LOD	<LOD	6.5 ^E (<LOD–16)	27 ^E (<LOD–46)
6 (2018–2019)	504	27.4 (19.3–37.3)	—	<LOD	<LOD	6.1 ^E (<LOD–13)	29 ^E (<LOD–84)
20–39 years							
3 (2012–2013)	328	44.6 (35.6–54.0)	—	<LOD	<LOD	11 ^E (<LOD–29)	54 ^E (<LOD–110)
4 (2014–2015)	362	44.5 (35.3–54.1)	—	<LOD	<LOD	11 ^E (<LOD–31)	41 ^E (<LOD–150)
5 (2016–2017)	372	43.4 (33.4–53.9)	—	<LOD	<LOD	9.4 ^E (<LOD–19)	32 ^E (<LOD–48)
6 (2018–2019)	332	33.8 (25.4–43.3)	—	<LOD	<LOD	20 ^E (<LOD–49)	76 ^E (19–130)
40–59 years							
3 (2012–2013)	284	46.4 (38.8–54.2)	—	<LOD	<LOD	37 ^E (<LOD–88)	110 ^E (20–190)
4 (2014–2015)	312	49.6 (38.2–61.1)	—	<LOD	<LOD	41 ^E (<LOD–70)	83 ^E (2.5–160)
5 (2016–2017)	359	34.6 (29.8–39.8)	—	<LOD	<LOD	13 ^E (<LOD–37)	65 ^E (<LOD–180)
6 (2018–2019)	343	39.1 (28.8–50.5)	—	<LOD	<LOD	18 ^E (<LOD–38)	43 ^E (13–73)
60–79 years							
3 (2012–2013)	314	46.5 (38.2–55.1)	—	<LOD	<LOD	39 ^E (<LOD–63)	80 (52–110)
4 (2014–2015)	360	41.7 (36.7–47.0)	—	<LOD	<LOD	44 ^E (26–62)	70 ^E (29–110)
5 (2016–2017)	353	51.7 (43.7–59.7)	—	<LOD	1.6 (<LOD–2.0)	78 ^E (36–120)	180 ^E (69–290)
6 (2018–2019)	342	40.2 (32.4–48.6)	—	<LOD	<LOD	32 ^E (1.8–62)	86 ^E (39–130)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 9.2.6

Propyl paraben—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
3 (2012–2013)	2339	79.2 (74.9–83.0)	2.9 (2.4–3.6)	<LOD	2.4 (1.8–3.0)	78 ^E (47–110)	110 ^E (38–190)
4 (2014–2015)	2564	78.7 (72.9–83.5)	2.5 (1.8–3.5)	<LOD	2.0 ^E (1.2–2.7)	59 ^E (34–85)	130 ^E (67–180)
5 (2016–2017)	2720	73.7 (67.4–79.1)	1.9 (1.4–2.4)	<LOD	1.1 (0.74–1.4)	65 ^E (39–91)	140 (92–180)
6 (2018–2019)	2531	60.8 (57.6–64.0)	—	<LOD	0.65 (0.44–0.85)	39 ^E (24–54)	85 ^E (48–120)
Males, 3–79 years							
3 (2012–2013)	1171	68.4 (60.5–75.4)	1.3 (0.94–1.8)	<LOD	0.84 (0.55–1.1)	33 ^E (<LOD–65)	98 ^E (<LOD–220)
4 (2014–2015)	1275	71.7 (65.2–77.4)	1.3 (0.96–1.8)	<LOD	0.77 (0.55–0.99)	34 ^E (8.9–60)	95 ^E (22–170)
5 (2016–2017)	1356	64.2 (55.5–72.0)	0.78 (0.63–0.97)	<LOD	0.46 ^E (<LOD–0.64)	11 ^E (0.60–21)	32 ^E (15–49)
6 (2018–2019)	1256	49.5 (45.1–53.9)	—	<LOD	<LOD	19 ^E (3.9–33)	47 ^E (<LOD–120)
Females, 3–79 years							
3 (2012–2013)	1168	90.3 (85.9–93.5)	6.7 ^E (4.2–10)	<LOD	6.8 ^E (0.58–13)	100 (71–130)	150 ^E (47–250)
4 (2014–2015)	1289	85.7 (79.0–90.5)	4.9 ^E (3.2–7.6)	<LOD	5.6 ^E (1.9–9.4)	83 ^E (38–130)	170 ^E (58–280)
5 (2016–2017)	1364	83.1 (76.2–88.4)	4.4 (3.1–6.2)	<LOD	4.4 ^E (2.8–6.0)	110 ^E (65–150)	160 (110–210)
6 (2018–2019)	1275	72.1 (66.2–77.4)	2.2 (1.7–2.9)	<LOD	1.6 ^E (0.93–2.2)	62 (39–84)	120 ^E (72–160)
3–5 years							
3 (2012–2013)	463	76.3 (67.5–83.3)	1.7 ^E (1.1–2.6)	<LOD	1.3 ^E (0.64–2.0)	28 ^E (10–47)	66 ^E (11–120)
4 (2014–2015)	511	81.9 (76.4–86.3)	1.5 (1.1–2.0)	<LOD	1.2 ^E (0.67–1.7)	16 ^E (7.3–24)	37 ^E (9.1–64)
5 (2016–2017)	552	70.7 (59.7–79.8)	1.2 ^E (0.77–1.8)	<LOD	0.87 ^E (0.47–1.3)	9.8 ^E (<LOD–20)	34 ^E (10–58)
6 (2018–2019)	512	60.8 (47.8–72.4)	—	<LOD	0.63 ^E (<LOD–1.0)	6.8 ^E (3.8–9.8)	17 ^E (0.94–32)
6–11 years							
3 (2012–2013)	481	71.7 (62.9–79.2)	0.99 (0.70–1.4)	<LOD	0.71 ^E (<LOD–1.2)	9.1 ^E (2.9–15)	18 ^E (<LOD–40)
4 (2014–2015)	514	81.1 (76.5–84.9)	1.2 (0.99–1.6)	<LOD	0.95 ^E (0.58–1.3)	11 (7.8–14)	29 ^E (1.7–56)
5 (2016–2017)	540	70.3 (62.1–77.4)	0.96 (0.69–1.3)	<LOD	0.69 (0.48–0.90)	14 ^E (6.7–21)	39 ^E (7.1–71)
6 (2018–2019)	498	49.3 (36.1–62.5)	—	<LOD	<LOD	6.6 ^E (<LOD–19)	64 ^E (11–120)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
3 (2012–2013)	469	81.3 (71.3–89.7)	2.5 ^E (1.4–4.4)	<LOD	1.4 ^E (0.31–2.6)	90 ^E (6.1–170)	250 ^E (84–420)
4 (2014–2015)	505	81.3 (73.7–87.1)	2.3 ^E (1.6–3.3)	<LOD	1.8 ^E (1.1–2.4)	55 ^E (17–92)	110 ^E (56–170)
5 (2016–2017)	538	70.1 (63.1–76.2)	1.4 (1.1–1.7)	<LOD	0.97 (0.67–1.3)	35 ^E (3.8–67)	89 ^E (36–140)
6 (2018–2019)	504	64.0 (56.3–71.0)	1.0 (0.79–1.4)	<LOD	0.57 ^E (<LOD–0.84)	35 ^E (11–58)	76 ^E (27–130)
20–39 years							
3 (2012–2013)	328	84.9 (78.9–89.5)	3.9 (2.7–5.6)	<LOD	2.7 ^E (1.0–4.4)	94 ^E (<LOD–230)	260 ^E (39–490)
4 (2014–2015)	362	78.7 (65.3–88.0)	2.6 ^E (1.2–5.6)	<LOD	1.7 ^E (<LOD–3.7)	61 ^E (<LOD–130)	150 ^E (34–260)
5 (2016–2017)	376	75.5 (67.5–82.0)	2.1 ^E (1.4–3.0)	<LOD	1.8 ^E (<LOD–3.4)	47 ^E (<LOD–98)	140 ^E (54–230)
6 (2018–2019)	332	63.9 (56.0–71.0)	1.3 (0.95–1.9)	<LOD	0.71 ^E (0.37–1.0)	48 ^E (6.6–90)	180 ^E (<LOD–440)
40–59 years							
3 (2012–2013)	284	76.6 (65.9–84.7)	2.8 (2.1–3.9)	<LOD	2.5 ^E (1.4–3.7)	75 ^E (23–130)	100 (73–140)
4 (2014–2015)	312	79.6 (66.9–88.3)	2.9 ^E (1.3–6.2)	<LOD	2.7 ^E (<LOD–5.2)	55 ^E (<LOD–120)	130 ^E (29–220)
5 (2016–2017)	360	77.0 (65.3–85.6)	2.0 ^E (1.3–2.9)	<LOD	0.98 ^E (<LOD–1.7)	71 ^E (31–110)	150 ^E (63–240)
6 (2018–2019)	343	59.2 (50.9–66.9)	1.1 ^E (0.78–1.6)	<LOD	0.54 ^E (<LOD–1.1)	31 ^E (13–49)	69 ^E (29–110)
60–79 years							
3 (2012–2013)	314	78.5 (70.5–84.8)	3.7 ^E (2.5–5.6)	<LOD	3.2 ^E (<LOD–8.4)	79 ^E (42–120)	110 (74–140)
4 (2014–2015)	360	74.5 (64.3–82.6)	3.0 ^E (2.0–4.6)	<LOD	2.6 ^E (0.40–4.8)	80 ^E (<LOD–160)	230 ^E (37–420)
5 (2016–2017)	354	69.5 (59.3–78.1)	2.3 (1.6–3.1)	<LOD	1.4 ^E (0.55–2.2)	100 ^E (60–150)	150 (120–180)
6 (2018–2019)	342	61.3 (53.9–68.3)	—	<LOD	1.3 ^E (<LOD–2.3)	63 ^E (17–110)	140 ^E (57–230)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 3, 4, 5 and 6 is 0.30 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 9.2.7

Propyl paraben (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
3 (2012–2013)	2338	79.2 (74.9–83.0)	3.0 (2.5–3.7)	<LOD	2.1 (1.4–2.7)	85 ^F (53–120)	130 (96–160)
4 (2014–2015)	2563	78.7 (72.9–83.5)	2.3 ^E (1.6–3.3)	<LOD	1.5 ^E (0.85–2.1)	63 ^E (30–96)	110 (73–140)
5 (2016–2017)	2688	73.7 (67.4–79.1)	1.8 (1.4–2.3)	<LOD	0.97 (0.70–1.2)	66 (49–82)	120 (88–150)
6 (2018–2019)	2530	60.8 (57.6–64.0)	—	<LOD	0.66 (0.48–0.84)	48 (32–64)	99 ^F (63–140)
Males, 3–79 years							
3 (2012–2013)	1171	68.4 (60.5–75.4)	1.1 (0.81–1.5)	<LOD	0.75 (0.49–1.0)	30 ^E (<LOD–52)	75 ^E (<LOD–160)
4 (2014–2015)	1274	71.7 (65.2–77.4)	1.0 (0.74–1.4)	<LOD	0.70 (0.46–0.93)	18 ^E (3.5–32)	52 ^E (<LOD–110)
5 (2016–2017)	1341	64.2 (55.5–72.0)	0.68 (0.56–0.82)	<LOD	0.46 (<LOD–0.55)	11 ^E (1.7–20)	42 ^E (18–66)
6 (2018–2019)	1255	49.5 (45.1–53.9)	—	<LOD	<LOD	18 ^E (3.2–33)	63 ^E (<LOD–120)
Females, 3–79 years							
3 (2012–2013)	1167	90.3 (85.9–93.5)	8.6 ^E (5.6–13)	<LOD	9.3 ^E (1.4–17)	120 (86–150)	190 ^E (94–280)
4 (2014–2015)	1289	85.7 (79.0–90.5)	5.1 ^E (3.0–8.5)	<LOD	4.8 ^E (0.54–9.1)	87 ^E (51–120)	160 ^E (91–230)
5 (2016–2017)	1347	83.1 (76.2–88.4)	4.8 (3.4–6.7)	<LOD	4.5 ^E (1.6–7.4)	110 (75–140)	150 (120–190)
6 (2018–2019)	1275	72.1 (66.2–77.4)	2.8 (2.1–3.7)	<LOD	1.9 ^E (0.63–3.2)	69 (54–84)	120 ^E (71–180)
3–5 years							
3 (2012–2013)	462	76.3 (67.5–83.3)	3.3 ^E (2.1–5.2)	<LOD	2.2 ^E (1.3–3.1)	57 ^E (11–100)	130 ^E (8.7–250)
4 (2014–2015)	511	81.9 (76.4–86.3)	2.6 (2.0–3.4)	<LOD	1.8 ^E (1.0–2.6)	30 ^E (17–43)	68 ^E (20–120)
5 (2016–2017)	542	70.7 (59.7–79.8)	2.0 ^E (1.3–3.0)	<LOD	1.3 ^E (0.59–2.1)	24 ^E (<LOD–39)	53 ^E (15–92)
6 (2018–2019)	511	60.8 (47.8–72.4)	—	<LOD	0.83 (<LOD–1.1)	12 ^E (7.5–17)	23 ^E (0.59–46)
6–11 years							
3 (2012–2013)	481	71.7 (62.9–79.2)	1.3 ^E (0.85–1.8)	<LOD	0.87 ^E (<LOD–1.3)	9.8 ^E (1.5–18)	22 ^E (<LOD–45)
4 (2014–2015)	513	81.1 (76.5–84.9)	1.4 (1.1–1.7)	<LOD	1.1 (0.74–1.4)	9.1 (6.4–12)	23 ^E (<LOD–51)
5 (2016–2017)	531	70.3 (62.1–77.4)	1.1 (0.82–1.5)	<LOD	0.85 (0.54–1.2)	14 ^E (4.9–23)	45 ^E (2.6–88)
6 (2018–2019)	498	49.3 (36.1–62.5)	—	<LOD	<LOD	9.9 ^E (<LOD–20)	50 ^E (20–80)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
3 (2012–2013)	469	81.3 (71.3–89.7)	1.9 ^E (1.1–3.2)	<LOD	1.1 ^E (0.51–1.7)	100 ^E (18–180)	140 ^E (87–200)
4 (2014–2015)	505	81.3 (73.7–87.1)	1.7 (1.2–2.4)	<LOD	1.1 ^E (0.64–1.6)	41 ^E (11–72)	85 ^E (42–130)
5 (2016–2017)	531	70.1 (63.1–76.2)	1.0 (0.81–1.3)	<LOD	0.64 (0.44–0.83)	20 ^E (<LOD–50)	60 ^E (5.3–110)
6 (2018–2019)	504	64.0 (56.3–71.0)	0.86 (0.61–1.2)	<LOD	0.48 ^E (<LOD–0.77)	27 ^E (12–42)	67 ^E (23–110)
20–39 years							
3 (2012–2013)	328	84.9 (78.9–89.5)	3.1 (2.3–4.1)	<LOD	1.8 ^E (0.59–3.0)	94 ^E (<LOD–170)	150 ^E (18–280)
4 (2014–2015)	362	78.7 (65.3–88.0)	2.1 ^E (0.93–4.8)	<LOD	1.2 ^E (<LOD–2.5)	74 ^E (<LOD–130)	120 ^E (27–210)
5 (2016–2017)	372	75.5 (67.5–82.0)	1.9 (1.3–2.7)	<LOD	1.0 ^E (<LOD–1.7)	58 ^E (<LOD–100)	130 ^E (60–190)
6 (2018–2019)	332	63.9 (56.0–71.0)	1.3 (0.93–1.7)	<LOD	0.64 ^E (0.38–0.89)	55 ^E (11–99)	150 ^E (<LOD–310)
40–59 years							
3 (2012–2013)	284	76.6 (65.9–84.7)	3.3 (2.4–4.5)	<LOD	2.6 ^E (1.2–3.9)	94 ^E (45–140)	120 (83–160)
4 (2014–2015)	312	79.6 (66.9–88.3)	2.6 ^E (1.2–5.6)	<LOD	1.8 ^E (<LOD–3.7)	51 ^E (<LOD–120)	96 ^E (29–160)
5 (2016–2017)	359	77.0 (65.3–85.6)	1.8 ^E (1.2–2.7)	<LOD	0.95 ^E (<LOD–1.4)	75 (50–100)	120 (83–150)
6 (2018–2019)	343	59.2 (50.9–66.9)	1.3 (1.0–1.8)	<LOD	0.77 ^E (<LOD–1.2)	35 ^E (6.7–62)	70 ^E (9.7–130)
60–79 years							
3 (2012–2013)	314	78.5 (70.5–84.8)	4.3 ^E (2.7–6.8)	<LOD	5.4 ^E (<LOD–10)	94 ^E (51–140)	130 ^E (54–210)
4 (2014–2015)	360	74.5 (64.3–82.6)	2.9 ^E (2.0–4.2)	<LOD	2.6 ^E (0.95–4.2)	99 ^E (<LOD–180)	190 ^E (110–280)
5 (2016–2017)	353	69.5 (59.3–78.1)	2.6 (2.0–3.3)	<LOD	1.7 ^E (0.85–2.5)	98 ^E (58–140)	190 ^E (85–300)
6 (2018–2019)	342	61.3 (53.9–68.3)	—	<LOD	1.4 ^E (<LOD–3.0)	70 ^E (25–110)	140 ^E (30–250)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 9.2.8

Butyl paraben—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
3 (2012–2013)	2339	24.6 (20.2–29.7)	—	<LOD	<LOD	2.4 ^E (<LOD–6.7)	11 ^E (0.39–21)
4 (2014–2015)	2564	19.4 (15.7–23.8)	—	<LOD	<LOD	1.2 ^E (0.31–2.0)	4.3 ^E (2.0–6.6)
5 (2016–2017)	2720	13.1 (10.6–16.0)	—	<LOD	<LOD	0.70 ^E (<LOD–1.1)	2.0 ^E (0.50–3.5)
6 (2018–2019)	2531	10.3 (7.7–13.5)	—	<LOD	<LOD	<LOD ^E (<LOD–0.47)	1.9 ^E (0.41–3.3)
Males, 3–79 years							
3 (2012–2013)	1171	12.2 ^E (7.8–18.7)	—	<LOD	<LOD	0.58 ^E (<LOD–1.4)	2.1 ^E (<LOD–22)
4 (2014–2015)	1275	11.4 ^E (7.4–17.0)	—	<LOD	<LOD	<LOD	1.1 ^E (<LOD–2.8)
5 (2016–2017)	1356	5.1 ^E (3.1–8.3)	—	<LOD	<LOD	<LOD	0.32 ^E (<LOD–1.3)
6 (2018–2019)	1256	5.4 ^E (3.5–8.1)	—	<LOD	<LOD	<LOD	0.30 ^E (<LOD–0.48)
Females, 3–79 years							
3 (2012–2013)	1168	37.4 (31.3–44.0)	—	<LOD	<LOD	9.4 ^E (1.1–18)	14 ^E (<LOD–29)
4 (2014–2015)	1289	27.5 (22.2–33.4)	—	<LOD	<LOD	2.9 ^E (<LOD–5.6)	7.3 ^E (<LOD–15)
5 (2016–2017)	1364	20.9 (16.8–25.8)	—	<LOD	<LOD	1.4 ^E (0.63–2.2)	3.3 ^E (<LOD–8.7)
6 (2018–2019)	1275	15.1 (11.3–20.1)	—	<LOD	<LOD	1.0 ^E (<LOD–2.3)	4.6 ^E (0.76–8.4)
3–5 years							
3 (2012–2013)	463	17.0 ^E (10.9–25.6)	—	<LOD	<LOD	1.1 ^E (<LOD–2.0)	2.2 ^E (<LOD–6.6)
4 (2014–2015)	511	15.7 ^E (10.7–22.3)	—	<LOD	<LOD	0.47 ^E (<LOD–1.0)	1.4 ^E (<LOD–3.9)
5 (2016–2017)	552	8.4 ^E (4.7–14.8)	—	<LOD	<LOD	<LOD	0.69 ^E (<LOD–1.4)
6 (2018–2019)	512	13.8 ^E (7.3–24.7)	—	<LOD	<LOD	<LOD	17 ^E (<LOD–49)
6–11 years							
3 (2012–2013)	481	11.8 ^E (6.6–20.4)	—	<LOD	<LOD	0.37 ^E (<LOD–0.65)	0.68 ^E (0.33–1.0)
4 (2014–2015)	514	10.8 ^E (7.1–16.2)	—	<LOD	<LOD	<LOD	1.1 ^E (0.30–1.8)
5 (2016–2017)	540	7.2 ^E (3.8–13.1)	—	<LOD	<LOD	<LOD	0.43 ^E (<LOD–0.77)
6 (2018–2019)	498	5.7 ^E (2.5–12.6)	—	<LOD	<LOD	<LOD	0.32 (<LOD–0.39)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
3 (2012–2013)	469	23.7 ^E (16.0–33.5)	—	<LOD	<LOD	2.5 ^E (0.85–4.2)	6.6 ^E (1.3–12)
4 (2014–2015)	505	19.7 (14.3–26.4)	—	<LOD	<LOD	1.1 ^E (<LOD–2.0)	3.7 ^E (<LOD–9.6)
5 (2016–2017)	538	9.8 (7.3–13.0)	—	<LOD	<LOD	<LOD	1.1 ^E (<LOD–7.0)
6 (2018–2019)	504	15.4 ^F (8.8–25.6)	—	<LOD	<LOD	0.43 ^E (<LOD–0.62)	0.73 ^E (<LOD–1.5)
20–39 years							
3 (2012–2013)	328	28.3 (21.3–36.5)	—	<LOD	<LOD	1.9 ^E (<LOD–14)	17 ^E (<LOD–40)
4 (2014–2015)	362	17.5 ^E (11.2–26.4)	—	<LOD	<LOD	1.1 ^E (<LOD–3.5)	3.5 ^E (<LOD–13)
5 (2016–2017)	376	13.0 ^F (6.9–23.2)	—	<LOD	<LOD	0.85 ^E (<LOD–1.9)	2.0 ^E (<LOD–5.6)
6 (2018–2019)	332	7.7 ^E (3.5–16.3)	—	<LOD	<LOD	<LOD	0.93 ^E (<LOD–4.7)
40–59 years							
3 (2012–2013)	284	26.4 (18.7–35.9)	—	<LOD	<LOD	3.3 ^E (<LOD–11)	9.9 ^E (2.2–18)
4 (2014–2015)	312	21.2 ^E (12.5–33.6)	—	<LOD	<LOD	1.2 ^E (<LOD–2.9)	3.0 ^E (<LOD–9.4)
5 (2016–2017)	360	15.5 (11.0–21.4)	—	<LOD	<LOD	1.3 ^E (0.53–2.1)	4.2 ^E (<LOD–10)
6 (2018–2019)	343	9.2 ^E (4.4–18.4)	—	<LOD	<LOD	<LOD	1.7 ^E (<LOD–4.1)
60–79 years							
3 (2012–2013)	314	23.7 (16.5–32.7)	—	<LOD	<LOD	7.2 ^E (<LOD–23)	23 ^E (<LOD–56)
4 (2014–2015)	360	23.1 (17.3–30.1)	—	<LOD	<LOD	3.1 ^E (<LOD–6.4)	6.8 (4.4–9.1)
5 (2016–2017)	354	13.8 (10.4–18.0)	—	<LOD	<LOD	0.65 ^E (<LOD–1.1)	1.2 ^E (<LOD–3.2)
6 (2018–2019)	342	14.0 (10.3–18.7)	—	<LOD	<LOD	0.89 ^E (<LOD–2.2)	5.2 ^E (<LOD–11)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 3, 4, 5 and 6 is 0.30 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 9.2.9

Butyl paraben (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
3 (2012–2013)	2338	24.6 (20.2–29.7)	—	<LOD	<LOD	2.8 ^E (<LOD–8.0)	16 ^F (4.6–27)
4 (2014–2015)	2563	19.4 (15.7–23.8)	—	<LOD	<LOD	1.1 ^E (<LOD–1.9)	4.2 ^E (1.5–6.8)
5 (2016–2017)	2688	13.1 (10.6–16.0)	—	<LOD	<LOD	0.87 (<LOD–1.2)	2.2 ^E (0.88–3.6)
6 (2018–2019)	2530	10.3 (7.7–13.5)	—	<LOD	<LOD	<LOD	2.3 ^E (<LOD–5.1)
Males, 3–79 years							
3 (2012–2013)	1171	12.2 ^E (7.8–18.7)	—	<LOD	<LOD	0.52 ^E (<LOD–0.84)	2.0 ^E (<LOD–14)
4 (2014–2015)	1274	11.4 ^E (7.4–17.0)	—	<LOD	<LOD	<LOD	0.79 ^E (<LOD–1.2)
5 (2016–2017)	1341	5.1 ^E (3.1–8.3)	—	<LOD	<LOD	<LOD	0.79 ^E (<LOD–1.3)
6 (2018–2019)	1255	5.4 ^E (3.5–8.1)	—	<LOD	<LOD	<LOD	0.80 ^E (<LOD–1.2)
Females, 3–79 years							
3 (2012–2013)	1167	37.4 (31.3–44.0)	—	<LOD	<LOD	8.9 ^E (<LOD–21)	29 ^E (<LOD–49)
4 (2014–2015)	1289	27.5 (22.2–33.4)	—	<LOD	<LOD	2.7 ^E (<LOD–4.8)	9.2 ^E (<LOD–15)
5 (2016–2017)	1347	20.9 (16.8–25.8)	—	<LOD	<LOD	1.6 ^E (0.90–2.4)	3.8 ^E (<LOD–9.3)
6 (2018–2019)	1275	15.1 (11.3–20.1)	—	<LOD	<LOD	2.0 ^E (<LOD–4.3)	5.7 ^E (3.0–8.4)
3–5 years							
3 (2012–2013)	462	17.0 ^E (10.9–25.6)	—	<LOD	<LOD	1.7 ^E (<LOD–3.1)	8.1 ^E (<LOD–14)
4 (2014–2015)	511	15.7 ^E (10.7–22.3)	—	<LOD	<LOD	1.2 ^E (<LOD–2.2)	3.1 ^E (<LOD–5.1)
5 (2016–2017)	542	8.4 ^E (4.7–14.8)	—	<LOD	<LOD	<LOD	1.3 ^E (<LOD–1.8)
6 (2018–2019)	511	13.8 ^E (7.3–24.7)	—	<LOD	<LOD	<LOD	17 ^E (<LOD–44)
6–11 years							
3 (2012–2013)	481	11.8 ^E (6.6–20.4)	—	<LOD	<LOD	0.73 ^F (<LOD–1.0)	0.99 (0.74–1.2)
4 (2014–2015)	513	10.8 ^E (7.1–16.2)	—	<LOD	<LOD	<LOD	0.81 ^E (0.30–1.3)
5 (2016–2017)	531	7.2 ^E (3.8–13.1)	—	<LOD	<LOD	<LOD	0.73 ^E (<LOD–1.4)
6 (2018–2019)	498	5.7 ^E (2.5–12.6)	—	<LOD	<LOD	<LOD	0.78 ^E (<LOD–2.1)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
3 (2012–2013)	469	23.7 ^E (16.0–33.5)	—	<LOD	<LOD	2.3 ^E (0.53–4.0)	5.3 ^E (<LOD–11)
4 (2014–2015)	505	19.7 (14.3–26.4)	—	<LOD	<LOD	0.66 ^E (<LOD–1.2)	4.1 ^E (<LOD–8.4)
5 (2016–2017)	531	9.8 (7.3–13.0)	—	<LOD	<LOD	<LOD	1.5 ^E (<LOD–5.4)
6 (2018–2019)	504	15.4 ^E (8.8–25.6)	—	<LOD	<LOD	0.65 ^E (<LOD–1.1)	1.9 ^E (<LOD–10)
20–39 years							
3 (2012–2013)	328	28.3 (21.3–36.5)	—	<LOD	<LOD	2.6 ^E (<LOD–9.0)	10 ^E (<LOD–21)
4 (2014–2015)	362	17.5 ^E (11.2–26.4)	—	<LOD	<LOD	0.77 ^E (<LOD–1.9)	2.4 ^E (<LOD–14)
5 (2016–2017)	372	13.0 ^E (6.9–23.2)	—	<LOD	<LOD	0.79 ^E (<LOD–2.0)	2.3 ^E (<LOD–4.4)
6 (2018–2019)	332	7.7 ^E (3.5–16.3)	—	<LOD	<LOD	<LOD	1.2 ^E (<LOD–5.1)
40–59 years							
3 (2012–2013)	284	26.4 (18.7–35.9)	—	<LOD	<LOD	5.0 ^E (<LOD–19)	18 ^E (2.0–33)
4 (2014–2015)	312	21.2 ^E (12.5–33.6)	—	<LOD	<LOD	1.4 ^E (<LOD–2.7)	2.6 ^E (<LOD–7.7)
5 (2016–2017)	359	15.5 (11.0–21.4)	—	<LOD	<LOD	1.6 ^E (0.62–2.5)	3.8 ^E (<LOD–8.5)
6 (2018–2019)	343	9.2 ^E (4.4–18.4)	—	<LOD	<LOD	<LOD	1.6 ^E (<LOD–5.1)
60–79 years							
3 (2012–2013)	314	23.7 (16.5–32.7)	—	<LOD	<LOD	6.9 ^E (<LOD–26)	34 ^E (<LOD–64)
4 (2014–2015)	360	23.1 (17.3–30.1)	—	<LOD	<LOD	4.2 ^E (<LOD–6.5)	6.7 ^E (2.1–11)
5 (2016–2017)	353	13.8 (10.4–18.0)	—	<LOD	<LOD	0.87 (<LOD–1.0)	1.5 ^E (<LOD–5.9)
6 (2018–2019)	342	14.0 (10.3–18.7)	—	<LOD	<LOD	1.4 ^E (<LOD–3.2)	6.3 ^E (<LOD–11)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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SUMMARY AND RESULTS FOR NICOTINE

10

10.1 NICOTINE

Cotinine (CASRN 486-56-6) is the major primary metabolite of nicotine, a chemical found naturally in the tobacco plant and present in tobacco products, such as cigarettes, cigars and smokeless tobacco products (e.g., chewing tobacco and snuff) (Benowitz and Jacob, 1994). Nicotine is also incorporated into nicotine delivery products, such as nicotine gum, patches, lozenges, inhalers, buccal sprays and vaping products (Etter et al., 2011).

Human exposure to nicotine occurs primarily through the use of tobacco, vaping and other nicotine delivery products, and from exposure to environmental tobacco smoke (HSDB, 2009). In addition, infants breastfed by women who smoke may be exposed to nicotine in breast milk (HSDB, 2009).

Inhalation is the most effective intake route; on average, 60% to 80% of nicotine is absorbed through the lungs (Iwase et al., 1991). Nicotine absorption through the mouth varies with the pH of the smoke or nicotine delivery product, increasing as alkalinity rises (Benowitz et al., 2009). Nicotine can also be absorbed through the skin and gastrointestinal tract, but at a much lower efficiency compared with inhalation (Karaconji, 2005). Once inside the body, approximately 70% to 80% of nicotine is metabolized into cotinine, primarily by a liver cytochrome P-450 enzyme. Cotinine has a half-life of 10 to 20 hours and can remain in the body at detectable levels for up to 7 days (Benowitz and Jacob, 1994; Curvall et al., 1990; Hecht et al., 1999). Cotinine is considered to be the most relevant biomarker for exposure to tobacco products and tobacco smoke

(Brown et al., 2005; CDC, 2009; Seaton and Vesell, 1993). It has also been shown to be a biomarker of exposure to nicotine via other types of nicotine delivery products, such as e-cigarettes (Schick et al., 2017; Vélez de Mendizábal et al., 2015). It should be noted that there are no validated biomarkers that can differentiate among the use of various combustible products (e.g., cigars, cigarillos, water pipes and cigarettes), and there are no validated biomarkers that are specific to nicotine-containing or nicotine-free vaping products (Schick et al., 2017).

Nicotine reaches the brain rapidly following inhalation and can cause several reactions in the body, such as increased heart rate and blood pressure, muscle relaxation, altered brain activity and constriction of blood vessels leading to a drop in temperature of the hands and feet (HC, 2013). Other effects may include nausea, weakness, stomach cramps and headache, with symptoms lessening as nicotine tolerance is developed. Nicotine mimics the effects of acetylcholine in the nervous system. Through the release of dopamine and effects on other neurotransmitters, it can activate areas of the brain that are associated with feelings of alertness, calmness and pleasure (Pandey et al., 2018). As the body builds tolerance to nicotine, the delivery product must continue to be used for the effects to last; use over time may lead to dependence and addiction (HC, 2013). While cotinine itself may contribute to the neuropharmacological effects of tobacco smoking (Benowitz, 1996; Crooks and Dwoskin, 1997), the use of nicotine-containing products is associated with exposure to other chemicals that have their own effects. For example, tobacco smoke contains more than 4,000 chemicals, including at least 70 that cause, initiate or

promote cancer and others that contribute to adverse health effects, such as emphysema, heart disease and increased risk of asthma (CDC, 2004; HC, 2011; IARC, 2004). Levels of cotinine in the blood and urine of non-smokers related to environmental tobacco smoke exposure have been correlated with adverse health effects.

As a result of the adverse health effects associated with tobacco use, the Government of Canada, along with provincial and territorial governments and various municipalities, has taken several steps to reduce the prevalence of tobacco use as well as exposure to tobacco smoke. These steps include prohibitions on the sale of tobacco products and electronic nicotine delivery systems to youth, requirements to apply health warnings on tobacco packaging, and restrictions on the promotion of tobacco products, including the display of tobacco products at retail outlets (HC, 2006). Additional steps include the offer of cessation help along with initiatives to eliminate smoking in workplaces and enclosed public locations (HC, 2006). In 2018, Health Canada enacted the *Tobacco and Vaping Products Act*, which amends the *Canada Consumer Product Safety Act* to allow the effective regulation of vaping products as well as the ability to establish plain and standardized appearance requirements for tobacco product packages (HC, 2018). This legislation aims to protect young people and non-smokers from inducements to nicotine addiction and tobacco use, and to enhance public awareness of the health and safety hazards posed by tobacco and vaping products.

Cotinine concentrations in urine have been measured in a limited number of biomonitoring studies conducted in Canada, including the First Nations Biomonitoring Initiative (AFN, 2013).

Data from cycle 1 (2007–2009) of the Canadian Health Measures Survey (CHMS) demonstrated that a substantial proportion of the Canadian population is exposed to second-hand smoke. The study found detectable cotinine levels (≥ 1.1 ng/ml) in non-smokers, indicating second-hand smoke exposure, and reported that children and adolescent subpopulations had higher levels compared with adults (Wong et al., 2013). A study of occupationally exposed non-smoking bar workers in the Toronto area examined the effects of a 2004 smoke-free workplace bylaw; the study showed

a 1-month post-ban decline in the geometric mean of urinary cotinine, from 10.3 $\mu\text{g/L}$ to 3.10 $\mu\text{g/L}$ (Repace et al., 2013). A concentration of 50 $\mu\text{g/L}$ urine for cotinine is recommended for determining smoking status; greater concentrations are attributed to smokers (SRNT Subcommittee on Biochemical Verification, 2002). Using this concentration, a study assessed the validity of self-reported cigarette smoking status among Canadians using urinary cotinine data from cycle 1 (2007–2009) of the CHMS (Wong et al., 2012). Compared with estimates based on urinary cotinine concentration, smoking prevalence based on self-reporting was only 0.3 percentage points lower. This indicates that accurate estimates of the prevalence of cigarette smoking among Canadians can be derived from self-reported smoking status data.

Cotinine was analyzed in the urine of CHMS participants aged 6–79 in cycle 1 (2007–2009) and cycle 6 (2018–2019), and aged 3–79 in cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015) and cycle 5 (2016–2017). Data from these cycles are presented as both $\mu\text{g/L}$ and $\mu\text{g/g}$ creatinine for non-smokers and smokers. Cotinine was analyzed in the serum of all CHMS participants aged 6–79 in cycle 6. Data from this cycle are presented in serum as $\mu\text{g/L}$ for non-smokers and smokers. Survey participants aged 3–11 were assumed to be non-smokers. In this survey, a smoker is defined as someone who is a current daily or occasional smoker, while a non-smoker is defined as someone who does not currently smoke and has either never smoked or was previously a daily or occasional smoker. These definitions are based on self-reported data. Finding a measurable amount of cotinine in urine or serum is an indicator of exposure to nicotine.

In addition to free cotinine, nicotine and several other metabolites (cotinine-N-glucuronide, nicotine-N-glucuronide, *trans*-3-hydroxycotinine, *trans*-3-hydroxycotinine-O-glucuronide and anabasine) were analyzed in CHMS cycles 1 and 3. Free and total 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanol (NNAL), a metabolite of a tobacco-specific N-nitrosamine found only in tobacco and products derived from tobacco, were also analyzed in CHMS cycles 1 and 3. Data on these tobacco-related chemicals and their metabolites are available from Statistics Canada through the [Research Data Centres Program](#).

Table 10.1.1

Cotinine (non-smokers)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 6–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 6–79 years							
1 (2007–2009)	4704	13.6 (11.5–16.0)	—	<LOD	<LOD	3.3 ^E (1.6–4.9)	12 ^E (<LOD–24)
2 (2009–2011)	4895	14.2 (11.5–17.4)	—	<LOD	<LOD	2.6 ^E (<LOD–4.2)	11 ^E (<LOD–23)
3 (2012–2013)	4456	9.3 (6.8–12.5)	—	<LOD	<LOD	<LOD	6.6 ^E (<LOD–14)
4 (2014–2015)	4395	11.1 (9.0–13.5)	—	<LOD	<LOD	1.9 ^E (<LOD–4.8)	15 ^E (2.0–28)
5 (2016–2017)	4385	9.8 (7.2–13.3)	—	<LOD	<LOD	<LOD	9.3 ^E (<LOD–20)
6 (2018–2019)	2262	10.5 (7.8–13.9)	—	<LOD	<LOD	1.4 ^E (<LOD–2.8)	25 ^E (<LOD–120)
Males, 6–79 years							
1 (2007–2009)	2252	15.9 (13.3–18.8)	—	<LOD	<LOD	4.4 ^E (1.7–7.0)	18 ^E (<LOD–66)
2 (2009–2011)	2304	17.9 (14.5–22.0)	—	<LOD	<LOD	4.1 ^E (<LOD–7.4)	22 ^E (<LOD–50)
3 (2012–2013)	2183	10.9 ^E (7.5–15.6)	—	<LOD	<LOD	1.5 ^E (<LOD–3.8)	12 ^E (<LOD–51)
4 (2014–2015)	2190	11.7 (9.4–14.6)	—	<LOD	<LOD	2.6 ^E (<LOD–6.8)	20 ^E (<LOD–110)
5 (2016–2017)	2170	12.7 ^E (8.1–19.2)	—	<LOD	<LOD	2.7 ^E (<LOD–12)	37 ^E (<LOD–290)
6 (2018–2019)	1169	13.9 (9.7–19.4)	—	<LOD	<LOD	3.4 ^E (<LOD–55)	260 ^E (<LOD–1200)
Females, 6–79 years							
1 (2007–2009)	2452	11.5 (9.2–14.3)	—	<LOD	<LOD	2.3 ^E (<LOD–4.2)	9.9 ^E (3.4–16)
2 (2009–2011)	2591	10.7 (8.5–13.3)	—	<LOD	<LOD	1.4 ^E (<LOD–2.3)	5.1 ^E (<LOD–13)
3 (2012–2013)	2273	7.8 (5.6–10.9)	—	<LOD	<LOD	<LOD	2.9 ^E (<LOD–6.0)
4 (2014–2015)	2205	10.4 (7.3–14.8)	—	<LOD	<LOD	<LOD	9.9 ^E (<LOD–28)
5 (2016–2017)	2215	7.2 (5.5–9.4)	—	<LOD	<LOD	<LOD	1.6 ^E (<LOD–2.6)
6 (2018–2019)	1093	7.2 ^E (4.2–12.0)	—	<LOD	<LOD	<LOD	4.2 ^E (<LOD–29)
6–11 years							
1 (2007–2009)	1045	15.9 (12.6–19.8)	—	<LOD	<LOD	3.9 ^E (1.9–5.8)	10 ^E (5.7–14)
2 (2009–2011)	1061	16.9 (12.4–22.8)	—	<LOD	<LOD	4.9 ^E (1.9–7.9)	12 ^E (6.3–18)
3 (2012–2013)	1007	10.5 (7.3–14.9)	—	<LOD	<LOD	1.9 ^E (<LOD–4.7)	7.1 ^E (2.7–11)
4 (2014–2015)	1008	9.6 ^E (6.3–14.5)	—	<LOD	<LOD	<LOD	4.8 ^E (<LOD–12)
5 (2016–2017)	991	9.2 ^E (5.8–14.2)	—	<LOD	<LOD	<LOD	3.3 ^E (1.1–5.5)
6 (2018–2019)	499	3.2 ^E (1.2–8.1)	—	<LOD	<LOD	<LOD	<LOD

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	882	22.4 (15.3–31.7)	—	<LOD	<LOD	8.3 ^E (3.8–13)	19 ^E (8.3–30)
2 (2009–2011)	928	21.5 (16.6–27.4)	—	<LOD	<LOD	10 ^E (<LOD–24)	45 ^E (3.0–86)
3 (2012–2013)	889	16.6 (12.0–22.6)	—	<LOD	<LOD	4.4 ^E (<LOD–9.1)	13 ^E (7.6–19)
4 (2014–2015)	901	14.1 (10.7–18.4)	—	<LOD	<LOD	4.0 ^E (<LOD–9.2)	19 ^E (<LOD–56)
5 (2016–2017)	903	16.5 (12.1–22.0)	—	<LOD	<LOD	3.3 ^E (<LOD–9.1)	23 ^E (<LOD–350)
6 (2018–2019)	891	17.5 (12.9–23.4)	—	<LOD	<LOD	20 ^E (<LOD–130)	240 ^E (<LOD–490)
20–39 years							
1 (2007–2009)	874	14.8 (11.0–19.7)	—	<LOD	<LOD	3.9 ^E (<LOD–7.7)	23 ^E (<LOD–180)
2 (2009–2011)	1009	20.5 ^E (14.0–29.0)	—	<LOD	<LOD	2.9 ^E (<LOD–17)	45 ^E (<LOD–140)
3 (2012–2013)	792	7.3 ^E (4.2–12.3)	—	<LOD	<LOD	<LOD	1.6 ^E (<LOD–5.6)
4 (2014–2015)	785	13.2 (9.1–18.7)	—	<LOD	<LOD	5.4 ^E (<LOD–9.8)	18 ^E (<LOD–75)
5 (2016–2017)	809	11.0 ^E (6.2–18.8)	—	<LOD	<LOD	1.3 ^E (<LOD–14)	19 ^E (<LOD–180)
6 (2018–2019)	343	9.7 ^E (4.7–19.2)	—	<LOD	<LOD	<LOD	14 ^E (<LOD–910)
40–59 years							
1 (2007–2009)	947	11.4 (9.0–14.2)	—	<LOD	<LOD	2.0 ^E (<LOD–4.4)	10 ^E (<LOD–21)
2 (2009–2011)	972	8.1 ^E (5.6–11.7)	—	<LOD	<LOD	<LOD	4.8 ^E (<LOD–11)
3 (2012–2013)	851	10.1 ^E (6.2–16.0)	—	<LOD	<LOD	<LOD	23 ^E (<LOD–230)
4 (2014–2015)	827	12.2 ^E (7.9–18.3)	—	<LOD	<LOD	<LOD	24 ^E (<LOD–380)
5 (2016–2017)	814	7.1 ^E (4.1–12.1)	—	<LOD	<LOD	<LOD	2.7 ^E (<LOD–12)
6 (2018–2019)	296	13.1 ^E (7.1–23.0)	—	<LOD	<LOD	2.2 ^E (<LOD–17)	53 ^E (<LOD–520)
60–79 years							
1 (2007–2009)	956	8.8 (6.3–12.2)	—	<LOD	<LOD	<LOD	4.7 ^E (<LOD–9.8)
2 (2009–2011)	925	8.9 (6.5–12.1)	—	<LOD	<LOD	<LOD	7.9 ^E (<LOD–16)
3 (2012–2013)	917	6.5 ^E (4.2–10.0)	—	<LOD	<LOD	<LOD	2.3 ^E (<LOD–4.2)
4 (2014–2015)	874	5.9 (4.5–7.7)	—	<LOD	<LOD	<LOD	2.9 ^E (<LOD–9.1)
5 (2016–2017)	868	9.0 (6.4–12.4)	—	<LOD	<LOD	<LOD	3.6 ^E (<LOD–38)
6 (2018–2019)	233	7.5 ^E (4.2–12.9)	—	<LOD	<LOD	<LOD	3.1 ^E (<LOD–490)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 3, 4, 5 and 6 are 1, 1, 1.1, 1.1 and 1.1 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

■ **Table 10.1.2**

Cotinine (non-smokers) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 6–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 6–79 years							
1 (2007–2009)	4694	13.6 (11.5–16.0)	—	<LOD	<LOD	4.6 (3.3–5.8)	15 ^E (<LOD–31)
2 (2009–2011)	4883	14.2 (11.5–17.4)	—	<LOD	<LOD	3.1 (<LOD–4.1)	11 ^E (<LOD–22)
3 (2012–2013)	4455	9.3 (6.8–12.5)	—	<LOD	<LOD	<LOD	5.7 ^E (<LOD–10)
4 (2014–2015)	4394	11.1 (9.0–13.5)	—	<LOD	<LOD	2.5 (<LOD–3.3)	15 ^E (<LOD–30)
5 (2016–2017)	4373	9.8 (7.2–13.3)	—	<LOD	<LOD	<LOD	6.9 ^E (<LOD–13)
6 (2018–2019)	2262	10.5 (7.8–13.9)	—	<LOD	<LOD	3.4 (<LOD–4.6)	23 ^E (<LOD–140)
Males, 6–79 years							
1 (2007–2009)	2246	15.9 (13.3–18.8)	—	<LOD	<LOD	4.8 ^E (2.7–6.9)	20 ^E (<LOD–63)
2 (2009–2011)	2299	17.9 (14.5–22.0)	—	<LOD	<LOD	3.8 ^E (<LOD–5.9)	17 ^E (<LOD–33)
3 (2012–2013)	2183	10.9 ^E (7.5–15.6)	—	<LOD	<LOD	2.3 ^E (<LOD–3.3)	9.7 ^E (<LOD–44)
4 (2014–2015)	2189	11.7 (9.4–14.6)	—	<LOD	<LOD	2.3 ^E (<LOD–4.3)	15 ^E (<LOD–66)
5 (2016–2017)	2166	12.7 ^E (8.1–19.2)	—	<LOD	<LOD	3.1 ^E (<LOD–7.4)	32 ^E (<LOD–200)
6 (2018–2019)	1169	13.9 (9.7–19.4)	—	<LOD	<LOD	3.5 ^E (<LOD–40)	250 ^E (<LOD–690)
Females, 6–79 years							
1 (2007–2009)	2448	11.5 (9.2–14.3)	—	<LOD	<LOD	4.0 (<LOD–5.3)	12 ^E (1.7–22)
2 (2009–2011)	2584	10.7 (8.5–13.3)	—	<LOD	<LOD	3.0 (<LOD–3.7)	5.9 ^E (<LOD–15)
3 (2012–2013)	2272	7.8 (5.6–10.9)	—	<LOD	<LOD	<LOD	4.4 ^E (<LOD–7.0)
4 (2014–2015)	2205	10.4 (7.3–14.8)	—	<LOD	<LOD	<LOD	16 ^E (<LOD–39)
5 (2016–2017)	2207	7.2 (5.5–9.4)	—	<LOD	<LOD	<LOD	4.1 ^E (<LOD–5.9)
6 (2018–2019)	1093	7.2 ^E (4.2–12.0)	—	<LOD	<LOD	<LOD	6.6 ^E (<LOD–35)
6–11 years							
1 (2007–2009)	1042	15.9 (12.6–19.8)	—	<LOD	<LOD	6.2 ^E (1.9–10)	14 ^E (2.2–26)
2 (2009–2011)	1059	16.9 (12.4–22.8)	—	<LOD	<LOD	5.2 ^E (1.9–8.5)	12 ^E (5.4–18)
3 (2012–2013)	1007	10.5 (7.3–14.9)	—	<LOD	<LOD	3.5 ^E (<LOD–5.8)	7.7 ^E (2.6–13)
4 (2014–2015)	1007	9.6 ^E (6.3–14.5)	—	<LOD	<LOD	<LOD	4.9 ^E (<LOD–12)
5 (2016–2017)	990	9.2 ^E (5.8–14.2)	—	<LOD	<LOD	<LOD	5.7 (3.9–7.6)
6 (2018–2019)	499	3.2 ^E (1.2–8.1)	—	<LOD	<LOD	<LOD	<LOD

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	881	21.3 (15.3–31.7)	—	<LOD	<LOD	7.9 ^E (4.6–11)	14 ^E (1.7–27)
2 (2009–2011)	926	21.5 (16.6–27.4)	—	<LOD	<LOD	6.8 ^E (<LOD–17)	26 ^E (<LOD–53)
3 (2012–2013)	889	16.6 (12.0–22.6)	—	<LOD	<LOD	3.2 ^E (<LOD–5.5)	7.5 ^E (1.7–13)
4 (2014–2015)	901	14.1 (10.7–18.4)	—	<LOD	<LOD	2.6 ^E (<LOD–5.0)	18 ^E (<LOD–42)
5 (2016–2017)	900	16.5 (12.1–22.0)	—	<LOD	<LOD	3.2 ^E (<LOD–5.7)	18 ^E (<LOD–130)
6 (2018–2019)	891	17.5 (12.9–23.4)	—	<LOD	<LOD	17 ^E (<LOD–84)	170 ^E (<LOD–350)
20–39 years							
1 (2007–2009)	871	14.8 (11.0–19.7)	—	<LOD	<LOD	4.5 ^E (<LOD–7.4)	25 ^E (<LOD–160)
2 (2009–2011)	1007	20.5 ^E (14.0–29.0)	—	<LOD	<LOD	3.9 ^E (<LOD–15)	29 ^E (<LOD–86)
3 (2012–2013)	792	7.3 ^E (4.2–12.3)	—	<LOD	<LOD	<LOD	3.3 ^E (<LOD–5.2)
4 (2014–2015)	785	13.2 (9.1–18.7)	—	<LOD	<LOD	3.0 ^E (<LOD–7.3)	20 ^E (<LOD–74)
5 (2016–2017)	807	11.0 ^E (6.2–18.8)	—	<LOD	<LOD	5.0 ^E (<LOD–8.8)	29 ^E (<LOD–130)
6 (2018–2019)	343	9.7 ^E (4.7–19.2)	—	<LOD	<LOD	<LOD	18 ^E (<LOD–610)
40–59 years							
1 (2007–2009)	944	11.4 (9.0–14.2)	—	<LOD	<LOD	4.6 ^E (<LOD–6.4)	14 ^E (<LOD–27)
2 (2009–2011)	970	8.1 ^E (5.6–11.7)	—	<LOD	<LOD	<LOD	4.7 ^E (<LOD–7.8)
3 (2012–2013)	850	10.1 ^E (6.2–16.0)	—	<LOD	<LOD	<LOD	11 ^E (<LOD–190)
4 (2014–2015)	827	12.2 ^E (7.9–18.3)	—	<LOD	<LOD	<LOD	27 ^E (<LOD–270)
5 (2016–2017)	810	7.1 ^E (4.1–12.1)	—	<LOD	<LOD	<LOD	4.1 ^E (<LOD–14)
6 (2018–2019)	296	13.1 ^E (7.1–23.0)	—	<LOD	<LOD	3.4 ^E (<LOD–26)	160 ^E (<LOD–390)
60–79 years							
1 (2007–2009)	956	8.8 (6.3–12.2)	—	<LOD	<LOD	<LOD	7.0 ^E (<LOD–14)
2 (2009–2011)	921	8.9 (6.5–12.1)	—	<LOD	<LOD	<LOD	9.7 ^E (<LOD–26)
3 (2012–2013)	917	6.5 ^E (4.2–10.0)	—	<LOD	<LOD	<LOD	4.1 ^E (<LOD–6.8)
4 (2014–2015)	874	5.9 (4.5–7.7)	—	<LOD	<LOD	<LOD	3.5 ^E (<LOD–7.7)
5 (2016–2017)	866	9.0 (6.4–12.4)	—	<LOD	<LOD	<LOD	4.2 ^E (<LOD–43)
6 (2018–2019)	233	7.5 ^E (4.2–12.9)	—	<LOD	<LOD	<LOD	4.3 ^E (<LOD–350)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 10.1.3

Cotinine (smokers)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 12–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 12–79 years							
1 (2007–2009)	805	96.8 (94.1–98.3)	590 (420–820)	73 ^E (<LOD–170)	1000 (810–1200)	2200 (2000–2400)	2600 (2300–2900)
2 (2009–2011)	819	94.5 (91.0–96.7)	490 (340–700)	13 ^E (<LOD–110)	1000 (810–1200)	2200 (1900–2500)	2600 (2100–3100)
3 (2012–2013)	701	95 (91.0–97.3)	490 (410–590)	38 ^E (<LOD–110)	990 (900–1100)	2000 (1600–2300)	2300 (2000–2600)
4 (2014–2015)	667	95.5 (91.2–97.7)	550 (420–710)	24 ^E (<LOD–100)	1000 (830–1200)	2300 (1900–2700)	2800 (2400–3200)
5 (2016–2017)	571	96.8 (93.5–98.5)	580 (460–730)	120 ^E (9.4–230)	910 (790–1000)	1900 (1700–2100)	2300 (2000–2600)
6 (2018–2019)	495	89.4 (68.0–97.1)	290 ^E (86–1000)	<LOD	770 (510–1000)	1600 (1400–1900)	2000 ^E (1200–2800)
Males, 12–79 years							
1 (2007–2009)	406	96.0 (91.2–98.3)	660 ^E (400–1100)	68 ^E (<LOD–340)	1200 (920–1500)	2300 (2000–2600)	2800 (2400–3300)
2 (2009–2011)	425	94.6 (89.3–97.4)	470 ^E (280–770)	13 ^E (<LOD–140)	1000 (780–1200)	2300 (1900–2700)	2900 (2300–3500)
3 (2012–2013)	387	94.4 (86.6–97.8)	460 (340–630)	29 ^E (<LOD–82)	990 (820–1100)	2100 (1700–2500)	2400 (2100–2600)
4 (2014–2015)	359	97.4 (89.3–99.4)	610 (470–800)	72 ^E (<LOD–240)	980 (830–1100)	2200 (1800–2500)	2600 (1800–3400)
5 (2016–2017)	312	97.8 (96.3–98.7)	660 (520–830)	290 ^E (<LOD–610)	940 (740–1100)	1900 (1600–2200)	2300 (1700–2800)
6 (2018–2019)	281	89.9 (75.0–96.3)	350 ^E (120–1100)	<LOD	860 (630–1100)	1800 ^E (1000–2500)	2100 (1500–2700)
Females, 12–79 years							
1 (2007–2009)	399	97.6 (95.4–98.8)	520 (390–700)	96 ^E (22–170)	860 (640–1100)	2100 (1900–2300)	2500 (2300–2700)
2 (2009–2011)	394	94.4 (87.2–97.6)	510 ^E (320–810)	19 ^E (<LOD–190)	1000 (720–1300)	2100 (1800–2400)	2400 (1900–2900)
3 (2012–2013)	314	95.9 (89.8–98.4)	550 (380–790)	71 ^E (<LOD–340)	990 (760–1200)	1700 (1200–2300)	2100 (1700–2500)
4 (2014–2015)	308	92.8 (82.8–97.2)	470 ^E (250–870)	12 ^E (<LOD–160)	1100 (820–1400)	2500 (1900–3100)	2800 (2500–3100)
5 (2016–2017)	259	95.1 (84.7–98.5)	460 ^E (280–760)	85 ^E (<LOD–210)	850 (640–1100)	1800 (1500–2100)	2300 (1700–3000)
6 (2018–2019)	214	88.9 (53.0–98.3)	230 ^E (54–990)	<LOD	690 ^E (420–960)	1400 (1100–1700)	1700 (1200–2100)
12–19 years							
1 (2007–2009)	102	90.7 (81.1–95.7)	160 ^E (78–330)	<LOD	410 ^E (<LOD–840)	1600 (1400–1900)	1900 (1500–2200)
2 (2009–2011)	102	82.4 (59.2–93.8)	82 ^E (20–340)	<LOD	260 ^E (<LOD–560)	1700 (1200–2300)	2100 (1600–2600)
3 (2012–2013)	98	84.1 (68.9–92.6)	140 ^E (43–430)	<LOD	360 ^E (45–670)	2100 ^E (1200–3000)	X
4 (2014–2015)	73	82.2 (53.7–94.8)	130 ^E (18–880)	<LOD	430 ^E (260–610)	1400 ^E (590–2200)	X
5 (2016–2017)	57	95.2 (83.4–98.7)	240 ^E (120–470)	1.7 ^E (<LOD–90)	430 ^E (200–660)	1500 ^E (880–2200)	X
6 (2018–2019)	49	73.7 (51.0–88.4)	59 ^E (4.6–760)	X	170 ^E (<LOD–550)	X	X

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	300	96.2 (88.8–98.8)	500 ^E (300–850)	68 ^E (<LOD–170)	930 (620–1200)	2000 (1800–2200)	2500 (2100–2900)
2 (2009–2011)	311	92.1 (85.0–95.9)	400 ^E (260–630)	7.8 ^E (<LOD–120)	850 (570–1100)	2200 (1600–2900)	2900 (2200–3600)
3 (2012–2013)	254	93.5 (76.4–98.4)	310 ^E (190–520)	12 ^E (<LOD–46)	700 ^E (350–1100)	1600 (1300–1900)	2000 (1600–2400)
4 (2014–2015)	271	93.0 (81.2–97.6)	360 ^E (220–600)	3.6 ^E (<LOD–24)	970 (620–1300)	2400 (1600–3200)	2900 (2200–3500)
5 (2016–2017)	220	95.4 (90.2–97.9)	520 ^E (340–780)	120 ^E (<LOD–320)	1000 (730–1300)	1900 (1700–2000)	2100 (1900–2200)
6 (2018–2019)	196	85.5 (68.7–94.1)	170 ^E (22–1300)	<LOD	720 (470–960)	1600 (1200–2100)	2000 (1600–2400)
40–59 years							
1 (2007–2009)	275	98.4 (96.1–99.3)	830 (610–1100)	190 ^E (12–370)	1200 (910–1500)	2500 (2200–2800)	2800 (2400–3100)
2 (2009–2011)	253	99.2 (96.6–99.8)	800 ^E (480–1300)	93 ^E (<LOD–620)	1400 (1000–1700)	2200 (1900–2600)	2600 (2000–3300)
3 (2012–2013)	228	96.9 (89.7–99.1)	770 (550–1100)	340 ^E (150–530)	1000 (890–1200)	2100 (1700–2600)	2300 (2000–2700)
4 (2014–2015)	208	98.7 (95.0–99.7)	880 (770–1000)	360 ^E (190–540)	1100 (870–1400)	2600 (1900–3200)	2900 (2400–3300)
5 (2016–2017)	182	97.6 (86.6–99.6)	630 ^E (430–920)	93 ^E (<LOD–360)	910 (730–1100)	2000 (1600–2500)	2800 (2000–3500)
6 (2018–2019)	152	92.0 (37.4–99.5)	480 ^E (160–1500)	59 ^E (<LOD–550)	1000 ^E (620–1400)	1700 (1100–2200)	2100 ^E (1300–2800)
60–79 years							
1 (2007–2009)	128	96.7 (86.1–99.3)	650 ^E (430–980)	140 ^E (<LOD–360)	860 (600–1100)	2200 (1900–2400)	2400 (1900–2900)
2 (2009–2011)	153	94.1 (75.3–98.8)	500 ^E (220–1100)	120 ^E (<LOD–410)	980 (720–1200)	1800 (1500–2000)	1900 (1600–2300)
3 (2012–2013)	121	99.5 (96.5–99.9)	940 (800–1100)	390 ^E (240–540)	990 (830–1200)	2100 (1400–2700)	2700 ^E (1700–3800)
4 (2014–2015)	115	99.0 (95.1–99.8)	920 (720–1200)	440 ^E (250–630)	990 ^E (620–1400)	1900 (1500–2200)	2200 (1700–2700)
5 (2016–2017)	112	99.4 (91.7–100)	850 (640–1100)	400 ^E (160–640)	910 (710–1100)	1900 ^E (970–2800)	2700 (2000–3500)
6 (2018–2019)	98	96.5 (80.1–99.5)	530 ^E (300–920)	180 ^E (<LOD–440)	880 (680–1100)	1600 (1300–1900)	X

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 3, 4, 5 and 6 are 1, 1, 1.1, 1.1, 1.1 and 1.1 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

X Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 10.1.4

Cotinine (smokers) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 12–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 12–79 years							
1 (2007–2009)	803	96.8 (94.1–98.3)	650 (480–890)	76 ^E (<LOD–210)	1000 (830–1200)	3000 (2500–3500)	4400 (3500–5300)
2 (2009–2011)	816	94.5 (91.0–96.7)	430 ^E (290–630)	17 ^E (<LOD–63)	840 (620–1100)	2700 (1800–3700)	3800 ^E (2300–5300)
3 (2012–2013)	701	95.0 (91.0–97.3)	440 (340–570)	23 ^E (<LOD–83)	750 (590–900)	2600 ^E (1600–3700)	3900 ^E (2100–5800)
4 (2014–2015)	666	95.5 (91.2–97.7)	480 (360–630)	35 ^E (<LOD–78)	780 (650–910)	2500 (1700–3300)	3300 (2900–3700)
5 (2016–2017)	571	96.8 (93.5–98.5)	590 (470–730)	130 ^E (36–230)	830 (700–970)	2700 (2200–3100)	3400 (2700–4100)
6 (2018–2019)	495	89.4 (68.0–97.1)	310 ^E (110–870)	<LOD	740 (480–990)	2100 ^E (990–3300)	3200 (2200–4300)
Males, 12–79 years							
1 (2007–2009)	405	96.0 (91.2–98.3)	560 ^E (360–880)	58 ^E (<LOD–230)	930 (680–1200)	2300 (1900–2700)	3200 (2300–4200)
2 (2009–2011)	425	94.6 (89.3–97.4)	370 ^E (210–620)	19 ^E (<LOD–85)	730 (480–980)	2700 ^E (1600–3700)	3700 ^E (2300–5100)
3 (2012–2013)	387	94.4 (86.6–97.8)	360 ^E (250–520)	17 ^E (<LOD–56)	710 (500–920)	2300 (1500–3100)	3000 ^E (1900–4100)
4 (2014–2015)	358	97.4 (89.3–99.4)	500 (410–610)	55 ^E (<LOD–120)	770 (630–900)	2900 ^E (1600–4200)	3300 (2500–4200)
5 (2016–2017)	312	97.8 (96.3–98.7)	600 (470–760)	160 ^E (<LOD–300)	830 (650–1000)	2400 (1600–3200)	3300 (2300–4300)
6 (2018–2019)	281	89.9 (75.0–96.3)	320 ^E (110–940)	<LOD	720 ^E (450–1000)	2300 ^E (1000–3600)	3100 ^E (1700–4600)
Females, 12–79 years							
1 (2007–2009)	398	97.6 (95.4–98.8)	780 (590–1000)	96 ^E (<LOD–270)	1100 (900–1400)	3700 (2900–4500)	5500 (4300–6600)
2 (2009–2011)	391	94.4 (87.2–97.6)	520 ^E (300–890)	13 ^E (<LOD–110)	1000 (650–1400)	2800 ^E (620–4900)	4800 ^E (2300–7400)
3 (2012–2013)	314	95.9 (89.8–98.4)	600 (420–850)	110 ^E (<LOD–320)	860 ^E (510–1200)	3200 ^E (1000–5300)	4900 (3300–6400)
4 (2014–2015)	308	92.8 (82.8–97.2)	450 ^E (240–850)	11 ^E (<LOD–120)	830 ^E (440–1200)	2500 (1800–3100)	3200 ^E (760–5700)
5 (2016–2017)	259	95.1 (84.7–98.5)	570 ^E (360–890)	110 ^E (<LOD–220)	850 ^E (510–1200)	2800 ^E (1600–4000)	3800 (2900–4700)
6 (2018–2019)	214	88.9 (53.0–98.3)	290 ^E (93–920)	<LOD	740 ^E (400–1100)	2000 ^E (1000–3000)	3300 ^E (1400–5300)
12–19 years							
1 (2007–2009)	102	90.7 (81.1–95.7)	120 ^E (58–250)	<LOD	290 ^E (<LOD–470)	1400 ^E (600–2200)	1700 ^E (940–2500)
2 (2009–2011)	102	82.4 (59.2–93.8)	53 ^E (12–230)	<LOD	110 ^E (<LOD–380)	1300 (990–1500)	1300 (1200–1500)
3 (2012–2013)	98	84.1 (68.9–92.6)	85 ^E (25–290)	<LOD	300 ^E (28–570)	940 (610–1300)	X
4 (2014–2015)	72	82.2 (53.7–94.8)	85 ^E (16–450)	<LOD	190 ^E (<LOD–390)	1100 ^E (360–1800)	X
5 (2016–2017)	57	95.2 (83.4–98.7)	170 ^E (81–350)	3.5 ^E (<LOD–40)	360 ^E (86–630)	990 ^E (620–1400)	X
6 (2018–2019)	49	73.7 (51.0–88.4)	44 ^E (2.6–760)	X	190 ^E (<LOD–360)	X	X

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	299	92.1 (88.8–98.8)	510 ^E (310–840)	57 ^E (<LOD–210)	850 (560–1100)	2200 (1900–2600)	2500 (1900–3000)
2 (2009–2011)	311	92.1 (85.0–95.9)	330 ^E (200–530)	11 ^E (<LOD–49)	710 (470–940)	2300 (1500–3000)	3200 ^E (1700–4700)
3 (2012–2013)	254	93.5 (76.4–98.4)	230 ^E (120–410)	7.2 ^E (<LOD–30)	520 ^E (310–720)	1500 ^E (830–2200)	2100 ^E (1300–2900)
4 (2014–2015)	271	93.0 (81.2–97.6)	300 ^E (170–520)	4.7 ^E (<LOD–25)	600 (390–800)	2300 ^E (1200–3400)	3200 (2300–4200)
5 (2016–2017)	220	95.4 (90.2–97.9)	420 ^E (270–640)	88 ^E (<LOD–250)	640 (480–810)	1800 ^E (960–2700)	1900 (1400–2400)
6 (2018–2019)	196	85.5 (68.7–94.1)	180 ^E (38–830)	<LOD	470 ^E (210–730)	1900 ^E (550–3200)	3200 ^E (1300–5000)
40–59 years							
1 (2007–2009)	275	98.4 (96.1–99.3)	1000 (810–1300)	260 ^E (64–460)	1300 (920–1600)	4100 (2900–5400)	5500 (4400–6600)
2 (2009–2011)	251	99.2 (96.6–99.8)	710 ^E (400–1200)	79 ^E (<LOD–340)	990 ^E (560–1400)	3400 ^E (1400–5400)	4900 ^E (2800–7000)
3 (2012–2013)	228	96.9 (89.7–99.1)	840 ^E (520–1300)	390 ^E (190–580)	940 ^E (570–1300)	3500 ^E (1500–5500)	5200 ^E (2500–7800)
4 (2014–2015)	208	98.7 (95.0–99.7)	780 (610–1000)	210 ^E (120–300)	1000 (740–1300)	3000 (2200–3700)	3300 (2700–4000)
5 (2016–2017)	182	97.6 (86.6–99.6)	850 ^E (560–1300)	210 ^E (<LOD–440)	1200 (840–1600)	3500 (2700–4300)	4100 (3400–4800)
6 (2018–2019)	152	92.0 (37.4–99.5)	520 ^E (190–1500)	44 ^E (<LOD–530)	860 (570–1200)	1900 ^E (110–3700)	3600 ^E (1500–5600)
60–79 years							
1 (2007–2009)	127	96.7 (86.1–99.3)	840 ^E (530–1300)	120 ^E (<LOD–480)	1300 (1000–1500)	3200 (2100–4300)	4300 ^E (2700–5900)
2 (2009–2011)	152	94.1 (75.3–98.8)	610 ^E (230–1600)	84 ^E (<LOD–440)	1000 (700–1400)	3000 ^E (1700–4300)	4100 (2800–5300)
3 (2012–2013)	121	99.5 (96.5–99.9)	960 (730–1200)	390 (270–500)	960 ^E (530–1400)	3100 ^E (1600–4700)	4500 ^E (2700–6300)
4 (2014–2015)	115	99.0 (95.1–99.8)	980 (780–1200)	400 ^E (250–560)	1100 (820–1400)	2100 (1700–2500)	3200 ^E (1800–4500)
5 (2016–2017)	112	99.4 (91.7–100)	970 (720–1300)	330 ^E (160–510)	1100 (980–1200)	2700 (1900–3400)	3000 (2200–3700)
6 (2018–2019)	98	96.5 (80.1–99.5)	520 ^E (300–880)	140 ^E (<LOD–290)	770 ^E (480–1100)	2300 ^E (560–3900)	X

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

X Suppressed to meet the confidentiality requirements of the *Statistics Act*.

Table 10.1.5

Cotinine (non-smokers)—Geometric means and selected percentiles of serum concentrations ($\mu\text{g/L}$) for the Canadian population aged 6–79 by age group, Canadian Health Measures Survey cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 6–79 years							
6 (2018–2019)	4391	94.7 (91.1–96.9)	0.029 (0.025–0.034)	0.0062 (0.0051–0.0073)	0.015 (0.013–0.017)	0.27 ^E (0.13–0.41)	5.5 ^E (<LOD–12)
Males, 6–79 years							
6 (2018–2019)	2190	95.9 (92.0–97.9)	0.041 (0.031–0.053)	0.0070 (0.0057–0.0083)	0.018 (0.013–0.023)	0.83 ^E (0.26–1.4)	33 ^E (<LOD–77)
Females, 6–79 years							
6 (2018–2019)	2201	93.5 (89.3–96.1)	0.021 (0.017–0.025)	0.0056 (<LOD–0.0068)	0.013 (0.012–0.015)	0.094 (0.063–0.13)	0.61 ^E (<LOD–1.5)
6–11 years							
6 (2018–2019)	863	91.9 (84.9–95.8)	0.019 (0.014–0.025)	0.0057 ^E (<LOD–0.0082)	0.013 (0.010–0.017)	0.089 ^E (<LOD–0.19)	0.39 ^E (0.11–0.68)
12–19 years							
6 (2018–2019)	871	94.2 (90.1–96.7)	0.047 ^E (0.030–0.075)	0.0068 (0.0053–0.0083)	0.018 (0.013–0.023)	3.0 ^E (<LOD–22)	45 ^E (<LOD–90)
20–39 years							
6 (2018–2019)	856	96.1 (90.1–98.5)	0.031 (0.023–0.042)	0.0066 (<LOD–0.0083)	0.016 (0.013–0.019)	0.28 ^E (<LOD–0.82)	3.9 ^E (<LOD–60)
40–59 years							
6 (2018–2019)	928	96.4 (93.7–98.0)	0.030 (0.022–0.040)	0.0065 (0.0050–0.0080)	0.015 (0.013–0.017)	0.19 ^E (<LOD–0.50)	27 ^E (<LOD–67)
60–79 years							
6 (2018–2019)	873	91.7 (85.7–95.3)	0.023 (0.017–0.032)	0.0054 (<LOD–0.0069)	0.014 (0.0095–0.018)	0.20 ^E (0.014–0.38)	0.85 ^E (<LOD–39)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycle 6 is 0.0050 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

■ **Table 10.1.6**

Cotinine (smokers)—Geometric means and selected percentiles of serum concentrations (µg/L) for the Canadian population aged 12–79 by age group, Canadian Health Measures Survey cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 12–79 years							
6 (2018–2019)	485	99.9 (99.5–100)	49 ^E (19–130)	0.14 ^E (<LOD–13)	130 ^E (74–190)	280 (180–380)	370 (290–440)
Males, 12–79 years							
6 (2018–2019)	276	99.8 (99.1–100)	51 ^E (15–170)	<LOD ^E (<LOD–22)	170 (110–230)	280 ^E (150–410)	370 (250–490)
Females, 12–79 years							
6 (2018–2019)	209	100 (99.7–100)	46 ^E (17–120)	0.40 ^E (<LOD–21)	110 ^E (67–160)	280 (180–380)	350 (270–430)
12–19 years							
6 (2018–2019)	48	100	7.9 ^E (0.57–110)	X	21 ^E (<LOD–81)	X	X
20–39 years							
6 (2018–2019)	194	99.8 (98.9–100)	28 ^E (6.3–120)	<LOD ^E (<LOD–5.0)	100 ^E (56–150)	270 (230–310)	280 (230–330)
40–59 years							
6 (2018–2019)	147	100 (99.6–100)	80 ^E (30–220)	2.6 ^E (<LOD–65)	190 ^E (110–280)	360 ^E (220–500)	400 (280–520)
60–79 years							
6 (2018–2019)	96	100	100 ^E (52–200)	35 ^E (<LOD–90)	170 (130–220)	340 (280–390)	X

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycle 6 is 0.10 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

X Suppressed to meet the confidentiality requirements of the *Statistics Act*.

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SUMMARY AND RESULTS FOR ACRYLAMIDE

11

11.1 ACRYLAMIDE

Acrylamide (CASRN 79-06-1) is a chemical used primarily in the production of polymers such as polyacrylamides (ATSDR, 2012). Polyacrylamides are used to clarify drinking water and treat effluent from water treatment plants and industrial processes (ATSDR, 2012). Polymers of acrylamide are also used in ore processing, food packaging and plastic products (EC and HC, 2009a). In Canada, polyacrylamides are used as coagulants and flocculants for the clarification of drinking water, in potting soils and as a non-medicinal ingredient in natural health products and pharmaceuticals (EC and HC, 2009b). Acrylamide can also form in certain foods as a product of reactions between naturally present components when foods are processed or cooked at high temperatures (HC, 2009a). It is formed mainly in carbohydrate-rich, plant-based foods, such as potatoes and grains; the highest concentrations have been detected in potato chips and french fries (HC, 2012).

Acrylamide may enter the environment during production and industrial use (ATSDR, 2012). The main source of acrylamide in drinking water is through the release of residual monomers from polyacrylamides used as clarifiers in drinking water treatment processes (ATSDR, 2012). Acrylamide is also a component of cigarette smoke and may be released to indoor air as a result of smoking (NTP, 2005; Urban et al., 2006).

Acrylamide exposure in the general population occurs primarily through food (ATSDR, 2012; EC and HC, 2009b). Inhalation of tobacco smoke, including

second-hand smoke, is also a major source of exposure for the general population; tobacco smoke may be the main source of acrylamide exposure for some smokers (ATSDR, 2012; EC and HC, 2009b; EFSA CONTAM Panel, 2015). Compared with food and cigarettes, exposure from other sources (e.g., drinking water, air and products available to consumers) is very low (EC and HC, 2009b). Animal studies indicate that acrylamide is readily absorbed via oral and pulmonary routes, and to a lesser degree following dermal exposure (ATSDR, 2012). Once absorbed, acrylamide is widely distributed throughout the body, accumulating in red blood cells (ATSDR, 2012). Acrylamide is metabolized via glutathione conjugation to form a mercapturic acid acrylamide derivative or by oxidation to form the epoxide derivative, glycidamide, which can also undergo conjugation with glutathione. Both acrylamide and glycidamide react with haemoglobin in red blood cells, forming adducts (ATSDR, 2012). Absorbed acrylamide and its metabolites are rapidly eliminated in urine, primarily as mercapturic acid conjugates of acrylamide and glycidamide (ATSDR, 2012). Acrylamide and glycidamide haemoglobin adducts are considered markers of exposure over the previous 120 days, the average life span of red blood cells (ATSDR, 2012).

Exposure to acrylamide has been reported to cause neurotoxicity in humans. Inhalation exposure to acrylamide in occupational settings has been associated with peripheral neuropathy, characterized by muscle weakness and numbness in hands and feet (EC and HC, 2009b). Studies with laboratory animals have observed adverse reproductive and developmental effects, and have shown that acrylamide is genotoxic

and carcinogenic (EC and HC, 2009b; FAO/WHO, 2006). Reviews of existing epidemiological studies have found inadequate evidence in humans to establish an association between acrylamide exposure and carcinogenicity (HC, 2008; IARC, 1994). However, on the basis of evidence in experimental animal studies, the International Agency for Research on Cancer has classified acrylamide as a Group 2A probable carcinogen (IARC, 1994). Further, on the basis of available evidence from animal studies, the Joint Food and Agriculture Organization (FAO) and World Health Organization (WHO) Expert Committee on Food Additives determined that the estimated intake of acrylamide from certain foods may be a human health concern (FAO/WHO, 2006; FAO/WHO, 2011). Similarly, an assessment by the European Food Safety Authority (EFSA) concluded that acrylamide in food potentially increases the risk of developing cancer for consumers in all age groups (EFSA CONTAM Panel, 2015).

The Government of Canada has conducted a science-based screening assessment under the Chemicals Management Plan to determine whether acrylamide may present a risk to the environment or human health as per the criteria set out in section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; EC and HC, 2009b). The assessment concluded that acrylamide is toxic under CEPA 1999, as it is considered harmful to human health (EC and HC, 2009b). Acrylamide is listed on Schedule 1, List of Toxic Substances, under CEPA 1999. The act allows the federal government to control the importation, manufacture, distribution and use of acrylamide in Canada (Canada, 1999; 2011). Health Canada's risk management strategy for acrylamide in food is focused on reducing foodborne exposure to acrylamide (HC, 2009b). To reduce exposure to acrylamide from food sources, Health Canada suggests following the recommendations provided in *Canada's Food Guide*, thereby limiting consumption of carbohydrate-rich foods that are high in fat (such as potato chips and French fries), sugar or salt (HC, 2009a). However, occasional consumption of these products is not likely to be a health concern. Other suggestions for reducing exposure to acrylamide from certain foods include paying careful attention to oil and baking temperatures, following the manufacturer's cooking instructions,

storing potatoes at a temperature above 8°C, washing or soaking cut potatoes in water prior to frying, and toasting bread or baked goods to the lightest colour acceptable (HC, 2009a). Health Canada regularly reviews data on the concentrations of acrylamide in foods sold on the Canadian market; these results may be shared with industry, particularly if elevated levels of acrylamide are identified in certain products. Health Canada continues to encourage the food industry to pursue efforts to reduce acrylamide in processed foods (HC, 2012). Data on the occurrence of acrylamide in foods available for sale in Canada do not demonstrate a decreasing trend in acrylamide concentrations in the food types that can significantly contribute to dietary acrylamide exposure; therefore, continued mitigation efforts are supported (HC, 2017). Health Canada has also approved the use of asparaginase in certain food products to reduce the formation of acrylamide during cooking (Canada, 2012; HC, 2013).

Because acrylamide-containing polymers are used in drinking water treatment, most Canadian jurisdictions have requirements to meet health-based standards for additives that limit the amount of acrylamide present in treated drinking water (NSF International, 2019; 2021). Health Canada has also set a maximum level for acrylamide in polyacrylamide-containing formulations used in natural health products in Canada (EC and HC, 2009a; HC, 2021). Acrylamide is on the List of Ingredients that are Prohibited for Use in Cosmetic Products (HC, 2019).

A limited number of biomonitoring studies conducted in Canada have measured the concentrations of haemoglobin adducts of acrylamide and glycidamide in blood (e.g. Brisson et al., 2014).

Acrylamide and its metabolite glycidamide were analyzed as haemoglobin adducts in the whole blood of CHMS participants aged 3–79 in cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019). Data are presented in blood as pmol/g haemoglobin (Hb). Finding a measurable amount of acrylamide or glycidamide haemoglobin adducts in blood is an indicator of exposure to acrylamide and does not necessarily mean that an adverse health effect will occur.

Table 11.1.1

Acrylamide—Geometric means and selected percentiles of haemoglobin adduct concentrations (pmol/g Hb) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
3 (2012–2013)	2492	100	73 (65–82)	35 (30–40)	64 (57–70)	190 (160–230)	240 (190–290)
4 (2014–2015)	2529	100 (99.5–100)	67 (62–73)	38 (35–41)	60 (55–66)	150 (130–180)	200 (180–230)
5 (2016–2017)	2573	100	73 (68–78)	39 (33–44)	65 (61–69)	160 (130–180)	220 (200–250)
6 (2018–2019)	2500	100	72 (66–79)	38 (33–44)	68 (62–73)	140 (110–170)	200 (170–240)
Males, 3–79 years							
3 (2012–2013)	1225	100	79 (69–90)	36 (31–40)	68 (61–75)	200 (150–260)	270 ^E (160–380)
4 (2014–2015)	1267	99.9 (98.9–100)	70 (62–79)	37 (33–42)	64 (57–71)	170 ^E (110–230)	220 (180–250)
5 (2016–2017)	1284	100	81 (74–89)	39 (33–44)	72 (65–79)	200 (160–230)	260 ^E (140–380)
6 (2018–2019)	1247	100	76 (69–83)	39 (35–43)	69 (62–76)	160 (110–200)	250 (180–310)
Females, 3–79 years							
3 (2012–2013)	1267	100	68 (59–78)	35 (29–41)	60 (51–69)	180 (130–230)	210 (180–250)
4 (2014–2015)	1262	100	65 (58–72)	38 (36–41)	58 (53–62)	140 (100–180)	180 (140–220)
5 (2016–2017)	1289	100	66 (61–71)	38 (32–45)	62 (58–65)	120 (96–140)	160 (120–210)
6 (2018–2019)	1253	100	69 (61–79)	37 (28–46)	66 (60–72)	130 (97–160)	160 (110–220)
3–5 years							
3 (2012–2013)	471	100	59 (55–64)	39 (35–43)	59 (55–63)	87 (73–100)	100 (82–120)
4 (2014–2015)	484	100	60 (56–65)	37 (32–43)	61 (55–66)	96 (84–110)	100 (83–120)
5 (2016–2017)	479	100	69 (63–75)	44 (39–48)	69 (61–76)	100 (91–110)	120 (100–130)
6 (2018–2019)	478	100	69 (64–74)	44 (38–49)	67 (62–71)	100 (87–120)	120 (88–150)
6–11 years							
3 (2012–2013)	505	100	61 (57–65)	37 (34–41)	62 (58–67)	100 (88–110)	110 (98–120)
4 (2014–2015)	507	100	62 (59–66)	42 (39–45)	62 (58–66)	90 (83–96)	100 (94–110)
5 (2016–2017)	507	100	71 (67–74)	47 (43–50)	70 (65–74)	100 (94–110)	130 (110–150)
6 (2018–2019)	499	100	66 (60–73)	43 (35–51)	67 (61–74)	95 (86–100)	100 (91–110)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
3 (2012–2013)	507	100	63 (59–67)	37 (31–42)	57 (53–61)	110 (87–130)	170 ^E (96–240)
4 (2014–2015)	505	100	63 (55–72)	37 (33–42)	60 (51–70)	100 (83–120)	120 (91–160)
5 (2016–2017)	530	100	68 (61–76)	42 (35–49)	64 (59–70)	100 (82–120)	140 (110–180)
6 (2018–2019)	504	100	65 (56–75)	37 (33–41)	60 (53–68)	100 (78–130)	150 ^E (<LOD–290)
20–39 years							
3 (2012–2013)	348	100	80 (65–97)	34 (24–43)	74 (59–89)	190 (130–260)	260 (190–340)
4 (2014–2015)	363	100	70 (60–80)	37 (33–41)	61 (53–70)	170 (120–220)	210 (170–250)
5 (2016–2017)	363	100	83 (72–97)	37 (27–47)	74 (63–85)	220 (170–280)	400 ^E (170–640)
6 (2018–2019)	330	100	79 (70–90)	41 (35–47)	71 (61–82)	150 ^E (92–200)	320 ^E (73–560)
40–59 years							
3 (2012–2013)	311	100	83 (67–100)	35 (24–47)	66 (49–82)	230 (180–290)	330 (210–450)
4 (2014–2015)	312	99.9 (98.3–100)	71 (62–80)	38 (34–42)	60 (50–70)	180 (130–230)	250 (170–330)
5 (2016–2017)	345	100	69 (62–78)	39 (35–43)	58 (48–68)	170 (130–210)	220 (200–240)
6 (2018–2019)	346	100	75 (63–89)	37 (26–47)	71 (60–82)	180 (130–240)	210 (160–260)
60–79 years							
3 (2012–2013)	350	100	63 (59–68)	34 (29–40)	62 (59–65)	130 (100–150)	160 (130–190)
4 (2014–2015)	358	100	63 (56–71)	34 (26–43)	59 (53–65)	150 (110–190)	190 (170–210)
5 (2016–2017)	349	100	69 (65–73)	38 (32–44)	65 (61–69)	130 (91–170)	170 (140–200)
6 (2018–2019)	343	100	66 (60–73)	36 (30–41)	64 (60–69)	110 (89–130)	140 (95–180)

CI: onfidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 3, 4, 5 and 6 is 11 pmol/g Hb.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 11.1.2

Glycidamide—Geometric means and selected percentiles of haemoglobin adduct concentrations (pmol/g Hb) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013), cycle 4 (2014–2015), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
3 (2012–2013)	2492	97.8 (94.9–99.1)	68 (62–75)	36 (34–38)	65 (59–70)	150 (120–180)	190 (150–220)
4 (2014–2015)	2529	97.4 (93.7–98.9)	60 (54–67)	34 (30–37)	57 (52–62)	120 (100–140)	170 (150–200)
5 (2016–2017)	2573	99.2 (97.3–99.8)	74 (69–80)	39 (34–43)	72 (67–77)	130 (110–160)	180 (140–210)
6 (2018–2019)	2500	99.6 (98.3–99.9)	76 (70–82)	41 (37–45)	70 (65–76)	140 (110–170)	190 (160–210)
Males, 3–79 years							
3 (2012–2013)	1225	97.3 (92.6–99.1)	69 (62–77)	37 (35–38)	66 (58–74)	170 (120–210)	210 (160–260)
4 (2014–2015)	1267	97.0 (93.6–98.6)	61 (53–70)	33 (27–39)	58 (50–66)	130 (100–160)	170 (130–200)
5 (2016–2017)	1284	98.5 (94.8–99.6)	76 (68–85)	37 (30–44)	74 (66–82)	150 (130–170)	210 (160–270)
6 (2018–2019)	1247	99.2 (96.6–99.8)	76 (70–83)	40 (33–47)	69 (63–76)	140 (100–180)	210 (150–260)
Females, 3–79 years							
3 (2012–2013)	1267	98.2 (90.5–99.7)	67 (60–74)	36 (32–40)	64 (57–71)	130 (100–160)	160 (120–200)
4 (2014–2015)	1262	97.8 (92.1–99.4)	59 (53–67)	34 (31–37)	56 (51–62)	110 (81–140)	170 (110–240)
5 (2016–2017)	1289	100 (99.7–100)	72 (68–78)	42 (38–46)	71 (66–75)	120 (100–130)	150 (110–200)
6 (2018–2019)	1253	100	75 (68–84)	43 (38–48)	71 (64–79)	130 (97–170)	170 (120–230)
3–5 years							
3 (2012–2013)	471	100	80 (75–85)	51 (43–59)	78 (74–81)	120 (110–130)	140 (120–150)
4 (2014–2015)	484	99.9 (99.5–100)	76 (69–84)	49 (44–53)	73 (65–82)	120 (100–130)	140 (110–180)
5 (2016–2017)	479	100	93 (85–100)	59 (48–69)	92 (83–100)	140 (120–160)	170 (150–190)
6 (2018–2019)	478	100	97 (91–100)	66 (58–73)	98 (91–100)	140 (120–150)	150 (110–200)
6–11 years							
3 (2012–2013)	505	100	73 (70–77)	47 (45–48)	74 (68–81)	110 (97–120)	130 (110–150)
4 (2014–2015)	507	99.7 (96.0–100)	70 (65–74)	44 (41–48)	66 (60–73)	100 (95–110)	120 (110–130)
5 (2016–2017)	507	99.9 (99.1–100)	88 (81–95)	52 (47–58)	86 (80–92)	140 (110–160)	170 (120–230)
6 (2018–2019)	499	100	85 (78–92)	57 (53–61)	82 (73–92)	120 (110–130)	140 (130–150)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
3 (2012–2013)	507	98.0 (96.8–99.7)	62 (59–65)	35 (32–37)	60 (57–62)	110 (95–130)	160 (120–200)
4 (2014–2015)	505	98.0 (93.8–99.4)	58 (51–67)	34 (27–41)	55 (49–62)	99 (83–120)	120 ^E (58–180)
5 (2016–2017)	530	99.9 (98.6–100)	71 (64–78)	42 (34–49)	70 (63–78)	110 (96–130)	140 (120–160)
6 (2018–2019)	504	99.8 (95.0–100)	73 (64–84)	45 (40–49)	67 (57–76)	120 (92–140)	140 ^E (31–260)
20–39 years							
3 (2012–2013)	348	96.6 (80.0–99.5)	72 (60–86)	38 (30–46)	74 (62–86)	160 (130–190)	210 (160–260)
4 (2014–2015)	363	97.0 (91.3–99.0)	62 (52–74)	34 (29–39)	57 (49–66)	170 (110–230)	190 (170–220)
5 (2016–2017)	363	99.7 (90.3–100)	82 (74–91)	45 (35–55)	74 (64–83)	170 (130–210)	220 ^E (82–360)
6 (2018–2019)	330	100	80 (70–91)	44 (36–52)	71 (61–80)	170 ^E (96–250)	230 ^E (61–400)
40–59 years							
3 (2012–2013)	311	97.4 (89.6–99.4)	71 (58–86)	36 (31–42)	62 (50–74)	180 (140–220)	230 (170–290)
4 (2014–2015)	312	98.3 (94.2–99.5)	63 (55–71)	35 (30–39)	58 (50–65)	130 (97–160)	160 ^E (57–260)
5 (2016–2017)	345	99.4 (96.4–99.9)	71 (65–79)	38 (33–42)	72 (64–80)	140 (100–170)	160 (110–210)
6 (2018–2019)	346	99.0 (94.6–99.8)	74 (64–86)	38 (32–44)	67 (57–78)	170 (130–220)	210 (160–270)
60–79 years							
3 (2012–2013)	350	98.2 (95.9–99.2)	60 (53–67)	34 (29–39)	60 (50–70)	100 (90–110)	120 (110–130)
4 (2014–2015)	358	94.8 (86.4–98.1)	50 (44–57)	25 (<LOD–33)	50 (44–56)	98 (87–110)	120 (93–150)
5 (2016–2017)	349	97.6 (90.3–99.5)	63 (58–70)	35 (31–39)	63 (56–69)	110 (88–140)	150 ^E (85–210)
6 (2018–2019)	343	99.7 (93.7–100)	68 (63–74)	39 (35–43)	67 (59–74)	110 (97–130)	140 (110–170)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 3, 4, 5 and 6 is 23 pmol/g Hb.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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SUMMARY AND RESULTS FOR PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES 12

12.1 PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are structurally related persistent organic compounds that have a fluorinated alkyl (carbon) chain structure. Perfluoroalkyl substances are characterized by the presence of a fully fluorinated alkyl chain connected to a functional group. In contrast, polyfluoroalkyl substances are not fully fluorinated and have a hydrogen or oxygen attached to at least 1 carbon in the alkyl chain. Nine perfluoroalkyl substances have been measured in the Canadian Health Measures Survey (CHMS) (Table 12.1.1).

Table 12.1.1
Perfluoroalkyl substances measured in the Canadian Health Measures Survey

Perfluoroalkyl substance	CASRN
Perfluorobutanoic acid (PFBA)	375-22-4
Perfluorohexanoic acid (PFHxA)	307-24-4
Perfluorooctanoic acid (PFOA)	335-67-1
Perfluorononanoic acid (PFNA)	375-95-1
Perfluorodecanoic acid (PFDA)	335-76-2
Perfluoroundecanoic acid (PFUnDA)	2058-94-8
Perfluorobutane sulfonate (PFBS)	375-73-5
Perfluorohexane sulfonate (PFHxS)	355-46-4
Perfluorooctane sulfonate (PFOS)	1763-23-1

PFAS are synthetic chemicals with high chemical and thermal stability and the ability to repel both water and oils (Kissa, 2001). These characteristics make them ideal for use as oil, grease, soil and water repellents and as surfactants in a wide range of industrial and consumer product applications (Bălan et al., 2021). These applications span many sectors of the economy, including building and construction, automotive, chemicals and pharmaceuticals, electronics and semiconductors, first-responder safety and health care (Bălan et al., 2021; Kissa, 2001). Fluoropolymers manufactured using salts of PFAS are used in many industrial and consumer products, including surface coatings on textiles and carpets, personal care products, and non-stick coatings on cookware (INAC, 2009; Kissa, 2001; Prevedouros et al., 2005).

Long-chain perfluoroalkyl substances include perfluoroalkyl carboxylates with 8 or more fully fluorinated carbons (e.g. PFOA) and perfluorinated sulfonates with 6 or more fully fluorinated carbons (e.g. PFOS and PFHxS), their salts, and precursor compounds capable of forming long-chain perfluoroalkyl substances (ITRC, 2020). PFOS and PFOA are the most extensively studied and measured PFAS in humans (Dallaire et al., 2009; Hölzer et al., 2008; Kato et al., 2011). PFHxS has been measured in humans, but not as extensively as PFOS and PFOA, while other PFAS, such as PFBA, PFHxA, PFNA, PFDA, PFUnDA and PFBS, have been measured less frequently in human populations.

Worldwide use of PFOS and PFOS-related products has decreased significantly since 2002, when the world's largest producer at the time completed its voluntary phase-out of production (ITRC, 2020). PFHxS, a known by-product in the production of PFOS, was also phased out as a result. Manufacturers have been developing replacement technologies, including reformulating longer-chain substances or substituting them with nonfluorinated chemicals, alternate technologies or shorter-chain PFAS (ITRC, 2020). However, these replacement PFAS may also be associated with environmental and/or human health effects.

PFAS enter the environment through releases during manufacturing and transport, use of products and the disposal and breakdown of larger PFAS. As a result, PFAS have been detected in a wide array of environmental media (Houde et al., 2006).

For the general public, exposure to PFAS is widespread through food, drinking water, consumer products, dust, soil and air (Fromme et al., 2007; 2009; Hölzer et al., 2008). PFAS have been analyzed as part of Health Canada's ongoing Total Diet Study surveys; levels in foods that were commercially sold in Canada were low, similar to levels that have been reported in other countries (HC, 2014; Tittlemier et al., 2006; Tittlemier et al., 2007). The contribution of individual pathways and sources of exposure appears to depend on age, exposure concentration and substance. Generally, ingestion of food, drinking water and house dust are expected to be the main routes of exposure for the general population, while hand-to-mouth contact with consumer products, such as carpets, clothing and upholstery, is a significant contributor for infants, toddlers and children (Sunderland et al., 2019; Trudel et al., 2008).

In general, PFAS are well absorbed in the body, poorly excreted, and not extensively metabolized (Harada et al., 2005; INAC, 2009; Johnson et al., 1984). Half-lives of PFOS, PFOA and PFHxS in humans can range from months to decades (Olsen et al., 2007; Zhang et al., 2013). Shorter-chain PFAS are eliminated much more quickly; for example, the elimination half-life for PFBA is 72 to 81 hours (ATSDR, 2018). In humans, PFOS and PFOA are found in serum, plasma, kidneys and the liver (Butenhoff et al., 2006; Fromme et al., 2009; Kärman et al., 2010). PFAS have also been measured in breast milk and umbilical cord blood (Kärman et al., 2010; Li et al., 2020; Monroy et al., 2008; Motas Guzmán et al., 2016). In general, PFAS have a strong

affinity for the protein fraction in blood and do not typically accumulate in lipids (Kärman et al., 2010; Martin et al., 2004). Serum levels of PFAS, in particular PFOA and PFOS, can reflect cumulative exposure over several years (CDC, 2009). The presence of these substances in serum may also be a result of exposure to other PFAS that can be subsequently metabolized to PFOS and PFOA (ATSDR, 2018). Absorbed PFOA and PFOS are ultimately excreted in urine (ATSDR, 2018).

The primary concern with PFAS is their persistence in the environment and potential persistence in the human body (Olsen et al., 2007). Possible associations between exposure to certain PFAS and adverse human health effects have been identified (ATSDR, 2018). For example, reports in children and neonates suggest associations between serum PFAS and thyroid effects (Lopez-Espinosa et al., 2012; Wang et al., 2014). A recent review by Ballesteros et al. (2017) also reported a positive association between maternal or teenage male exposure to certain PFAS and thyroid-stimulating hormone levels, despite heterogeneity across studies. Research suggests that exposure to certain PFAS may be associated with other health effects, including increased cholesterol levels, the body's ability to respond to vaccines, decreased fertility in women and an increased risk of conditions like high blood pressure or pre-eclampsia in pregnant women (ATSDR, 2018). In several animal species, the liver has been identified as the primary target organ of toxicity for certain PFAS, while effects on the immune system and development have also been noted (ATSDR, 2018; EPA, 2002; HC, 2006). PFOA has been associated with increased incidence of tumours in rodent bioassays and was classified as possibly carcinogenic to humans (Group 2B) based on limited evidence in humans for a positive association with cancers of the testes and kidneys (IARC, 2017).

The Government of Canada evaluated the risks of PFOS, PFOA and long-chain perfluorocarboxylic acids that have the molecular formula $C_nF_{2n+1}CO_2H$ in which $8 \leq n \leq 20$, as well as their salts and precursors (LC-PFCAs), and published the findings in screening assessment reports in 2006 and 2012 (EC, 2006; 2012; EC and HC, 2012). These substances were found to be toxic to the environment and were added to the List of Toxic Substances under Schedule 1 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; 2012a). As a result, measures to manage risks from these substances were put in place.

In response to risk management measures taken over the past decade by the Government of Canada and other international jurisdictions, industry has shifted from using PFOS, PFOA and LC-PFCAs to using other PFAS as substitutes.

In Canada, risk management actions for PFOS have been in place since 2008. Since 2016, the manufacture, use, sale, offer for sale or import of PFOS, PFOA, LC-PFCAs and products that contain them have been prohibited, with a limited number of exemptions (e.g., manufactured items containing PFOA or LC-PFCAs) under the Prohibition of Certain Toxic Substances Regulations, 2012 (Canada, 2012b). In 2018, a consultation document was published outlining a proposal to further restrict these substances by removing all current exemptions (ECCC, 2018). The proposed regulations are targeted for publication in fall 2021. Internationally, Canada is working with the United Nations to eliminate or restrict the production and use of PFOA, PFOS and related substances through the Stockholm Convention on Persistent Organic Pollutants.

Health Canada, in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water,

has also developed guidelines for Canadian drinking water quality that establish maximum acceptable concentrations for PFOS and PFOA in drinking water (HC, 2018a; 2018b). Health Canada has also developed drinking water screening values for several additional PFAS, including PFBA, PFHxA, PFNA, PFBS and PFHxS (HC, 2019; 2020).

A number of biomonitoring studies conducted in Canada have measured concentrations of PFAS in plasma, including the Maternal–Infant Research on Environmental Chemicals (Fisher et al., 2016) and the First Nations Biomonitoring Initiative (AFN, 2013).

PFOS, PFOA and PFHxS were measured in the plasma of CHMS participants aged 20–79 in cycle 1 (2007–2009). PFOS, PFOA and PFHxS, along with PFBA, PFHxA, PFBS, PFNA, PFDA and PFUnDA, were measured in the plasma of CHMS participants aged 12–79 in cycle 2 (2009–2011) and aged 3–79 in cycle 5 (2016–2017) and cycle 6 (2018–2019). Data for PFAS are presented as µg/L in plasma (Tables 12.1.2 to 12.1.19). Finding a measurable amount of PFAS in plasma is an indicator of exposure to PFAS and does not necessarily mean that an adverse health effect will occur.

Table 12.1.2

Perfluorobutanoic acid (PFBA)—Geometric means and selected percentiles of plasma concentrations ($\mu\text{g/L}$) for the Canadian population aged 12–79^a, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 12–79 years							
2 (2009–2011)	1524	0.40 ^E (0.10–1.6)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1583	3.8 ^E (1.8–7.8)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1525	5.4 ^E (3.3–8.8)	—	<LOD	<LOD	<LOD	<LOD
Males, 12–79 years							
2 (2009–2011)	765	0	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	788	5.0 ^E (2.1–11.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	754	7.1 ^E (4.1–12.0)	—	<LOD	<LOD	<LOD	<LOD
Females, 12–79 years							
2 (2009–2011)	759	0.90 ^E (0.20–3.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	795	2.6 ^E (1.2–5.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	771	3.7 ^E (1.2–11.1)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.5, 0.075 and 0.075 $\mu\text{g/L}$, respectively.

- a For the purpose of total population comparisons, only values from participants aged 12–79 years were included, as participants under the age of 12 years were not included in cycle 2.
- b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
- E Use data with caution.

Table 12.1.3

Perfluorobutanoic acid (PFBA)—Geometric means and selected percentiles of plasma concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	2590	4.2 ^E (2.3–7.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2509	5.4 ^E (3.3–8.6)	—	<LOD	<LOD	<LOD	0.078 (<LOD–0.091)
Males, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1292	5.4 ^E (2.7–10.3)	—	<LOD	<LOD	<LOD	0.082 (<LOD–0.092)
6 (2018–2019)	1249	6.8 ^E (4.0–11.4)	—	<LOD	<LOD	<LOD	0.083 (<LOD–0.091)
Females, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1298	3.1 ^E (1.7–5.8)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1260	4.0 ^E (1.5–10.2)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	489	12.9 ^E (7.6–21.2)	—	<LOD	<LOD	0.081 (<LOD–0.10)	0.099 (<LOD–0.13)
6 (2018–2019)	482	12.0 ^E (6.9–19.9)	—	<LOD	<LOD	0.080 ^E (<LOD–0.13)	0.13 ^E (<LOD–0.26)
6–11 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	518	5.9 ^E (3.8–9.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	502	2.1 ^E (0.70–5.8)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
2 (2009–2011)	507	0.40 ^E (0.10–1.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	527	2.0 ^E (1.0–4.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	507	4.3 ^E (1.9–9.5)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
2 (2009–2011)	362	0	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	362	0.70 ^E (0.30–1.8)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	330	4.4 ^E (1.5–12.2)	—	<LOD	<LOD	<LOD	<LOD

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
40–59 years							
2 (2009–2011)	334	0	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	345	4.9 ^E (1.3–16.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	345	7.0 ^E (3.1–14.9)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
2 (2009–2011)	321	2.2 ^E (0.40–10.1)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	349	7.5 ^E (3.7–14.5)	—	<LOD	<LOD	<LOD	0.096 ^E (<LOD–0.14)
6 (2018–2019)	343	5.1 ^E (2.4–10.4)	—	<LOD	<LOD	<LOD	<LOD ^E (<LOD–0.13)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.5, 0.075 and 0.075 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of 12 years were not included in cycle 2.

E Use data with caution.

Table 12.1.4

Perfluorohexanoic acid (PFHxA)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79^a, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 12–79 years							
2 (2009–2011)	1524	1.6 ^E (0.50–4.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1583	9.2 ^E (4.9–16.4)	—	<LOD	<LOD	<LOD	0.13 ^E (<LOD–0.18)
6 (2018–2019)	1526	1.0 ^E (0.30–3.0)	—	<LOD	<LOD	<LOD	<LOD
Males, 12–79 years							
2 (2009–2011)	765	2.1 ^E (0.60–7.1)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	788	11.0 ^E (6.0–19.3)	—	<LOD	<LOD	0.095 ^E (<LOD–0.14)	0.15 ^E (0.094–0.21)
6 (2018–2019)	757	0.80 ^E (0.20–2.5)	—	<LOD	<LOD	<LOD	<LOD
Females, 12–79 years							
2 (2009–2011)	759	1.2 ^E (0.40–3.6)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	795	7.4 ^E (3.6–14.5)	—	<LOD	<LOD	<LOD	0.11 ^E (<LOD–0.16)
6 (2018–2019)	769	1.2 ^E (0.30–4.3)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.1, 0.084 and 0.084 µg/L, respectively.

a For the purpose of total population comparisons, only values from participants aged 12–79 years were included, as participants under the age of 12 years were not included in cycle 2.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 12.1.5

Perfluorohexanoic acid (PFHxA)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	2593	9.2 ^E (5.0–16.2)	—	<LOD	<LOD	<LOD	0.13 ^E (<LOD–0.18)
6 (2018–2019)	2512	1.0 ^E (0.30–2.9)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1294	10.9 ^E (6.0–18.9)	—	<LOD	<LOD	0.094 ^E (<LOD–0.13)	0.15 ^E (0.094–0.21)
6 (2018–2019)	1253	0.70 ^E (0.20–2.3)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1299	7.5 ^E (3.7–14.4)	—	<LOD	<LOD	<LOD	0.11 ^E (<LOD–0.16)
6 (2018–2019)	1259	1.2 ^E (0.30–4.3)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	490	7.0 ^E (3.2–14.5)	—	<LOD	<LOD	<LOD	0.12 ^E (<LOD–0.18)
6 (2018–2019)	482	0.30 ^E (0–1.8)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	520	10.2 ^E (5.6–17.7)	—	<LOD	<LOD	<LOD	0.14 ^E (<LOD–0.21)
6 (2018–2019)	504	0.80 ^E (0.20–3.8)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
2 (2009–2011)	507	1.7 ^E (0.60–4.2)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	527	9.8 ^E (4.5–20.0)	—	<LOD	<LOD	<LOD	0.11 ^E (<LOD–0.16)
6 (2018–2019)	508	1.5 ^E (0.40–6.4)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
2 (2009–2011)	362	0.30 ^E (0.10–0.90)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	362	3.6 ^E (1.5–8.3)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	330	0.30 ^E (0.10–1.2)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
2 (2009–2011)	334	2.4 ^E (0.60–9.7)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	346	15.2 ^E (7.6–28.1)	—	<LOD	<LOD	0.12 ^E (<LOD–0.17)	0.19 ^E (0.091–0.30)
6 (2018–2019)	344	0.90 ^E (0.30–2.3)	—	<LOD	<LOD	<LOD	<LOD

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
60–79 years							
2 (2009–2011)	321	2.8 ^E (0.50–13.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	348	8.1 ^E (3.1–19.6)	—	<LOD	<LOD	<LOD	0.11 ^E (<LOD–0.21)
6 (2018–2019)	344	1.9 ^E (0.40–7.7)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.1, 0.084 and 0.084 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of 12 years were not included in cycle 2.

E Use data with caution.

Table 12.1.6

Perfluorooctanoic acid (PFOA)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79^a, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 20–79 years							
1 (2007–2009)	2880	99.0 (97.7–99.6)	2.5 (2.4–2.7)	1.3 (1.1–1.4)	2.6 (2.4–2.8)	4.6 (4.3–5.0)	5.5 (5.1–5.8)
2 (2009–2011)	1017	100	2.3 (2.1–2.5)	1.1 (0.91–1.2)	2.4 (2.1–2.6)	4.3 (3.9–4.7)	5.3 (3.9–6.7)
5 (2016–2017)	1055	100	1.3 (1.2–1.5)	0.63 (0.57–0.68)	1.3 (1.1–1.4)	2.7 (2.2–3.2)	3.2 (2.5–3.8)
6 (2018–2019)	1019	100	1.2 (1.1–1.3)	0.59 (0.53–0.65)	1.2 (1.1–1.3)	2.5 (2.2–2.8)	2.9 (2.6–3.3)
Males, 20–79 years							
1 (2007–2009)	1376	99.4 (98.6–99.8)	2.9 (2.7–3.2)	1.6 (1.4–1.7)	3.1 (2.8–3.3)	5.0 (4.5–5.5)	5.9 (5.4–6.4)
2 (2009–2011)	511	100	2.6 (2.4–2.9)	1.3 (0.99–1.6)	2.7 (2.5–2.9)	4.5 (3.2–5.8)	6.0 (4.3–7.7)
5 (2016–2017)	525	100	1.5 (1.3–1.7)	0.89 (0.80–0.98)	1.4 (1.1–1.6)	2.8 (2.1–3.6)	3.5 (2.6–4.3)
6 (2018–2019)	501	100	1.4 (1.2–1.6)	0.69 (0.54–0.84)	1.3 (1.1–1.5)	2.8 (2.5–3.1)	3.3 (2.8–3.8)
Females, 20–79 years							
1 (2007–2009)	1504	98.6 (96.3–99.5)	2.2 (2.0–2.4)	1.0 (0.92–1.2)	2.2 (2.1–2.4)	4.1 (3.7–4.5)	5.0 (4.4–5.5)
2 (2009–2011)	506	100	2.0 (1.8–2.2)	0.92 (0.73–1.1)	2.0 (1.7–2.3)	3.9 (3.6–4.3)	4.4 (3.8–5.1)
5 (2016–2017)	530	100	1.1 (1.0–1.3)	0.54 (0.47–0.60)	1.0 (0.90–1.2)	2.5 (2.0–3.0)	3.0 (2.7–3.3)
6 (2018–2019)	518	100	1.1 (0.97–1.2)	0.51 (0.44–0.59)	1.0 (0.84–1.2)	2.1 (1.8–2.3)	2.5 (2.1–2.9)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.3, 0.1, 0.066 and 0.066 µg/L, respectively.

a For the purpose of total population comparisons, only values from participants aged 20–79 years were included, as participants under the age of 20 years were not included in cycle 1.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

Table 12.1.7

Perfluorooctanoic acid (PFOA)—Geometric means and selected percentiles of plasma concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	2593	100	1.3 (1.2–1.4)	0.64 (0.58–0.71)	1.2 (1.1–1.3)	2.6 (2.2–3.0)	3.1 (2.6–3.6)
6 (2018–2019)	2513	100	1.2 (1.1–1.3)	0.60 (0.54–0.65)	1.1 (1.0–1.2)	2.4 (2.1–2.7)	2.9 (2.6–3.3)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	1294	100	1.5 (1.3–1.6)	0.87 (0.79–0.95)	1.3 (1.2–1.5)	2.6 (2.1–3.2)	3.4 (2.5–4.3)
6 (2018–2019)	1253	100	1.3 (1.2–1.5)	0.69 (0.57–0.80)	1.3 (1.1–1.4)	2.7 (2.4–3.1)	3.2 (2.8–3.7)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	1299	100	1.1 (1.0–1.3)	0.56 (0.51–0.60)	1.1 (0.95–1.2)	2.4 (2.0–2.8)	2.9 (2.7–3.2)
6 (2018–2019)	1260	100	1.1 (0.97–1.2)	0.53 (0.46–0.59)	1.0 (0.89–1.1)	2.0 (1.8–2.2)	2.5 (2.1–2.8)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	491	100	1.5 (1.3–1.6)	0.81 (0.72–0.90)	1.3 (1.1–1.5)	2.7 (2.1–3.2)	3.6 (2.4–4.7)
6 (2018–2019)	482	100	1.3 (1.2–1.4)	0.75 (0.63–0.87)	1.2 (1.1–1.3)	2.4 (2.2–2.7)	2.7 (1.9–3.5)
6–11 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	520	100	1.3 (1.2–1.4)	0.81 (0.74–0.88)	1.2 (1.1–1.3)	2.1 (1.7–2.4)	2.4 (2.0–2.9)
6 (2018–2019)	504	100	1.2 (1.1–1.4)	0.77 (0.66–0.89)	1.1 (0.97–1.2)	2.0 (1.4–2.6)	2.8 ^E (1.7–3.8)
12–19 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	507	100	2.1 (1.9–2.3)	1.2 (1.0–1.4)	2.1 (1.9–2.3)	3.4 (3.0–3.7)	4.1 (3.6–4.5)
5 (2016–2017)	527	100	1.1 (0.95–1.2)	0.63 (0.57–0.70)	1.0 (0.90–1.1)	1.6 (1.5–1.8)	1.9 (1.4–2.4)
6 (2018–2019)	508	100	0.96 (0.86–1.1)	0.59 (0.53–0.65)	0.92 (0.82–1.0)	1.5 (1.3–1.8)	1.8 (1.2–2.3)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	979	99.1 (96.5–99.8)	2.4 (2.2–2.7)	1.1 (0.95–1.3)	2.5 (2.3–2.8)	4.5 (4.0–5.1)	5.4 (4.8–5.9)
2 (2009–2011)	362	100	2.2 (1.9–2.5)	0.88 (0.64–1.1)	2.3 (1.9–2.8)	4.4 (3.2–5.7)	5.8 (3.9–7.6)
5 (2016–2017)	362	100	1.1 (1.0–1.2)	0.56 (0.49–0.62)	1.1 (0.94–1.2)	2.1 (1.8–2.4)	2.5 (2.2–2.9)
6 (2018–2019)	330	100	1.0 (0.92–1.1)	0.45 (0.34–0.56)	1.0 (0.88–1.1)	2.4 (1.5–3.2)	2.8 (2.0–3.7)
40–59 years							
1 (2007–2009)	983	99.3 (97.9–99.8)	2.5 (2.3–2.7)	1.3 (1.2–1.4)	2.5 (2.3–2.8)	4.5 (4.0–4.9)	5.4 (4.6–6.1)
2 (2009–2011)	334	100	2.2 (2.0–2.4)	1.1 (0.87–1.3)	2.1 (1.7–2.5)	3.9 (3.6–4.1)	4.4 (3.9–5.0)
5 (2016–2017)	345	100	1.4 (1.2–1.6)	0.68 (0.58–0.77)	1.3 (1.1–1.4)	3.1 ^E (1.8–4.3)	3.8 ^E (2.3–5.3)
6 (2018–2019)	345	100	1.2 (1.1–1.4)	0.60 (0.46–0.73)	1.1 (0.95–1.2)	2.4 (1.8–3.1)	2.8 (1.8–3.7)
60–79 years							
1 (2007–2009)	918	98.3 (95.3–99.4)	2.8 (2.5–3.0)	1.5 (1.3–1.7)	2.8 (2.6–3.0)	5.2 (4.7–5.7)	6.3 (5.4–7.1)
2 (2009–2011)	321	100	2.8 (2.4–3.2)	1.5 (1.0–2.0)	2.7 (2.1–3.2)	4.6 (3.1–6.0)	6.4 (4.6–8.1)
5 (2016–2017)	348	100	1.6 (1.4–1.8)	0.86 (0.71–1.0)	1.6 (1.3–1.9)	2.9 (2.8–3.1)	3.4 (2.7–4.1)
6 (2018–2019)	344	100	1.5 (1.4–1.7)	0.83 (0.75–0.91)	1.5 (1.3–1.7)	2.7 (2.4–3.0)	3.1 (2.5–3.7)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.3, 0.1, 0.066 and 0.066 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
- b Data are not available, as participants under the age of 20 years were not included in cycle 1.
- c Data are not available, as participants under the age of 12 years were not included in cycle 2.
- E Use data with caution.

Table 12.1.8

Perfluorononanoic acid (PFNA)—Geometric means and selected percentiles of plasma concentrations ($\mu\text{g/L}$) for the Canadian population aged 12–79^a, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 12–79 years							
2 (2009–2011)	1524	99.4 (98.6–99.8)	0.82 (0.75–0.90)	0.39 (0.33–0.44)	0.80 (0.70–0.90)	1.5 (1.3–1.8)	1.9 ^E (1.1–2.7)
5 (2016–2017)	1497	98.8 (96.9–99.6)	0.51 (0.45–0.58)	0.24 (0.21–0.27)	0.50 (0.46–0.54)	1.1 (0.80–1.4)	1.5 (1.2–1.8)
6 (2018–2019)	1457	98.4 (97.1–99.1)	0.44 (0.41–0.47)	0.22 (0.20–0.24)	0.41 (0.38–0.44)	0.95 (0.86–1.0)	1.2 (1.1–1.3)
Males, 12–79 years							
2 (2009–2011)	765	99.2 (97.5–99.8)	0.84 (0.75–0.94)	0.43 (0.37–0.48)	0.80 (0.69–0.91)	1.6 (1.4–1.8)	1.9 (1.5–2.2)
5 (2016–2017)	755	99.4 (97.9–99.8)	0.54 (0.47–0.62)	0.27 (0.24–0.31)	0.51 (0.46–0.56)	1.1 (0.72–1.4)	1.4 (1.0–1.9)
6 (2018–2019)	730	99.1 (97.1–99.7)	0.48 (0.44–0.53)	0.24 (0.22–0.27)	0.45 (0.39–0.50)	1.1 (0.95–1.2)	1.4 (1.1–1.8)
Females, 12–79 years							
2 (2009–2011)	759	99.6 (99.1–99.8)	0.81 (0.73–0.89)	0.35 (0.30–0.40)	0.79 (0.69–0.90)	1.5 (1.1–2.0)	2.3 ^E (1.2–3.4)
5 (2016–2017)	742	98.2 (94.8–99.4)	0.49 (0.43–0.55)	0.21 (0.19–0.23)	0.48 (0.44–0.53)	1.1 (0.77–1.5)	1.7 ^E (0.79–2.5)
6 (2018–2019)	727	97.6 (95.9–98.6)	0.41 (0.37–0.44)	0.20 (0.18–0.23)	0.39 (0.34–0.44)	0.80 (0.69–0.91)	1.0 (0.83–1.2)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.2, 0.13 and 0.13 $\mu\text{g/L}$, respectively.

- a For the purpose of total population comparisons, only values from participants aged 12–79 years were included, as participants under the age of 12 years were not included in cycle 2.
- b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
- E Use data with caution.

Table 12.1.9

Perfluorononanoic acid (PFNA)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	2442	98.8 (97.1–99.5)	0.51 (0.45–0.57)	0.24 (0.21–0.26)	0.49 (0.45–0.53)	1.1 (0.81–1.3)	1.5 (1.2–1.8)
6 (2018–2019)	2396	98.5 (97.3–99.1)	0.44 (0.41–0.47)	0.22 (0.20–0.23)	0.41 (0.39–0.43)	0.94 (0.84–1.0)	1.2 (1.1–1.3)
Males, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1236	99.3 (98.1–99.8)	0.53 (0.46–0.61)	0.27 (0.23–0.30)	0.51 (0.46–0.56)	1.0 (0.73–1.4)	1.4 (1.0–1.8)
6 (2018–2019)	1198	99.1 (97.3–99.7)	0.47 (0.43–0.52)	0.23 (0.21–0.26)	0.43 (0.39–0.47)	1.1 (0.92–1.2)	1.4 (1.1–1.7)
Females, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1206	98.3 (95.2–99.4)	0.48 (0.43–0.54)	0.21 (0.19–0.23)	0.47 (0.42–0.52)	1.1 (0.76–1.4)	1.6 ^E (0.79–2.5)
6 (2018–2019)	1198	97.8 (96.2–98.7)	0.40 (0.37–0.44)	0.20 (0.19–0.22)	0.39 (0.35–0.43)	0.80 (0.68–0.92)	1.0 (0.86–1.2)
3–5 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	453	99.3 (97.7–99.8)	0.45 (0.40–0.51)	0.21 (0.19–0.24)	0.39 (0.34–0.44)	0.95 (0.81–1.1)	1.3 ^E (0.76–1.8)
6 (2018–2019)	456	99.2 (94.7–99.9)	0.38 (0.35–0.41)	0.19 (0.16–0.21)	0.39 (0.32–0.45)	0.79 (0.61–0.96)	0.99 (0.83–1.1)
6–11 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	492	98.7 (95.8–99.6)	0.45 (0.37–0.53)	0.23 (0.19–0.28)	0.40 (0.35–0.44)	1.0 (0.66–1.4)	1.5 ^E (0.45–2.6)
6 (2018–2019)	483	99.3 (96.7–99.9)	0.38 (0.33–0.45)	0.20 (0.19–0.21)	0.36 (0.30–0.43)	0.86 ^E (0.44–1.3)	1.3 ^E (0.74–1.9)
12–19 years							
2 (2009–2011)	507	99.1 (97.8–99.6)	0.71 (0.62–0.81)	0.33 (0.27–0.38)	0.69 (0.63–0.75)	1.4 (1.0–1.7)	1.7 ^E (0.47–2.9)
5 (2016–2017)	494	99.4 (97.2–99.9)	0.41 (0.33–0.51)	0.21 (0.18–0.24)	0.37 (0.33–0.41)	1.0 ^E (0.51–1.5)	1.5 ^E (<LOD–3.0)
6 (2018–2019)	474	96.8 (85.5–99.4)	0.34 (0.30–0.40)	0.17 (0.13–0.21)	0.34 (0.30–0.39)	0.75 (0.55–0.95)	0.90 (0.71–1.1)
20–39 years							
2 (2009–2011)	362	99.0 (96.9–99.7)	0.79 (0.72–0.86)	0.38 (0.30–0.46)	0.77 (0.62–0.92)	1.5 (1.3–1.7)	1.6 ^E (0.41–2.9)
5 (2016–2017)	336	98.4 (95.6–99.4)	0.41 (0.36–0.47)	0.21 (0.14–0.28)	0.44 (0.37–0.50)	0.77 (0.61–0.92)	0.91 (0.71–1.1)
6 (2018–2019)	312	97.7 (95.8–98.8)	0.37 (0.33–0.41)	0.20 (0.17–0.22)	0.35 (0.31–0.40)	0.83 (0.54–1.1)	0.95 (0.70–1.2)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
40–59 years							
2 (2009–2011)	334	98.7 (97.6–100)	0.79 (0.69–0.90)	0.41 (0.32–0.50)	0.78 (0.65–0.91)	1.3 (0.99–1.6)	1.7 (1.1–2.2)
5 (2016–2017)	332	98.7 (90.2–99.8)	0.60 (0.48–0.74)	0.27 (0.22–0.33)	0.56 (0.47–0.64)	1.4 (0.94–2.0)	1.7 ^E (0.77–2.6)
6 (2018–2019)	331	99.3 (98.2–99.7)	0.44 (0.40–0.49)	0.24 (0.22–0.27)	0.42 (0.38–0.45)	0.92 (0.66–1.2)	1.2 (0.93–1.4)
60–79 years							
2 (2009–2011)	321	100	1.1 (0.87–1.3)	0.45 ^E (0.25–0.65)	1.0 (0.86–1.1)	2.0 ^E (1.2–2.8)	2.7 ^E (1.5–3.8)
5 (2016–2017)	335	99.3 (98.2–99.7)	0.62 (0.55–0.69)	0.31 ^E (0.19–0.43)	0.61 (0.56–0.66)	1.2 (0.99–1.4)	1.5 (1.2–1.8)
6 (2018–2019)	340	98.5 (95.1–99.6)	0.61 (0.55–0.69)	0.32 (0.23–0.40)	0.57 (0.52–0.62)	1.3 (0.87–1.7)	1.8 (1.5–2.0)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.2, 0.13 and 0.13 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of 12 years were not included in cycle 2.

E Use data with caution.

Table 12.1.10

Perfluorodecanoic acid (PFDA)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79^a, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 12–79 years							
2 (2009–2011)	1524	79.3 (72.6–84.7)	0.20 (0.17–0.22)	<LOD	0.17 (0.15–0.19)	0.46 (0.31–0.62)	0.66 (0.45–0.87)
5 (2016–2017)	1450	91.4 (85.9–94.9)	0.18 (0.16–0.21)	<LOD	0.17 (0.15–0.18)	0.48 (0.34–0.62)	0.65 (0.45–0.84)
6 (2018–2019)	1427	69.0 (63.1–74.4)	0.12 (0.11–0.14)	<LOD	0.12 (0.11–0.14)	0.37 (0.30–0.44)	0.51 (0.45–0.58)
Males, 12–79 years							
2 (2009–2011)	765	83.1 (75.2–88.9)	0.20 (0.18–0.23)	<LOD	0.18 (0.15–0.20)	0.38 (0.26–0.51)	0.55 (0.41–0.70)
5 (2016–2017)	715	94.1 (80.3–98.4)	0.18 (0.16–0.22)	0.10 (<LOD–0.13)	0.17 (0.14–0.19)	0.44 ^E (0.28–0.60)	0.55 (0.35–0.74)
6 (2018–2019)	701	68.3 (60.3–75.3)	0.13 (0.11–0.15)	<LOD	0.13 (0.11–0.14)	0.47 (0.35–0.59)	0.56 (0.46–0.66)
Females, 12–79 years							
2 (2009–2011)	759	75.6 (66.9–82.5)	0.19 (0.16–0.23)	<LOD	0.17 (0.14–0.19)	0.50 (0.32–0.68)	0.73 ^E (<LOD–1.4)
5 (2016–2017)	735	88.8 (82.3–93.0)	0.18 (0.16–0.21)	<LOD	0.17 (0.15–0.18)	0.54 (0.35–0.73)	0.76 ^E (0.32–1.2)
6 (2018–2019)	726	69.7 (61.9–76.5)	0.12 (0.10–0.14)	<LOD	0.12 (0.10–0.14)	0.33 (0.25–0.41)	0.43 (0.34–0.52)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.1, 0.092 and 0.092 µg/L, respectively.

a For the purpose of total population comparisons, only values from participants aged 12–79 years were included, as participants under the age of 12 years were not included in cycle 2.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 12.1.11

Perfluorodecanoic acid (PFDA)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	2360	91.4 (86.0–94.8)	0.18 (0.16–0.20)	0.094 (<LOD–0.12)	0.16 (0.15–0.18)	0.44 (0.31–0.56)	0.64 (0.47–0.81)
6 (2018–2019)	2354	67.6 (61.4–73.2)	0.12 (0.11–0.14)	<LOD	0.12 (0.11–0.13)	0.35 (0.28–0.41)	0.51 (0.44–0.57)
Males, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1175	94.0 (81.9–98.2)	0.18 (0.15–0.21)	0.10 (<LOD–0.13)	0.16 (0.14–0.18)	0.40 ^E (0.25–0.56)	0.52 (0.34–0.71)
6 (2018–2019)	1165	66.6 (58.7–73.7)	0.12 (0.11–0.14)	<LOD	0.12 (0.10–0.14)	0.44 (0.32–0.55)	0.56 (0.48–0.63)
Females, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1185	89.0 (82.8–93.1)	0.18 (0.15–0.20)	<LOD	0.16 (0.14–0.18)	0.48 ^E (0.29–0.67)	0.74 ^E (0.37–1.1)
6 (2018–2019)	1189	68.5 (60.8–75.2)	0.12 (0.10–0.14)	<LOD	0.12 (0.10–0.14)	0.32 (0.24–0.40)	0.40 (0.31–0.50)
3–5 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	443	91.6 (83.7–95.9)	0.14 (0.13–0.16)	0.095 (<LOD–0.13)	0.14 (0.13–0.15)	0.25 (0.20–0.30)	0.32 (0.25–0.38)
6 (2018–2019)	451	58.6 (46.2–70.1)	—	<LOD	0.10 (<LOD–0.11)	0.21 (0.15–0.26)	0.28 ^E (<LOD–0.53)
6–11 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	467	91.7 (85.9–95.2)	0.14 (0.13–0.15)	0.093 (<LOD–0.10)	0.14 (0.13–0.15)	0.24 (0.22–0.26)	0.28 (0.24–0.31)
6 (2018–2019)	476	53.6 (41.3–65.6)	<LOD (<LOD–0.11)	<LOD	0.098 (<LOD–0.12)	0.23 (0.17–0.28)	0.30 ^E (0.19–0.41)
12–19 years							
2 (2009–2011)	507	72.1 (62.0–80.3)	0.15 (0.13–0.18)	<LOD	0.14 (0.12–0.16)	0.31 (0.24–0.37)	0.39 ^E (0.22–0.55)
5 (2016–2017)	474	86.7 (78.9–91.9)	0.13 (0.11–0.15)	<LOD	0.13 (0.11–0.14)	0.22 (0.19–0.26)	0.34 ^E (0.11–0.57)
6 (2018–2019)	486	46.6 (30.6–63.3)	—	<LOD	<LOD	0.23 (0.17–0.28)	0.28 (0.20–0.36)
20–39 years							
2 (2009–2011)	362	84.7 (76.1–90.6)	0.22 (0.20–0.23)	<LOD	0.17 (0.16–0.19)	0.39 ^E (0.21–0.56)	0.74 ^E (<LOD–1.6)
5 (2016–2017)	331	88.9 (71.0–96.3)	0.16 (0.13–0.20)	<LOD	0.15 (0.12–0.18)	0.32 (0.23–0.41)	0.47 ^E (0.23–0.71)
6 (2018–2019)	298	66.4 (57.8–74.0)	0.11 (0.094–0.13)	<LOD	0.11 (<LOD–0.13)	0.25 ^E (0.14–0.37)	0.39 ^E (0.22–0.55)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
40–59 years							
2 (2009–2011)	334	73.6 (62.3–82.5)	0.17 (0.14–0.21)	<LOD	0.16 (0.13–0.19)	0.34 ^E (0.17–0.52)	0.51 (0.35–0.66)
5 (2016–2017)	322	91.7 (82.6–96.3)	0.21 (0.17–0.26)	0.099 (<LOD–0.12)	0.18 (0.15–0.21)	0.64 ^E (0.36–0.93)	0.89 ^E (0.40–1.4)
6 (2018–2019)	326	69.3 (60.6–76.8)	0.13 (0.11–0.15)	<LOD	0.12 (0.098–0.14)	0.42 (0.27–0.56)	0.54 (0.42–0.66)
60–79 years							
2 (2009–2011)	321	83.7 (70.9–91.5)	0.25 (0.17–0.35)	<LOD	0.23 (0.17–0.29)	0.65 (0.43–0.87)	0.80 ^E (0.21–1.4)
5 (2016–2017)	323	96.6 (90.7–98.8)	0.21 (0.19–0.24)	0.10 (<LOD–0.13)	0.20 (0.17–0.22)	0.47 (0.36–0.58)	0.62 (0.44–0.79)
6 (2018–2019)	317	81.9 (73.9–87.8)	0.17 (0.15–0.20)	<LOD	0.17 (0.15–0.20)	0.50 (0.37–0.62)	0.66 (0.49–0.83)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.1, 0.092 and 0.092 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of 12 years were not included in cycle 2.

E Use data with caution.

Table 12.12

Perfluoroundecanoic acid (PFUnDA)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79^a, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 12–79 years							
2 (2009–2011)	1522	59.3 (47.5–70.0)	0.12 (0.098–0.14)	<LOD	0.095 (<LOD–0.10)	0.37 (0.28–0.45)	0.56 ^E (0.30–0.82)
5 (2016–2017)	1576	38.5 (29.1–48.9)	—	<LOD	<LOD	0.35 (0.23–0.47)	0.50 (0.34–0.67)
6 (2018–2019)	1527	39.0 (31.3–47.2)	—	<LOD	<LOD	0.36 (0.28–0.44)	0.47 (0.35–0.60)
Males, 12–79 years							
2 (2009–2011)	765	55.5 (43.1–67.3)	—	<LOD	0.094 (<LOD–0.11)	0.34 (0.26–0.42)	0.47 ^E (0.27–0.67)
5 (2016–2017)	783	35.7 (24.7–48.5)	—	<LOD	<LOD	0.37 ^E (0.21–0.52)	0.42 ^E (0.25–0.58)
6 (2018–2019)	756	38.3 (31.6–45.4)	—	<LOD	<LOD	0.38 (0.30–0.46)	0.52 ^E (0.31–0.72)
Females, 12–79 years							
2 (2009–2011)	757	63.0 (50.8–73.7)	0.12 (0.10–0.15)	<LOD	0.096 (<LOD–0.11)	0.39 (0.26–0.52)	0.63 ^E (0.24–1.0)
5 (2016–2017)	793	41.2 (32.2–50.9)	—	<LOD	<LOD	0.33 ^E (0.19–0.47)	0.55 ^E (0.30–0.79)
6 (2018–2019)	771	39.6 (28.2–52.4)	—	<LOD	<LOD	0.32 (0.24–0.41)	0.41 (0.31–0.52)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.09, 0.12 and 0.12 µg/L, respectively.

a For the purpose of total population comparisons, only values from participants aged 12–79 years were included, as participants under the age of 12 years were not included in cycle 2.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 12.1.13

Perfluoroundecanoic acid (PFUnDA)—Geometric means and selected percentiles of plasma concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	2583	35.8 (26.9–45.8)	—	<LOD	<LOD	0.32 (0.21–0.43)	0.46 (0.30–0.63)
6 (2018–2019)	2508	36.3 (29.2–44.0)	—	<LOD	<LOD	0.33 (0.27–0.40)	0.43 (0.34–0.53)
Males, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1289	33.3 (23.2–45.2)	—	<LOD	<LOD	0.34 ^E (0.19–0.49)	0.42 (0.27–0.57)
6 (2018–2019)	1250	35.3 (29.2–42.0)	—	<LOD	<LOD	0.37 (0.28–0.46)	0.50 (0.32–0.67)
Females, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1294	38.3 (29.8–47.7)	—	<LOD	<LOD	0.31 (0.21–0.41)	0.54 ^E (0.32–0.76)
6 (2018–2019)	1258	37.2 (26.7–49.0)	—	<LOD	<LOD	0.31 (0.22–0.39)	0.38 (0.29–0.47)
3–5 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	487	10.0 ^E (6.3–15.4)	—	<LOD	<LOD	<LOD	0.14 (<LOD–0.17)
6 (2018–2019)	479	10.3 ^E (6.0–17.1)	—	<LOD	<LOD	<LOD ^E (<LOD–0.19)	0.16 ^E (<LOD–0.28)
6–11 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	520	13.6 ^E (7.6–23.1)	—	<LOD	<LOD	0.13 (<LOD–0.16)	0.20 ^E (<LOD–0.28)
6 (2018–2019)	502	14.0 (9.7–19.8)	—	<LOD	<LOD	0.14 ^E (<LOD–0.20)	0.21 (0.14–0.27)
12–19 years							
2 (2009–2011)	506	36.8 (25.1–50.2)	—	<LOD	<LOD	0.19 (0.13–0.24)	0.30 (0.21–0.38)
5 (2016–2017)	525	16.4 ^E (10.5–24.7)	—	<LOD	<LOD	0.15 (<LOD–0.19)	0.19 (0.14–0.23)
6 (2018–2019)	508	22.1 ^E (13.2–34.6)	—	<LOD	<LOD	0.21 (0.14–0.27)	0.38 ^E (0.13–0.63)
20–39 years							
2 (2009–2011)	362	58.9 (45.7–71.0)	0.13 (0.10–0.16)	<LOD	0.098 (<LOD–0.12)	0.36 ^E (0.21–0.51)	0.64 ^E (0.22–1.1)
5 (2016–2017)	358	33.2 ^E (20.9–48.3)	—	<LOD	<LOD	0.27 ^E (0.15–0.40)	0.36 ^E (0.16–0.56)
6 (2018–2019)	329	34.2 (26.2–43.2)	—	<LOD	<LOD	0.32 ^E (0.15–0.49)	0.38 ^E (0.21–0.55)
40–59 years							
2 (2009–2011)	334	66.0 (51.3–78.1)	0.11 (0.095–0.14)	<LOD	0.095 (<LOD–0.10)	0.35 ^E (0.22–0.49)	0.43 (0.28–0.58)
5 (2016–2017)	346	43.2 (29.7–57.7)	—	<LOD	<LOD	0.43 ^E (0.19–0.67)	0.64 ^E (0.36–0.91)
6 (2018–2019)	346	39.4 (27.3–52.8)	—	<LOD	<LOD	0.37 (0.27–0.46)	0.52 ^E (0.26–0.77)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
60–79 years							
2 (2009–2011)	320	62.2 (38.9–81.0)	0.14 ^E (0.090–0.23)	<LOD	0.11 ^E (<LOD–0.17)	0.54 ^E (0.17–0.90)	0.84 ^E (0.42–1.3)
5 (2016–2017)	347	49.5 (38.7–60.4)	—	<LOD	<LOD	0.36 (0.27–0.46)	0.49 (0.37–0.62)
6 (2018–2019)	344	52.3 (44.0–60.4)	—	<LOD	0.13 (<LOD–0.17)	0.38 (0.30–0.47)	0.54 ^E (0.33–0.75)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.09, 0.12 and 0.12 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of 12 years were not included in cycle 2.

E Use data with caution.

Table 12.14

Perfluorobutane sulfonate (PFBS)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 12–79^a, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 12–79 years							
2 (2009–2011)	1524	0	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1577	0.10 ^E (0–0.30)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1528	0.20 ^E (0.10–0.70)	—	<LOD	<LOD	<LOD	<LOD
Males, 12–79 years							
2 (2009–2011)	765	0	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	784	0.20 ^E (0.10–0.50)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	757	0.40 ^E (0.10–1.5)	—	<LOD	<LOD	<LOD	<LOD
Females, 12–79 years							
2 (2009–2011)	759	0	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	793	0 ^E (0–0.10)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	771	0 ^E (0–0.40)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.4, 0.066 and 0.066 µg/L, respectively.

a For the purpose of total population comparisons, only values from participants aged 12–79 years were included, as participants under the age of 12 years were not included in cycle 2.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 12.1.15

Perfluorobutane sulfonate (PFBS)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	2584	0.10 ^E (0.10–0.30)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2514	0.30 ^E (0.10–0.80)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1289	0.30 ^E (0.10–0.60)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1253	0.40 ^E (0.10–1.3)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	1295	0 ^E (0–0.10)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1261	0.30 ^E (0.10–1.3)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	490	0.60 ^E (0.10–2.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	482	3.5 ^E (0.60–17.2)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
2 (2009–2011) ^b	—	—	—	—	—	—	—
5 (2016–2017)	517	0.20 ^E (0–1.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	504	0.40 ^E (0.10–1.2)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
2 (2009–2011)	507	0	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	526	0.70 ^E (0.20–2.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	508	1.4 ^E (0.30–5.4)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
2 (2009–2011)	362	0	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	361	0.10 ^E (0–0.60)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	330	0	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
2 (2009–2011)	334	0	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	343	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	346	0	—	<LOD	<LOD	<LOD	<LOD

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
60–79 years							
2 (2009–2011)	321	0	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	347	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	344	0.30 ^E (0–2.8)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.4, 0.066 and 0.066 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of 12 years were not included in cycle 2.

E Use data with caution.

Table 12.1.16

Perfluorohexane sulfonate (PFHxS)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 20–79^a, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 20–79 years							
1 (2007–2009)	2880	97.8 (96.2–98.8)	2.3 (2.0–2.6)	0.70 (0.50–0.89)	2.2 (1.8–2.5)	7.3 (6.6–8.1)	12 (9.2–15)
2 (2009–2011)	1015	98.4 (96.4–99.3)	1.7 (1.6–2.0)	0.55 (0.44–0.65)	1.7 (1.5–1.9)	5.9 (4.0–7.9)	8.9 ^E (4.6–13)
5 (2016–2017)	1057	99.6 (98.6–99.9)	0.98 (0.85–1.1)	0.28 (0.21–0.34)	0.99 (0.88–1.1)	3.1 (2.2–4.0)	5.8 ^E (0.39–11)
6 (2018–2019)	1020	99.6 (98.9–99.9)	0.83 (0.75–0.93)	0.26 (0.21–0.31)	0.80 (0.68–0.92)	2.6 (1.8–3.4)	4.1 (3.2–5.1)
Males, 20–79 years							
1 (2007–2009)	1376	99.8 (99.6–99.9)	3.2 (2.8–3.7)	1.3 (1.1–1.6)	2.8 (2.4–3.2)	9.3 (7.6–11)	16 (11–20)
2 (2009–2011)	510	99.6 (98.4–99.9)	2.4 (2.0–2.7)	0.94 (0.76–1.1)	2.1 (1.9–2.4)	6.1 (4.5–7.7)	9.4 ^E (4.9–14)
5 (2016–2017)	525	99.6 (97.7–99.9)	1.5 (1.3–1.8)	0.56 (0.40–0.73)	1.3 (1.0–1.5)	3.9 ^E (<LOD–8.6)	7.8 ^E (<LOD–19)
6 (2018–2019)	501	99.5 (96.7–99.9)	1.2 (1.0–1.4)	0.48 (0.38–0.59)	1.1 (0.94–1.3)	4.0 ^E (2.4–5.5)	4.4 (3.9–4.9)
Females, 20–79 years							
1 (2007–2009)	1504	95.9 (92.8–97.7)	1.6 (1.4–1.9)	0.50 (0.38–0.62)	1.5 (1.2–1.7)	5.3 (3.9–6.7)	8.5 (6.6–10)
2 (2009–2011)	505	97.2 (93.9–98.8)	1.3 (1.1–1.5)	0.40 (0.34–0.45)	1.2 (1.0–1.3)	4.3 ^E (0.92–7.6)	8.2 ^E (3.4–13)
5 (2016–2017)	532	99.6 (97.8–99.9)	0.65 (0.57–0.74)	0.20 (0.15–0.25)	0.62 (0.50–0.74)	1.9 ^E (0.96–2.8)	3.8 (2.4–5.1)
6 (2018–2019)	519	99.7 (94.1–100)	0.58 (0.50–0.68)	0.21 (0.18–0.25)	0.59 (0.51–0.68)	1.6 (1.1–2.1)	2.1 ^E (0.54–3.7)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.3, 0.2, 0.063 and 0.063 µg/L, respectively.

a For the purpose of total population comparisons, only values from participants aged 20–79 years were included, as participants under the age of 20 years were not included in cycle 1.

b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 12.1.17

Perfluorohexane sulfonate (PFHxS)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	2595	99.7 (98.9–99.9)	0.90 (0.78–1.0)	0.27 (0.21–0.33)	0.90 (0.76–1.0)	3.0 (2.4–3.7)	5.3 ^E (1.8–8.7)
6 (2018–2019)	2514	99.6 (99.1–99.9)	0.76 (0.69–0.85)	0.25 (0.21–0.29)	0.72 (0.64–0.80)	2.4 (1.7–3.1)	4.0 (2.9–5.2)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	1294	99.7 (98.2–99.9)	1.3 (1.1–1.5)	0.43 (0.35–0.50)	1.1 (0.96–1.3)	3.6 ^E (1.2–6.0)	7.3 ^E (<1.0–18)
6 (2018–2019)	1253	99.5 (97.7–99.9)	1.0 (0.91–1.2)	0.37 (0.30–0.43)	0.99 (0.88–1.1)	3.3 (2.1–4.4)	4.3 (3.9–4.7)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	1301	99.7 (98.2–99.9)	0.64 (0.55–0.73)	0.20 (0.16–0.25)	0.58 (0.48–0.68)	1.9 (1.2–2.6)	3.5 (2.2–4.8)
6 (2018–2019)	1261	99.8 (95.5–100)	0.56 (0.49–0.64)	0.21 (0.19–0.24)	0.56 (0.48–0.65)	1.5 (1.1–2.0)	2.1 ^F (0.72–3.5)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	491	100	0.61 (0.46–0.81)	0.24 (0.19–0.30)	0.54 (0.37–0.72)	1.8 ^E (1.1–2.5)	3.1 ^F (1.0–5.1)
6 (2018–2019)	482	99.3 (96.0–99.9)	0.52 (0.48–0.57)	0.21 (0.17–0.25)	0.49 (0.43–0.54)	1.3 (1.0–1.6)	1.6 ^F (0.38–2.8)
6–11 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	520	100	0.59 (0.45–0.77)	0.24 (0.16–0.31)	0.49 (0.41–0.58)	1.7 (1.1–2.3)	3.2 ^E (0.43–6.0)
6 (2018–2019)	504	100	0.54 (0.44–0.67)	0.22 (0.15–0.29)	0.44 (0.37–0.51)	1.4 ^E (0.37–2.5)	3.8 ^E (1.1–6.5)
12–19 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	506	99.2 (97.5–99.7)	1.9 (1.6–2.3)	0.60 (0.50–0.70)	1.6 (1.3–1.9)	7.8 (5.0–11)	11 ^F (5.7–16)
5 (2016–2017)	527	100	0.69 (0.59–0.80)	0.25 (0.17–0.32)	0.58 (0.48–0.67)	2.1 (1.6–2.6)	3.6 (3.0–4.3)
6 (2018–2019)	508	99.8 (98.6–100)	0.53 (0.45–0.62)	0.21 ^E (0.13–0.29)	0.50 (0.43–0.57)	1.4 (0.91–1.9)	1.8 (1.3–2.2)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	979	96.0 (93.2–97.6)	2.1 (1.8–2.4)	0.61 (0.49–0.73)	1.9 (1.5–2.2)	7.9 (5.4–10)	16 ^E (10–23)
2 (2009–2011)	361	97.1 (92.1–99.0)	1.5 (1.3–1.8)	0.41 (0.28–0.54)	1.6 (1.1–2.1)	4.7 (3.1–6.3)	6.0 ^E (2.1–9.9)
5 (2016–2017)	362	99.5 (96.9–99.9)	0.84 (0.73–0.97)	0.20 ^E (0.096–0.30)	0.69 (0.46–0.92)	3.6 ^E (<LOD–8.7)	7.3 ^E (<LOD–17)
6 (2018–2019)	330	99.8 (98.4–100)	0.70 (0.59–0.84)	0.21 (0.15–0.27)	0.66 (0.53–0.80)	2.6 ^E (0.45–4.7)	4.4 ^E (1.6–7.3)
40–59 years							
1 (2007–2009)	983	98.8 (96.7–99.6)	2.2 (1.9–2.5)	0.79 (0.54–1.0)	2.2 (1.8–2.5)	6.9 (6.2–7.5)	9.2 (7.4–11)
2 (2009–2011)	333	99.3 (97.8–99.8)	1.8 (1.4–2.3)	0.58 ^E (0.33–0.83)	1.7 (1.3–2.0)	6.2 ^E (0.91–12)	12 ^E (3.5–21)
5 (2016–2017)	346	100	0.93 (0.72–1.2)	0.28 (0.20–0.36)	0.91 (0.68–1.1)	2.6 (1.8–3.4)	4.2 ^E (2.1–6.3)
6 (2018–2019)	346	99.2 (96.3–99.8)	0.81 (0.69–0.94)	0.27 (0.20–0.35)	0.80 (0.64–0.95)	2.1 (1.4–2.8)	2.7 (1.7–3.7)
60–79 years							
1 (2007–2009)	918	99.3 (98.4–99.7)	2.8 (2.4–3.3)	1.1 (0.90–1.3)	2.6 (2.1–3.0)	8.4 (6.3–11)	13 (9.0–16)
2 (2009–2011)	321	99.4 (94.1–99.9)	2.2 (1.8–2.7)	0.86 (0.64–1.1)	2.0 (1.6–2.4)	6.9 ^E (3.5–10)	9.8 (6.7–13)
5 (2016–2017)	349	99.1 (95.0–99.9)	1.3 (1.0–1.7)	0.58 (0.38–0.79)	1.1 (0.89–1.4)	3.4 ^E (1.4–5.3)	5.8 ^E (0.81–11)
6 (2018–2019)	344	99.8 (99.1–100)	1.1 (0.95–1.3)	0.45 (0.37–0.52)	1.0 (0.83–1.2)	3.3 (2.1–4.4)	4.3 (3.3–5.4)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.3, 0.2, 0.063 and 0.063 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
- b Data are not available, as participants under the age of 20 years were not included in cycle 1.
- c Data are not available, as participants under the age of 12 years were not included in cycle 2.
- E Use data with caution.

Table 12.1.18

Perfluorooctane sulfonate (PFOS)—Geometric means and selected percentiles of plasma concentrations ($\mu\text{g/L}$) for the Canadian population aged 20–79^a, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^b (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 20–79 years							
1 (2007–2009)	2880	99.9 (99.9–100)	8.9 (8.0–9.8)	3.6 (3.1–4.1)	9.1 (8.1–10)	19 (16–22)	27 (22–32)
2 (2009–2011)	1017	99.8 (99.1–99.9)	6.9 (6.2–7.6)	2.6 (1.9–3.2)	6.8 (6.0–7.6)	16 (13–18)	19 (13–25)
5 (2016–2017)	1057	99.9 (99.8–100)	3.4 (3.0–3.9)	1.3 (1.2–1.5)	3.3 (2.9–3.7)	8.5 (7.0–9.9)	13 (8.0–17)
6 (2018–2019)	1020	99.3 (98.3–99.7)	2.9 (2.7–3.1)	1.1 (0.99–1.3)	2.8 (2.5–3.1)	6.6 (5.9–7.4)	8.6 (6.9–10)
Males, 20–79 years							
1 (2007–2009)	1376	100 (98.4–100)	11 (10–12)	5.1 (4.3–6.0)	11 (9.5–12)	23 (18–29)	31 (23–39)
2 (2009–2011)	511	99.7 (98.3–99.9)	8.3 (7.4–9.3)	4.7 (3.6–5.8)	8.2 (6.6–9.8)	16 (14–18)	19 (14–25)
5 (2016–2017)	525	99.9 (99.4–100)	4.3 (3.7–5.1)	1.9 (1.3–2.5)	3.9 (3.1–4.7)	9.1 ^E (5.7–13)	13 ^E (7.8–19)
6 (2018–2019)	501	99.7 (96.5–100)	3.6 (3.3–4.0)	1.5 (1.2–1.7)	3.6 (2.9–4.2)	8.2 (6.6–9.8)	12 ^E (7.5–16)
Females, 20–79 years							
1 (2007–2009)	1504	99.9 (99.7–99.9)	7.1 (6.3–7.9)	3.0 (2.6–3.4)	7.4 (6.4–8.4)	15 (14–17)	20 (15–24)
2 (2009–2011)	506	99.9 (99.1–100)	5.7 (4.9–6.5)	2.0 (1.5–2.4)	6.0 (5.1–6.9)	15 (11–19)	19 ^E (7.8–30)
5 (2016–2017)	532	99.9 (99.6–100)	2.7 (2.4–3.1)	0.99 (0.83–1.2)	2.4 (1.9–2.8)	7.6 (6.2–9.0)	10 ^E (5.6–14)
6 (2018–2019)	519	98.9 (97.3–99.5)	2.3 (2.1–2.6)	0.93 (0.78–1.1)	2.3 (2.0–2.7)	5.4 (4.8–5.9)	6.4 (5.3–7.4)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.3, 0.3, 0.43 and 0.43 $\mu\text{g/L}$, respectively.

- a For the purpose of total population comparisons, only values from participants aged 20–79 years were included, as participants under the age of 20 years were not included in cycle 1.
- b If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
- E Use data with caution.

Table 12.1.19

Perfluorooctane sulfonate (PFOS)—Geometric means and selected percentiles of plasma concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	2594	99.9 (99.8–99.9)	3.0 (2.7–3.4)	1.1 (1.0–1.3)	2.9 (2.5–3.3)	8.1 (7.0–9.3)	11 (7.1–15)
6 (2018–2019)	2514	99.3 (98.6–99.7)	2.5 (2.3–2.8)	0.97 (0.90–1.0)	2.5 (2.3–2.7)	6.2 (5.6–6.7)	8.3 (7.2–9.4)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	1294	99.9 (99.8–99.9)	3.6 (3.2–4.1)	1.4 (1.3–1.6)	3.5 (3.1–3.9)	8.6 (6.6–11)	13 ^E (7.7–17)
6 (2018–2019)	1253	99.6 (97.9–99.9)	3.1 (2.8–3.4)	1.2 (1.1–1.3)	3.0 (2.6–3.4)	7.4 (5.9–8.8)	9.8 ^E (5.4–14)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	1300	99.9 (99.8–100)	2.5 (2.2–2.8)	0.99 (0.91–1.1)	2.3 (2.0–2.5)	6.9 (5.8–8.1)	8.7 ^E (5.1–12)
6 (2018–2019)	1261	99.1 (97.9–99.6)	2.1 (1.9–2.4)	0.85 (0.72–0.98)	2.2 (2.0–2.3)	5.3 (4.5–6.0)	6.0 (5.2–6.9)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	491	99.8 (99.2–100)	1.7 (1.5–2.1)	0.89 (0.76–1.0)	1.6 (1.1–2.0)	3.7 (2.7–4.6)	5.5 ^E (3.2–7.8)
6 (2018–2019)	482	99.7 (99.1–99.9)	1.4 (1.3–1.6)	0.71 (0.61–0.82)	1.3 (1.1–1.4)	3.1 (2.6–3.7)	3.9 ^E (<LOD–8.8)
6–11 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011) ^c	—	—	—	—	—	—	—
5 (2016–2017)	520	99.3 (98.0–99.8)	1.7 (1.5–2.0)	0.96 (0.85–1.1)	1.6 (1.3–1.8)	3.4 (3.0–3.9)	4.2 (3.8–4.7)
6 (2018–2019)	504	99.6 (98.3–99.9)	1.5 (1.3–1.8)	0.74 (0.55–0.93)	1.4 (1.1–1.6)	3.2 (2.4–3.9)	4.7 ^E (2.9–6.5)
12–19 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	507	99.8 (97.9–100)	4.6 (4.0–5.2)	2.1 (1.9–2.4)	4.6 (3.9–5.3)	9.0 (7.7–10)	11 (9.2–13)
5 (2016–2017)	526	100	1.9 (1.7–2.0)	1.0 (0.90–1.1)	1.8 (1.6–2.0)	3.3 (3.0–3.5)	3.9 (3.7–4.2)
6 (2018–2019)	508	99.7 (98.1–100)	1.6 (1.4–1.8)	0.81 (0.69–0.93)	1.5 (1.3–1.8)	3.2 (2.3–4.2)	3.6 (3.1–4.0)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	979	99.9 (97.6–100)	8.2 (7.2–9.3)	3.5 (2.8–4.1)	8.6 (7.3–9.9)	17 (15–18)	21 (19–24)
2 (2009–2011)	362	99.8 (99.2–100)	6.2 (5.4–7.1)	2.1 ^E (0.99–3.2)	6.7 (5.8–7.6)	15 ^E (9.7–21)	19 ^E (9.6–29)
5 (2016–2017)	362	99.9 (99.5–100)	2.5 (2.3–2.8)	1.2 (0.95–1.5)	2.6 (2.2–2.9)	5.1 (4.1–6.1)	6.4 ^E (4.0–8.9)
6 (2018–2019)	330	99.0 (96.5–99.7)	2.3 (2.0–2.5)	0.95 (0.81–1.1)	2.2 (1.8–2.6)	5.5 (4.4–6.6)	6.2 (4.3–8.2)
40–59 years							
1 (2007–2009)	983	99.9 (98.7–100)	8.6 (7.7–9.5)	3.4 (2.8–4.0)	8.8 (7.9–9.7)	19 (13–24)	28 (19–37)
2 (2009–2011)	334	99.6 (97.7–99.9)	6.4 (5.7–7.2)	2.3 (1.6–3.0)	6.7 (5.7–7.7)	13 (9.8–17)	16 (13–19)
5 (2016–2017)	346	100	3.8 (3.1–4.7)	1.4 (1.1–1.6)	3.4 (2.9–4.0)	9.2 ^E (1.8–17)	19 ^F (5.2–33)
6 (2018–2019)	346	99.9 (99.2–100)	2.9 (2.6–3.2)	1.3 (0.97–1.6)	2.9 (2.5–3.3)	5.9 (5.0–6.8)	7.9 (5.8–9.9)
60–79 years							
1 (2007–2009)	918	100	11 (9.6–13)	4.4 (3.3–5.5)	11 (9.6–13)	24 (21–28)	30 (24–35)
2 (2009–2011)	321	100	9.4 (8.3–11)	4.6 (3.9–5.3)	9.8 (8.1–11)	19 (16–21)	21 ^E (7.5–35)
5 (2016–2017)	349	99.8 (98.9–99.9)	4.5 (3.7–5.6)	1.8 ^E (0.81–2.9)	5.0 (4.0–6.0)	9.9 (7.9–12)	12 (10–14)
6 (2018–2019)	344	98.7 (95.2–99.7)	3.9 (3.5–4.5)	1.9 (1.6–2.3)	3.7 (3.1–4.2)	9.6 (7.4–12)	13 ^E (3.3–22)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.3, 0.3, 0.43 and 0.43 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
- b Data are not available, as participants under the age of 20 years were not included in cycle 1.
- c Data are not available, as participants under the age of 12 years were not included in cycle 2.
- E Use data with caution.

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SUMMARIES AND RESULTS FOR PESTICIDES

13

13.1 ORGANOPHOSPHATE PESTICIDES

Organophosphates are a group of closely related chemicals that are used extensively in Canada as pesticides in agriculture, in and around the home, and in veterinary practice (HC, 2013; 2021a; 2021b). This class of pesticides gained popularity when organochlorine pesticides were banned in the 1970s. Organophosphate pesticides are less persistent in the environment and less susceptible to pest resistance compared with organochlorine pesticides (Wessels et al., 2003). Thirteen organophosphate pesticides, listed in Table 13.1.1, were registered for use in Canada during the Canadian Health Measures Survey (CHMS) cycle 6 sampling period (2018–2019) (HC, 2021b).

Organophosphate pesticides have been linked to naturally occurring compounds produced by bacteria; however, their presence in the environment is almost exclusively due to their anthropogenic use as pesticides (Neumann and Peter, 1987). Despite their rapid degradation in the environment, small amounts can be detected in food and drinking water (CFIA, 2017; Hao et al., 2010; HC, 2003; 2004).

Major uses of organophosphates include as an insecticide on food and feed crops, livestock and ornamental plants; for seed treatment and insect control in food storage areas, greenhouses and forestry structures; for control of pet parasites; and for mosquito control (HC, 2013; 2021b). Although the majority of organophosphates are used as insecticides, bensulide is used as a selective herbicide to control weeds in turf and

cucumbers (HC, 2013). Dichlorvos has veterinary uses for the control of parasites in livestock (HC, 2021a).

The primary route of exposure for the general public is through ingestion of food previously treated with organophosphate pesticides and drinking water contaminated with agricultural runoff (ATSDR, 1997a; 1997b; 2003). Other routes of exposure include dermal contact and inhalation during the use of products containing organophosphates or during activity in areas previously treated with organophosphates.

Organophosphates are efficiently absorbed through inhalation and ingestion. Absorption following dermal penetration can vary with the specific substance (EPA, 2013). After entry into the body, organophosphate pesticides are metabolized rapidly, primarily in the liver, and excreted in urine (Barr and Needham, 2002). Desulfuration of the parent compound occurs in the liver and results in the formation of the more reactive oxon metabolite, which is responsible for the cholinesterase inhibition seen with most organophosphate pesticides of the thioate group (e.g., dimethoate, chlorpyrifos) (Gupta et al., 2011).

Hydrolysis of the parent compound yields various dialkyl phosphate metabolites. Each metabolite is associated with several different organophosphate pesticides, and many organophosphates can form more than 1 of these metabolites (Table 13.1.1). These metabolites also occur in the environment following degradation of the parent compound. Dialkyl phosphate metabolites are not considered toxic, but are considered to be biomarkers of exposure to the parent pesticides or their metabolites in the environment (CDC, 2009;

EPA, 2013). In addition to the dialkyl phosphate metabolites, organophosphate parent compounds and other breakdown products can be measured in blood and urine; detection generally reflects exposures over the previous few days (CDC, 2009; EPA, 2013). Examples of organophosphate metabolites other than dialkyl phosphates include 3,5,6-trichloro-2-pyridinol, which is formed by the metabolism of chlorpyrifos or chlorpyrifos-methyl, and malathion dicarboxylic acid, which is formed by the metabolism of malathion (although metabolism of the parent organophosphates also results in the formation of dialkyl phosphate metabolites). Some organophosphate pesticides, namely acephate and methamidophos, do not break down into

dialkyl phosphate metabolites (Barr and Needham, 2002; Wessels et al., 2003).

The following table outlines the dialkyl phosphate metabolites that were measured in urine collected from CHMS participants, along with their corresponding organophosphate pesticide parent compounds (Bravo et al., 2004; CDC, 2009; Wessels et al., 2003). There are 6 dialkyl phosphate metabolites: dimethylphosphate (DMP), dimethylthiophosphate (DMTP), dimethyldithiophosphate (DMDTP), diethylphosphate (DEP), diethylthiophosphate (DETP) and diethyldithiophosphate (DEDTP).

■ **Table 13.1.1**

Dialkyl phosphate metabolites measured in the Canadian Health Measures Survey and their parent organophosphate pesticides registered for use in Canada during the cycle 6 sampling period (2018–2019)

Organophosphate pesticide	Dialkyl phosphate metabolites (CASRN)					
	DMP (813-79-5)	DMTP (1112-38-5)	DMDTP (765-80-9)	DEP (598-02-7)	DETP (2465-65-8)	DEDTP (298-06-6)
Acephate	—	—	—	—	—	—
Bensulide	—	—	—	—	—	—
Chlorpyrifos	—	—	—	Yes	Yes	—
Coumaphos	—	—	—	Yes	Yes	—
Diazinon	—	—	—	Yes	Yes	—
Dichlorvos	Yes	—	—	—	—	—
Dimethoate	Yes	Yes	Yes	—	—	—
Malathion	Yes	Yes	Yes	—	—	—
Naled	Yes	—	—	—	—	—
Phorate	—	—	—	Yes	Yes	Yes
Phosmet	Yes	Yes	Yes	—	—	—
Propetamphos	—	—	—	—	—	—
Tetrachlorvinphos	Yes	—	—	—	—	—

Organophosphates are cholinesterase-inhibiting pesticides that act to overstimulate the nervous systems of insects and mammals by interrupting the transmission of nerve impulses (EPA, 2013). In humans, symptoms of acute overexposure may include headache, dizziness, fatigue, irritation of the eyes or nose, nausea, vomiting, salivation, sweating and changes in heart rate. Very high exposures can have effects such as paralysis, seizures, loss of consciousness or even death (ATSDR, 1997a; 1997b; 2003; EPA, 2013). However, typical exposure to organophosphate pesticides through food ingestion is generally low. Nevertheless, there is potential for toxic effects resulting from chronic low-dose exposure (Ray and Richards, 2001). Prenatal exposure to organophosphates has been associated with shortened gestation, reduced birth weight, and impaired neurodevelopment in young children (Bouchard et al., 2011; EPA, 2016; Eskenazi et al., 2007; González-Alzaga et al., 2014; Muñoz-Quezada et al., 2013; Rauch et al., 2012). Several organophosphate pesticides registered for use in Canada have been classified by the International Agency for Research on Cancer. Malathion and diazinon are classified as probably carcinogenic to humans (Group 2A), while tetrachlorvinphos and dichlorvos are classified as possibly carcinogenic to humans (Group 2B) (IARC, 1991; 2017).

The sale and use of organophosphate pesticides is regulated in Canada by the Pest Management Regulatory Agency (PMRA) under the *Pest Control Products Act* (Canada, 2002). PMRA evaluates the toxicity of pesticides and potential exposure in order to determine whether a pesticide should be registered for a specific use. As part of the registration process, the PMRA establishes maximum residue limits of pesticides in food, including registered organophosphate pesticides, and re-evaluates registered pesticides on a cyclical basis (HC, 2012). Re-evaluation decisions have been published for some organophosphate pesticides, including acephate, dichlorvos, phosmet, chlorpyrifos and their associated end-use products (HC, 2020b; 2020c; 2020d; 2020e). These re-evaluation decisions have determined that continued registration

of certain products containing acephate, dichlorvos and phosmet—and certain uses of chlorpyrifos—are acceptable if risk mitigation measures are in place. Certain uses and application methods for these pesticides are being cancelled to address potential risks of concern to human health and/or the environment.

Health Canada has established Canadian drinking water quality guidelines that set out the maximum acceptable concentrations of chlorpyrifos, diazinon, dimethoate, malathion and phorate (HC, 1989a; 1989b; 1989c; 1990; 1991). Several organophosphate pesticides have also been analyzed as part of Health Canada's Total Diet Study surveys (HC, 2020a). These surveys provide estimated levels of chemicals to which Canadians in different age-sex groups are exposed through the food supply.

Organophosphate metabolite concentrations in urine have been measured in a number of biomonitoring studies conducted in Canada, including the Maternal–Infant Research on Environmental Chemicals study (Sokoloff et al., 2016) and the First Nations Biomonitoring Initiative (AFN, 2013).

Six dialkyl phosphate metabolites (see Table 13.1.1) were measured in the urine of CHMS participants aged 6–79 in cycle 1 (2007–2009), and aged 3–79 in cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented as both µg/L and µg/g creatinine (Tables 13.1.2 to 13.1.13). Finding a measurable amount of organophosphate pesticides or their metabolites in urine is an indicator of exposure to organophosphate pesticides and/or their metabolites and does not necessarily mean that an adverse health effect will occur. The organophosphate metabolites 3,5,6-trichloro-2-pyridinol and malathion dicarboxylic acid were analyzed in the urine of CHMS participants aged 3–79 in cycle 3 (2012–2013) and cycle 4 (2014–2015), and the organophosphate pesticides acephate and methamidophos were measured in the urine of CHMS participants aged 3–79 in cycle 3.

Table 13.1.2

Dimethylphosphate (DMP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2556	83.0 (78.3–86.8)	3.3 (2.9–3.7)	<LOD	3.5 (3.0–4.0)	17 (15–20)	26 (22–29)
5 (2016–2017)	2633	80.9 (75.1–85.6)	1.7 (1.4–2.1)	<LOD	1.6 (1.3–1.9)	8.6 (6.2–11)	14 (10–18)
6 (2018–2019)	2526	78.7 (72.4–83.8)	1.5 (1.3–1.9)	<LOD	1.4 (1.2–1.7)	7.5 (5.3–9.6)	11 (8.7–14)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1280	82.5 (76.3–87.4)	3.3 (2.8–3.8)	<LOD	3.4 (2.8–4.0)	17 (13–21)	26 (21–31)
5 (2016–2017)	1308	77.6 (69.2–84.3)	1.6 (1.3–2.1)	<LOD	1.5 (0.97–2.0)	8.4 (6.5–10)	13 (9.4–18)
6 (2018–2019)	1250	79.7 (70.3–86.7)	1.5 (1.2–1.8)	<LOD	1.4 (1.2–1.7)	6.7 (5.1–8.3)	9.9 (8.1–12)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1276	83.4 (77.9–87.8)	3.4 (2.9–3.9)	<LOD	3.6 (2.8–4.5)	17 (14–20)	24 (17–31)
5 (2016–2017)	1325	84.1 (79.6–87.8)	1.8 (1.6–2.2)	<LOD	1.6 (1.4–1.8)	9.9 ^E (6.1–14)	16 (10–21)
6 (2018–2019)	1276	77.6 (72.5–82.0)	1.6 (1.3–1.9)	<LOD	1.5 (1.1–1.8)	8.5 (5.5–12)	13 ^E (4.8–21)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	93.9 (90.7–96.0)	6.7 (5.6–8.1)	1.4 (1.0–1.8)	6.8 (4.9–8.6)	32 ^E (19–46)	70 ^E (15–120)
5 (2016–2017)	545	93.9 (90.2–96.3)	3.2 (2.6–3.8)	0.78 (0.59–0.97)	3.0 ^E (1.8–4.1)	15 (12–19)	22 (16–28)
6 (2018–2019)	514	89.4 (82.2–93.9)	3.1 (2.3–4.1)	<LOD	2.8 (2.1–3.4)	22 ^E (<LOD–44)	35 ^E (6.7–63)
6–11 years							
1 (2007–2009)	1028	80.7 (74.6–85.6)	3.8 (3.3–4.5)	<LOD	4.3 (3.9–4.8)	21 (18–23)	29 (23–36)
2 (2009–2011)	516	92.2 (89.2–94.4)	6.1 (5.2–7.2)	<LOD	5.9 (4.6–7.3)	24 ^E (14–35)	46 ^E (12–80)
5 (2016–2017)	515	90.4 (81.4–95.3)	2.9 ^E (2.0–4.2)	<LOD ^E (<LOD–0.88)	2.7 (1.8–3.6)	17 ^E (8.5–26)	28 ^E (13–42)
6 (2018–2019)	498	86.6 (75.4–93.2)	2.4 ^E (1.7–3.5)	<LOD	2.4 ^E (1.3–3.4)	11 ^E (6.7–15)	18 ^E (9.6–26)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	980	82.8 (75.0–88.5)	3.9 (3.2–4.7)	<LOD	4.1 (3.3–4.9)	21 (18–24)	28 (23–32)
2 (2009–2011)	512	87.5 (82.1–91.5)	3.8 (3.2–4.5)	<LOD	4.0 (3.2–4.8)	18 (12–24)	30 (19–41)
5 (2016–2017)	519	84.3 (73.6–91.2)	2.1 ^E (1.4–3.1)	<LOD	2.0 ^E (1.1–2.8)	11 ^E (4.9–18)	19 ^E (10–27)
6 (2018–2019)	500	77.8 (70.3–83.8)	1.6 (1.2–2.1)	<LOD	1.7 ^E (1.0–2.5)	6.6 (5.1–8.0)	10 ^E (4.1–16)
20–39 years							
1 (2007–2009)	1162	76.0 (69.3–81.6)	2.7 (2.2–3.3)	<LOD	2.9 (2.2–3.7)	13 (9.8–17)	23 ^E (10–36)
2 (2009–2011)	356	81.0 (69.2–89.0)	3.1 (2.4–4.0)	<LOD	3.5 (2.6–4.5)	17 (11–23)	29 (20–39)
5 (2016–2017)	358	76.3 (62.8–86.0)	1.5 (1.2–1.9)	<LOD	1.5 (1.2–1.8)	6.8 (4.4–9.2)	12 ^E (6.3–19)
6 (2018–2019)	330	79.4 (67.2–87.9)	1.4 (1.1–1.7)	<LOD	1.3 (1.0–1.7)	6.0 ^E (3.6–8.4)	8.4 ^E (4.9–12)
40–59 years							
1 (2007–2009)	1221	74.3 (66.0–81.1)	2.6 (2.1–3.3)	<LOD	2.9 ^E (1.4–4.4)	15 (11–18)	24 (18–31)
2 (2009–2011)	360	80.7 (71.4–87.5)	2.8 (2.2–3.7)	<LOD	2.8 (2.1–3.5)	13 ^E (5.2–20)	20 ^E (12–27)
5 (2016–2017)	347	79.5 (71.1–85.9)	1.6 (1.3–1.9)	<LOD	1.4 (1.2–1.7)	6.8 ^E (2.5–11)	11 ^E (4.1–18)
6 (2018–2019)	342	74.6 (63.8–83.1)	1.4 (1.1–1.9)	<LOD	1.4 ^E (0.80–1.9)	6.8 ^E (2.5–11)	11 ^E (3.2–19)
60–79 years							
1 (2007–2009)	1076	80.7 (76.1–84.6)	3.1 (2.6–3.6)	<LOD	3.3 (2.7–3.9)	15 (12–17)	20 (15–26)
2 (2009–2011)	290	81.9 (73.2–88.2)	3.1 (2.5–3.7)	<LOD	3.4 (2.7–4.2)	14 ^E (7.3–20)	19 ^E (9.9–28)
5 (2016–2017)	349	82.5 (73.4–89.0)	1.7 (1.3–2.4)	<LOD	1.6 ^E (0.90–2.3)	7.7 ^E (4.5–11)	13 ^E (6.5–19)
6 (2018–2019)	342	79.1 (70.4–85.7)	1.5 (1.1–2.2)	<LOD	1.3 ^E (0.67–2.0)	8.0 ^E (4.6–11)	12 (9.5–13)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 1, 1, 0.58 and 0.58 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.1.3

Dimethylphosphate (DMP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2546	83.0 (78.3–86.8)	3.2 (2.9–3.6)	<LOD	3.0 (2.7–3.3)	15 (11–18)	24 (19–30)
5 (2016–2017)	2606	80.9 (75.1–85.6)	1.7 (1.4–2.0)	<LOD	1.5 (1.3–1.8)	7.2 (5.3–9.0)	12 (8.7–15)
6 (2018–2019)	2525	78.7 (72.4–83.8)	1.7 (1.3–2.1)	<LOD	1.5 (1.1–2.0)	7.6 (5.6–9.6)	12 (8.5–15)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1276	82.5 (76.3–87.4)	2.8 (2.5–3.1)	<LOD	2.5 (2.1–2.9)	13 (9.6–16)	21 (17–25)
5 (2016–2017)	1298	77.6 (69.2–84.3)	1.4 (1.1–1.8)	<LOD	1.3 (1.0–1.6)	5.7 (4.5–6.9)	9.4 (6.3–13)
6 (2018–2019)	1249	79.7 (70.3–86.7)	1.4 (1.2–1.7)	<LOD	1.3 (1.0–1.6)	5.4 (4.2–6.7)	8.6 (7.4–9.8)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1270	83.4 (77.9–87.8)	3.8 (3.2–4.6)	<LOD	3.4 (2.6–4.2)	16 (11–21)	28 (20–36)
5 (2016–2017)	1308	84.1 (79.6–87.8)	2.0 (1.7–2.4)	<LOD	1.8 (1.5–2.0)	8.8 (6.2–11)	13 ^E (7.7–18)
6 (2018–2019)	1276	77.6 (72.5–82.0)	2.0 (1.5–2.6)	<LOD	1.9 (1.3–2.5)	9.7 (7.1–12)	17 ^E (9.4–25)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	521	93.9 (90.7–96.0)	12 (9.8–14)	2.6 (1.9–3.3)	12 (8.6–15)	51 (33–68)	100 ^E (41–160)
5 (2016–2017)	536	93.9 (90.2–96.3)	5.4 (4.2–6.9)	1.1 ^E (0.61–1.6)	5.4 (3.8–7.0)	22 (15–28)	33 (23–43)
6 (2018–2019)	513	89.4 (82.2–93.9)	5.1 (3.8–6.8)	<LOD	4.5 (3.3–5.7)	35 ^E (<LOD–58)	54 ^E (22–86)
6–11 years							
1 (2007–2009)	1025	80.7 (74.6–85.6)	5.9 (5.2–6.7)	<LOD	6.3 (5.0–7.6)	26 (23–30)	40 (36–45)
2 (2009–2011)	514	92.2 (89.2–94.4)	6.9 (6.0–7.9)	<LOD	7.2 (6.0–8.4)	32 ^E (18–46)	52 ^E (22–83)
5 (2016–2017)	506	90.4 (81.4–95.3)	3.5 ^E (2.4–5.1)	<LOD	3.1 ^E (1.8–4.3)	19 ^E (9.1–29)	26 (17–36)
6 (2018–2019)	498	86.6 (75.4–93.2)	2.9 (2.1–4.0)	<LOD	2.6 ^E (1.6–3.7)	12 (9.3–16)	16 (12–20)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	978	82.8 (75.0–88.5)	3.4 (2.9–4.0)	<LOD	3.7 (3.0–4.5)	14 (11–16)	20 (15–24)
2 (2009–2011)	510	87.5 (82.1–91.5)	2.9 (2.5–3.4)	<LOD	2.9 (2.4–3.3)	12 (8.0–15)	18 ^E (9.3–27)
5 (2016–2017)	515	84.3 (73.6–91.2)	1.6 (1.2–2.2)	<LOD	1.5 (1.1–1.9)	8.2 ^E (5.1–11)	10 (7.8–12)
6 (2018–2019)	500	77.8 (70.3–83.8)	1.3 (1.1–1.7)	<LOD	1.3 (0.97–1.6)	5.2 ^E (2.1–8.2)	11 ^E (5.7–17)
20–39 years							
1 (2007–2009)	1158	76.0 (69.3–81.6)	3.0 (2.6–3.6)	<LOD	3.0 (2.6–3.3)	12 (9.0–16)	21 ^E (13–30)
2 (2009–2011)	354	81.0 (69.2–89.0)	2.6 (2.1–3.4)	<LOD	2.4 (1.8–3.1)	16 ^E (8.0–25)	23 (16–31)
5 (2016–2017)	355	76.3 (62.8–86.0)	1.4 (1.1–1.6)	<LOD	1.4 (1.2–1.7)	5.2 (3.7–6.7)	7.0 (5.3–8.8)
6 (2018–2019)	330	79.4 (67.2–87.9)	1.3 (1.0–1.6)	<LOD	1.3 (1.0–1.6)	4.1 ^E (2.5–5.7)	6.7 ^E (4.0–9.5)
40–59 years							
1 (2007–2009)	1216	74.3 (66.0–81.1)	3.4 (2.8–4.2)	<LOD	3.4 (2.6–4.2)	14 (9.9–18)	24 (16–32)
2 (2009–2011)	358	80.7 (71.4–87.5)	2.9 (2.4–3.5)	<LOD	2.8 (2.4–3.2)	9.6 (7.9–11)	16 ^E (7.6–25)
5 (2016–2017)	346	79.5 (71.1–85.9)	1.4 (1.1–1.8)	<LOD	1.3 (1.1–1.4)	5.7 ^E (2.5–9.0)	9.5 ^E (3.9–15)
6 (2018–2019)	342	74.6 (63.8–83.1)	1.7 (1.3–2.2)	<LOD	1.5 ^E (0.97–2.1)	7.5 (5.0–9.9)	12 ^E (1.3–23)
60–79 years							
1 (2007–2009)	1076	80.7 (76.1–84.6)	4.3 (3.7–5.1)	<LOD	4.3 (3.4–5.1)	16 (14–17)	23 (18–27)
2 (2009–2011)	289	81.9 (73.2–88.2)	3.5 (2.9–4.3)	<LOD	3.7 (2.8–4.7)	13 (10–17)	19 (14–24)
5 (2016–2017)	348	82.5 (73.4–89.0)	2.0 (1.5–2.7)	<LOD	1.9 (1.3–2.5)	7.5 ^E (4.0–11)	12 ^E (5.5–18)
6 (2018–2019)	342	79.1 (70.4–85.7)	1.8 ^E (1.2–2.6)	<LOD	1.6 ^E (0.73–2.5)	8.4 (6.2–11)	9.8 ^E (4.4–15)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.1.4

Dimethylthiophosphate (DMTP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2559	80.0 (75.1–84.0)	2.7 (2.3–3.2)	<LOD	2.8 (2.2–3.5)	23 (17–28)	37 (27–47)
5 (2016–2017)	2645	70.6 (64.8–75.8)	1.3 (1.1–1.5)	<LOD	1.1 (0.89–1.3)	10 (8.8–12)	20 (15–25)
6 (2018–2019)	2536	68.9 (63.8–73.6)	1.2 (1.0–1.5)	<LOD	1.0 (0.74–1.3)	10 (7.4–13)	18 (13–22)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1281	80.2 (73.8–85.4)	2.5 (2.1–3.0)	<LOD	2.4 (1.8–3.0)	22 ^E (13–32)	37 ^E (17–57)
5 (2016–2017)	1315	70.6 (60.7–78.9)	1.3 (1.0–1.6)	<LOD	1.1 ^E (0.65–1.5)	9.9 (7.3–12)	16 ^E (8.3–24)
6 (2018–2019)	1257	69.7 (64.2–74.6)	1.2 (0.99–1.4)	<LOD	1.1 (0.75–1.4)	8.6 (6.1–11)	14 ^E (5.2–22)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1278	79.7 (74.4–84.2)	2.9 (2.4–3.6)	<LOD	3.2 (2.4–4.1)	23 (17–30)	37 (29–45)
5 (2016–2017)	1330	70.6 (64.3–76.2)	1.3 (1.1–1.6)	<LOD	1.1 (0.82–1.4)	11 (8.4–13)	21 (16–25)
6 (2018–2019)	1279	68.2 (60.1–75.3)	1.2 (0.97–1.6)	<LOD	1.0 (0.68–1.3)	11 ^E (7.0–16)	18 (12–25)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	524	92.6 (89.2–95.1)	6.3 (5.1–7.8)	0.72 (<LOD–0.97)	6.4 (4.5–8.3)	49 (33–66)	89 (60–120)
5 (2016–2017)	547	86.6 (81.3–90.6)	2.6 (2.1–3.3)	<LOD	2.1 ^E (0.94–3.2)	23 ^E (13–33)	39 ^E (22–56)
6 (2018–2019)	517	84.9 (78.9–89.5)	3.0 (2.2–4.0)	<LOD	2.6 ^E (1.5–3.6)	27 ^E (10–45)	49 ^E (28–70)
6–11 years							
1 (2007–2009)	1029	67.3 (58.5–75.1)	2.5 (1.9–3.2)	<LOD	2.5 ^E (1.4–3.5)	36 (29–42)	54 (45–64)
2 (2009–2011)	516	91.6 (89.4–93.3)	5.0 (4.2–6.0)	<LOD	5.3 (3.7–6.9)	32 (21–43)	66 ^E (31–100)
5 (2016–2017)	516	84.6 (80.1–88.3)	2.3 (1.8–3.0)	<LOD	2.0 (1.5–2.4)	24 ^E (10–37)	55 ^E (24–86)
6 (2018–2019)	497	78.7 (65.6–87.7)	2.3 ^E (1.5–3.4)	<LOD	2.3 ^E (1.3–3.3)	18 ^E (3.8–33)	34 ^E (<LOD–73)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	980	68.7 (60.7–75.6)	2.3 (1.8–2.8)	<LOD	2.1 (1.4–2.8)	26 (19–32)	44 (30–58)
2 (2009–2011)	512	80.0 (73.0–85.6)	2.6 (2.1–3.3)	<LOD	2.7 (2.0–3.3)	19 ^E (12–26)	36 ^E (22–50)
5 (2016–2017)	524	76.5 (68.8–82.8)	1.5 (1.2–2.0)	<LOD	1.4 ^E (0.85–1.9)	10 ^E (5.6–14)	19 ^E (5.5–33)
6 (2018–2019)	505	65.0 (56.7–72.6)	1.1 (0.82–1.5)	<LOD	1.1 ^E (0.52–1.7)	8.9 ^E (4.6–13)	15 (9.8–21)
20–39 years							
1 (2007–2009)	1163	66.0 (57.1–73.9)	1.8 (1.3–2.4)	<LOD	1.6 ^E (<LOD–2.6)	17 ^E (10–24)	36 ^E (19–53)
2 (2009–2011)	356	78.1 (65.6–86.9)	2.4 (1.8–3.2)	<LOD	2.7 (1.8–3.7)	20 ^E (10–29)	29 ^E (17–41)
5 (2016–2017)	361	60.8 (52.0–68.9)	1.0 (0.80–1.3)	<LOD	0.71 ^E (0.44–0.99)	7.3 ^E (<LOD–17)	20 ^E (5.3–35)
6 (2018–2019)	332	66.6 (53.8–77.4)	0.96 (0.72–1.3)	<LOD	0.85 ^E (0.51–1.2)	5.7 ^E (2.4–9.1)	11 ^E (5.4–16)
40–59 years							
1 (2007–2009)	1223	63.9 (58.0–69.4)	1.8 (1.5–2.2)	<LOD	1.4 ^E (<LOD–2.3)	20 (15–25)	38 (27–49)
2 (2009–2011)	360	79.2 (70.6–85.8)	2.4 (1.8–3.2)	<LOD	2.2 ^E (1.2–3.1)	20 ^E (7.8–33)	36 ^E (5.8–67)
5 (2016–2017)	347	70.1 (56.6–80.8)	1.2 (0.89–1.6)	<LOD	1.0 (0.68–1.4)	9.9 ^E (5.3–15)	12 ^E (6.6–17)
6 (2018–2019)	342	68.7 (60.1–76.2)	1.3 (0.98–1.7)	<LOD	1.1 ^E (0.46–1.8)	10 ^E (5.0–16)	18 ^E (9.1–27)
60–79 years							
1 (2007–2009)	1079	73.6 (67.0–79.3)	2.6 (2.2–3.2)	<LOD	3.0 (2.1–3.8)	26 (21–31)	40 (35–45)
2 (2009–2011)	291	77.4 (67.0–85.3)	2.8 (2.1–3.8)	<LOD	3.3 ^E (2.1–4.6)	23 ^E (12–35)	44 ^E (20–68)
5 (2016–2017)	350	75.2 (69.7–80.1)	1.4 (1.1–1.8)	<LOD	1.4 (1.1–1.7)	11 ^E (3.6–18)	21 ^E (11–32)
6 (2018–2019)	343	68.3 (58.8–76.5)	1.1 ^E (0.71–1.8)	<LOD	0.82 ^E (<LOD–1.5)	10 ^E (6.3–15)	17 (11–23)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.6, 0.6, 0.44 and 0.44 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.1.5

Dimethylthiophosphate (DMTP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2549	80.0 (75.1–84.0)	2.7 (2.3–3.1)	<LOD	2.5 (1.8–3.1)	21 (17–25)	35 (31–39)
5 (2016–2017)	2618	70.6 (64.8–75.8)	1.3 (1.1–1.5)	<LOD	1.0 (0.88–1.1)	10 (7.0–13)	19 ^E (12–27)
6 (2018–2019)	2535	68.9 (63.8–73.6)	1.3 (1.0–1.7)	<LOD	1.1 (0.86–1.4)	12 (8.1–16)	23 (16–31)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1277	80.2 (73.8–85.4)	2.1 (1.8–2.5)	<LOD	1.9 (1.5–2.4)	16 (11–22)	28 (18–38)
5 (2016–2017)	1305	70.6 (60.7–78.9)	1.1 (0.91–1.4)	<LOD	0.88 (0.62–1.1)	7.3 ^E (3.7–11)	19 ^E (7.3–30)
6 (2018–2019)	1256	69.7 (64.2–74.6)	1.1 (0.90–1.4)	<LOD	1.1 (0.84–1.3)	8.4 ^E (4.1–13)	17 ^E (8.4–27)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1272	79.7 (74.4–84.2)	3.3 (2.6–4.2)	<LOD	3.3 (2.3–4.4)	27 (20–35)	37 (25–50)
5 (2016–2017)	1313	70.6 (64.3–76.2)	1.4 (1.2–1.7)	<LOD	1.1 (0.89–1.3)	12 (8.2–16)	21 ^F (10–33)
6 (2018–2019)	1279	68.2 (60.1–75.3)	1.6 (1.2–2.1)	<LOD	1.2 ^E (0.72–1.6)	15 (11–19)	26 (19–34)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	523	92.6 (89.2–95.1)	11 (9.1–13)	1.3 ^E (<LOD–2.1)	11 (8.0–13)	79 (61–98)	110 (87–140)
5 (2016–2017)	538	86.6 (81.3–90.6)	4.5 (3.3–6.1)	<LOD	4.2 ^E (2.6–5.8)	39 ^E (22–56)	61 ^F (37–84)
6 (2018–2019)	516	84.9 (78.9–89.5)	5.0 (3.6–6.8)	<LOD	4.3 ^E (2.3–6.4)	63 ^E (24–100)	91 (68–110)
6–11 years							
1 (2007–2009)	1026	67.3 (58.5–75.1)	3.8 (3.1–4.8)	<LOD	3.8 (2.7–4.9)	45 (36–54)	70 (52–88)
2 (2009–2011)	514	91.6 (89.4–93.3)	5.7 (4.6–7.0)	<LOD	5.9 ^E (3.4–8.4)	40 ^E (19–60)	90 ^E (31–150)
5 (2016–2017)	507	84.6 (80.1–88.3)	2.8 (2.1–3.6)	<LOD	2.7 (2.0–3.4)	29 ^E (9.5–49)	43 ^E (18–67)
6 (2018–2019)	497	78.7 (65.6–87.7)	2.7 ^E (1.9–3.9)	<LOD	2.6 ^E (1.2–4.1)	18 ^E (3.3–33)	35 ^E (<LOD–68)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	978	68.7 (60.7–75.6)	2.0 (1.6–2.4)	<LOD	2.0 (1.8–2.1)	19 (13–24)	30 (23–36)
2 (2009–2011)	510	80.0 (73.0–85.6)	2.0 (1.6–2.5)	<LOD	1.9 (1.3–2.5)	13 ^E (7.6–19)	25 ^E (12–38)
5 (2016–2017)	520	76.5 (68.8–82.8)	1.2 (0.95–1.5)	<LOD	1.1 (0.89–1.3)	8.4 ^E (4.3–13)	17 ^E (1.8–32)
6 (2018–2019)	505	65.0 (56.7–72.6)	0.92 (0.68–1.2)	<LOD	0.83 ^E (0.52–1.1)	7.8 ^E (2.8–13)	21 ^E (5.8–36)
20–39 years							
1 (2007–2009)	1159	66.0 (57.1–73.9)	2.0 (1.6–2.6)	<LOD	1.9 (<LOD–2.5)	17 ^E (9.0–25)	34 ^F (18–51)
2 (2009–2011)	354	78.1 (65.6–86.9)	2.0 (1.6–2.6)	<LOD	2.0 (1.5–2.5)	14 ^E (6.8–21)	33 ^E (17–50)
5 (2016–2017)	358	60.8 (52.0–68.9)	0.91 (0.67–1.2)	<LOD	0.69 (0.46–0.92)	6.5 ^E (<LOD–16)	14 ^F (<LOD–30)
6 (2018–2019)	332	66.6 (53.8–77.4)	0.91 (0.67–1.3)	<LOD	0.86 ^E (0.50–1.2)	5.5 ^E (2.2–8.8)	12 ^E (5.4–18)
40–59 years							
1 (2007–2009)	1218	63.9 (58.0–69.4)	2.3 (1.9–2.7)	<LOD	1.9 (<LOD–2.4)	19 (15–22)	45 (37–54)
2 (2009–2011)	358	79.2 (70.6–85.8)	2.4 (1.9–3.1)	<LOD	2.4 ^E (1.4–3.4)	15 ^E (7.2–22)	29 (19–40)
5 (2016–2017)	346	70.1 (56.6–80.8)	1.1 (0.90–1.4)	<LOD	0.92 (0.76–1.1)	7.7 ^E (2.1–13)	13 ^E (6.3–19)
6 (2018–2019)	342	68.7 (60.1–76.2)	1.5 (1.1–2.1)	<LOD	1.3 (0.87–1.8)	13 ^E (7.7–18)	24 ^E (3.5–45)
60–79 years							
1 (2007–2009)	1079	73.6 (67.0–79.3)	3.7 (3.1–4.4)	<LOD	3.9 (2.9–5.0)	30 (22–38)	53 (40–67)
2 (2009–2011)	290	77.4 (67.0–85.3)	3.2 (2.4–4.3)	<LOD	3.5 ^E (2.1–4.8)	25 (16–34)	37 ^E (7.4–66)
5 (2016–2017)	349	75.2 (69.7–80.1)	1.6 (1.2–2.1)	<LOD	1.5 ^E (0.95–2.1)	10 ^E (1.8–18)	21 ^E (5.7–37)
6 (2018–2019)	343	68.3 (58.8–76.5)	1.4 ^E (0.81–2.3)	<LOD	1.1 ^E (<LOD–2.0)	15 ^E (2.9–27)	29 ^E (15–43)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.1.6

Dimethyldithiophosphate (DMDTP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2537	49.1 (44.2–53.9)	—	<LOD	<LOD	2.9 (2.4–3.5)	6.5 (5.2–7.8)
5 (2016–2017)	2618	51.8 (46.9–56.6)	—	<LOD	0.097 (<LOD–0.12)	1.4 (0.94–1.9)	4.1 ^F (2.6–5.6)
6 (2018–2019)	2525	53.4 (46.9–59.8)	0.16 (0.13–0.19)	<LOD	0.10 (<LOD–0.14)	1.2 (0.81–1.5)	2.6 ^F (0.66–4.6)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1271	42.2 (37.4–47.2)	—	<LOD	<LOD	2.6 ^E (1.5–3.7)	5.7 (3.8–7.6)
5 (2016–2017)	1296	49.5 (43.2–55.8)	—	<LOD	<LOD	1.2 ^E (0.64–1.7)	4.1 ^F (1.2–7.0)
6 (2018–2019)	1249	59.3 (51.4–66.8)	0.17 (0.14–0.21)	<LOD	0.14 ^E (<LOD–0.20)	1.1 (0.92–1.4)	2.1 ^F (0.24–3.9)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1266	55.8 (49.5–61.8)	—	<LOD	0.33 (<LOD–0.42)	3.4 (2.5–4.2)	7.8 (5.5–10)
5 (2016–2017)	1322	54.0 (46.4–61.4)	0.17 (0.14–0.21)	<LOD	0.099 ^E (<LOD–0.14)	1.5 ^E (0.48–2.5)	3.8 ^E (1.9–5.7)
6 (2018–2019)	1276	47.6 (41.3–54.0)	0.15 (0.12–0.18)	<LOD	<LOD	1.3 ^E (0.35–2.2)	3.9 ^E (0.95–6.8)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	523	63.0 (55.1–70.2)	0.85 (0.68–1.1)	<LOD	0.57 ^E (0.32–0.83)	8.8 ^E (4.4–13)	18 ^E (9.6–26)
5 (2016–2017)	542	64.0 (53.6–73.2)	0.29 ^F (0.20–0.44)	<LOD	0.25 ^E (<LOD–0.42)	3.9 ^E (2.1–5.7)	6.6 ^E (1.4–12)
6 (2018–2019)	517	75.9 (68.4–82.0)	0.38 (0.27–0.53)	<LOD	0.34 ^E (0.21–0.48)	4.1 ^E (<LOD–9.2)	12 ^E (0.61–23)
6–11 years							
1 (2007–2009)	1029	40.7 (32.2–49.7)	—	<LOD	<LOD	3.6 (2.5–4.6)	7.2 (4.8–9.5)
2 (2009–2011)	512	62.0 (55.2–68.3)	—	<LOD	0.49 ^E (<LOD–0.75)	4.5 ^E (1.7–7.4)	9.3 ^E (5.6–13)
5 (2016–2017)	515	68.2 (60.6–75.0)	0.27 (0.20–0.36)	<LOD	0.19 (0.14–0.23)	3.2 ^E (0.81–5.6)	8.0 ^E (4.0–12)
6 (2018–2019)	498	73.1 (65.9–79.2)	0.32 (0.23–0.43)	<LOD	0.26 ^E (0.15–0.36)	2.8 ^E (<LOD–6.0)	6.9 ^E (1.3–12)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	980	35.1 (28.0–43.0)	—	<LOD	<LOD	2.3 ^E (1.4–3.2)	7.0 (4.9–9.1)
2 (2009–2011)	512	43.7 (37.3–50.3)	—	<LOD	<LOD	2.0 ^E (0.84–3.1)	4.5 ^E (1.1–7.9)
5 (2016–2017)	521	54.9 (45.2–64.1)	—	<LOD	0.12 (<LOD–0.16)	1.4 ^E (0.82–2.0)	4.9 ^E (1.9–7.9)
6 (2018–2019)	502	56.3 (47.3–64.8)	—	<LOD	0.12 ^E (<LOD–0.19)	0.83 (0.60–1.1)	1.6 ^E (<LOD–3.3)
20–39 years							
1 (2007–2009)	1163	34.6 (25.0–45.6)	—	<LOD	<LOD	1.9 ^E (1.1–2.7)	4.6 ^E (2.4–6.7)
2 (2009–2011)	357	43.9 (34.8–53.5)	—	<LOD	<LOD	2.5 ^E (0.79–4.3)	4.4 ^E (2.3–6.4)
5 (2016–2017)	360	46.1 (37.6–54.9)	—	<LOD	<LOD	0.73 ^E (0.45–1.0)	1.9 ^E (<LOD–4.0)
6 (2018–2019)	330	48.5 (38.6–58.6)	—	<LOD	<LOD	0.63 ^E (0.36–0.90)	1.2 ^E (0.42–2.0)
40–59 years							
1 (2007–2009)	1223	33.9 (26.9–41.7)	—	<LOD	<LOD	2.4 ^E (0.74–4.0)	5.8 (4.3–7.4)
2 (2009–2011)	353	48.1 (41.0–55.3)	—	<LOD	<LOD	2.8 ^E (1.7–3.9)	6.1 ^E (2.7–9.5)
5 (2016–2017)	346	51.4 (43.0–59.6)	—	<LOD	0.099 ^E (<LOD–0.14)	1.4 ^E (<LOD–3.2)	3.7 ^E (<LOD–9.3)
6 (2018–2019)	340	53.1 (45.2–60.9)	—	<LOD	0.11 ^E (<LOD–0.16)	1.2 ^E (0.70–1.6)	4.4 ^E (<LOD–8.9)
60–79 years							
1 (2007–2009)	1080	44.5 (40.0–49.2)	—	<LOD	<LOD	3.9 ^E (2.4–5.4)	7.5 (5.0–9.9)
2 (2009–2011)	280	55.3 (45.7–64.6)	—	<LOD	0.34 ^E (<LOD–0.64)	4.4 ^E (0.42–8.3)	9.5 ^E (3.7–15)
5 (2016–2017)	334	51.5 (42.8–60.0)	—	<LOD	0.098 ^E (<LOD–0.15)	2.0 ^E (0.75–3.2)	4.5 ^E (0.80–8.3)
6 (2018–2019)	338	49.2 (36.4–62.2)	—	<LOD	<LOD	1.4 ^E (0.32–2.5)	2.7 ^E (0.096–5.3)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.3, 0.3, 0.093 and 0.093 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.1.7

Dimethyldithiophosphate (DMDTP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2527	49.1 (44.2–53.9)	—	<LOD	<LOD	3.3 (2.4–4.2)	7.2 (5.2–9.3)
5 (2016–2017)	2591	51.8 (46.9–56.6)	—	<LOD	0.11 (<LOD–0.13)	1.4 (1.1–1.8)	3.9 ^E (1.4–6.4)
6 (2018–2019)	2524	53.4 (46.9–59.8)	0.18 (0.14–0.22)	<LOD	0.13 (<LOD–0.17)	1.4 ^E (0.48–2.4)	4.0 ^E (2.0–6.0)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1267	42.2 (37.4–47.2)	—	<LOD	<LOD	2.0 (1.5–2.5)	4.4 (3.0–5.8)
5 (2016–2017)	1286	49.5 (43.2–55.8)	—	<LOD	<LOD	1.2 ^E (0.61–1.8)	3.0 ^E (<LOD–6.9)
6 (2018–2019)	1248	59.3 (51.4–66.8)	0.16 (0.13–0.21)	<LOD	0.15 (<LOD–0.20)	1.1 ^E (0.59–1.6)	3.1 ^E (1.2–5.0)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1260	55.8 (49.5–61.8)	—	<LOD	0.40 ^E (<LOD–0.55)	4.6 (3.2–6.0)	9.4 (7.5–11)
5 (2016–2017)	1305	54.0 (46.4–61.4)	0.19 (0.14–0.24)	<LOD	0.13 ^E (<LOD–0.19)	1.5 ^E (0.40–2.6)	4.9 ^E (1.5–8.4)
6 (2018–2019)	1276	47.6 (41.3–54.0)	0.19 (0.15–0.24)	<LOD	<LOD	2.1 ^E (0.49–3.6)	5.4 ^E (1.1–9.6)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	63.0 (55.1–70.2)	1.3 (1.0–1.6)	<LOD	0.97 (0.71–1.2)	17 ^E (8.4–25)	27 ^E (16–38)
5 (2016–2017)	533	64.0 (53.6–73.2)	0.50 ^E (0.31–0.81)	<LOD	0.37 ^E (<LOD–0.62)	5.5 ^E (2.5–8.4)	12 ^E (5.4–18)
6 (2018–2019)	516	75.9 (68.4–82.0)	0.63 ^E (0.43–0.92)	<LOD	0.48 (0.31–0.64)	7.4 ^E (<LOD–14)	17 ^E (<LOD–37)
6–11 years							
1 (2007–2009)	1026	40.7 (32.2–49.7)	—	<LOD	<LOD	5.5 (3.6–7.4)	11 (8.5–13)
2 (2009–2011)	510	62.0 (55.2–68.3)	—	<LOD	0.50 ^E (<LOD–0.70)	6.8 ^E (3.1–10)	9.8 ^E (5.3–14)
5 (2016–2017)	506	68.2 (60.6–75.0)	0.32 (0.23–0.43)	<LOD	0.22 ^E (0.12–0.31)	4.6 ^E (1.5–7.7)	7.1 ^E (2.6–12)
6 (2018–2019)	498	73.1 (65.9–79.2)	0.38 (0.30–0.48)	<LOD	0.32 ^E (0.19–0.44)	3.0 ^E (<LOD–6.1)	7.2 ^E (1.8–13)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	978	35.1 (28.0–43.0)	—	<LOD	<LOD	2.1 ^E (1.3–3.0)	5.3 ^E (3.2–7.4)
2 (2009–2011)	510	43.7 (37.3–50.3)	—	<LOD	<LOD	1.5 ^E (0.84–2.1)	2.8 ^E (<LOD–5.3)
5 (2016–2017)	517	54.9 (45.2–64.1)	—	<LOD	0.098 (<LOD–0.13)	1.1 ^E (0.60–1.5)	3.0 ^E (<LOD–6.2)
6 (2018–2019)	502	56.3 (47.3–64.8)	—	<LOD	0.099 (<LOD–0.12)	0.92 ^E (0.26–1.6)	2.0 ^E (<LOD–5.7)
20–39 years							
1 (2007–2009)	1159	34.6 (25.0–45.6)	—	<LOD	<LOD	2.0 ^E (0.95–3.0)	4.8 ^E (2.6–6.9)
2 (2009–2011)	355	43.9 (34.8–53.5)	—	<LOD	<LOD	1.9 ^E (1.2–2.6)	4.2 ^E (1.3–7.0)
5 (2016–2017)	357	46.1 (37.6–54.9)	—	<LOD	<LOD	1.2 ^E (0.48–2.0)	2.0 ^E (<LOD–2.7)
6 (2018–2019)	330	48.5 (38.6–58.6)	—	<LOD	<LOD	0.52 ^E (0.12–0.91)	1.2 ^E (0.74–1.7)
40–59 years							
1 (2007–2009)	1218	33.9 (26.9–41.7)	—	<LOD	<LOD	3.2 (2.3–4.1)	8.7 (6.1–11)
2 (2009–2011)	351	48.1 (41.0–55.3)	—	<LOD	<LOD	2.9 ^E (0.92–4.9)	6.7 ^E (3.0–10)
5 (2016–2017)	345	51.4 (43.0–59.6)	—	<LOD	0.11 (<LOD–0.15)	1.0 ^E (<LOD–2.9)	3.7 ^E (<LOD–9.1)
6 (2018–2019)	340	53.1 (45.2–60.9)	—	<LOD	0.16 (<LOD–0.19)	2.0 ^E (<LOD–3.8)	5.4 ^E (<LOD–11)
60–79 years							
1 (2007–2009)	1080	44.5 (40.0–49.2)	—	<LOD	<LOD	4.6 (2.9–6.2)	9.3 ^E (3.8–15)
2 (2009–2011)	279	55.3 (45.7–64.6)	—	<LOD	0.50 ^E (<LOD–0.72)	5.3 ^E (1.7–8.9)	10 ^F (6.0–14)
5 (2016–2017)	333	51.5 (42.8–60.0)	—	<LOD	0.14 ^E (<LOD–0.19)	2.0 ^E (<LOD–4.1)	7.6 ^E (2.9–12)
6 (2018–2019)	338	49.2 (36.4–62.2)	—	<LOD	<LOD	2.3 ^E (<LOD–4.7)	4.5 ^E (2.4–6.5)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.1.8

Diethylphosphate (DEP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2556	83.3 (79.1–86.7)	2.8 (2.6–3.1)	<LOD	2.8 (2.5–3.1)	11 (8.4–13)	19 (16–21)
5 (2016–2017)	2646	97.8 (95.9–98.8)	2.2 (2.0–2.5)	0.52 (0.44–0.60)	2.1 (1.8–2.4)	9.9 (8.4–11)	14 (10–17)
6 (2018–2019)	2538	96.7 (94.7–97.9)	2.2 (2.0–2.3)	0.49 (0.40–0.59)	2.1 (1.9–2.3)	9.7 (8.2–11)	15 (11–19)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1279	85.3 (81.7–88.3)	2.9 (2.6–3.3)	<LOD	2.9 (2.5–3.4)	10 (8.4–12)	18 ^F (11–26)
5 (2016–2017)	1315	97.9 (95.9–98.9)	2.2 (1.9–2.6)	0.53 (0.44–0.61)	2.1 (1.6–2.6)	9.8 (7.9–12)	15 (11–20)
6 (2018–2019)	1258	96.7 (92.8–98.5)	2.2 (1.9–2.6)	0.55 (0.41–0.70)	2.2 (1.9–2.5)	10 (7.8–12)	15 ^F (6.6–23)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1277	81.2 (75.4–85.9)	2.7 (2.4–3.1)	<LOD	2.6 (2.2–2.9)	12 ^F (7.5–17)	19 (15–23)
5 (2016–2017)	1331	97.7 (93.6–99.2)	2.2 (1.9–2.6)	0.51 (0.37–0.64)	2.1 (1.7–2.5)	9.7 (7.6–12)	12 (8.3–16)
6 (2018–2019)	1280	96.7 (94.1–98.1)	2.1 (1.9–2.3)	0.45 (0.32–0.58)	2.0 (1.7–2.4)	9.1 (6.9–11)	15 ^F (9.6–21)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	523	92.9 (89.5–95.3)	4.9 (4.1–5.9)	1.2 (<LOD–1.6)	5.1 (4.1–6.1)	19 ^F (10–27)	29 ^F (9.9–48)
5 (2016–2017)	547	98.7 (96.6–99.5)	4.2 (3.4–5.0)	0.99 (0.77–1.2)	4.1 (2.8–5.4)	16 (13–19)	22 ^F (11–33)
6 (2018–2019)	517	99.3 (94.7–99.9)	3.8 (3.2–4.6)	1.0 (0.82–1.2)	3.8 (2.7–4.8)	15 ^F (6.2–24)	23 (15–32)
6–11 years							
1 (2007–2009)	1029	80.9 (68.2–89.3)	2.8 (2.2–3.6)	<LOD	3.0 (2.3–3.6)	11 (9.3–14)	17 (14–20)
2 (2009–2011)	515	92.0 (89.5–94.0)	4.1 (3.7–4.7)	<LOD	4.0 (3.5–4.5)	16 (12–19)	23 ^F (12–33)
5 (2016–2017)	516	98.2 (96.5–99.1)	3.2 (2.8–3.6)	0.80 (0.52–1.1)	2.9 (2.2–3.6)	12 ^F (7.3–17)	19 ^F (11–27)
6 (2018–2019)	498	96.7 (82.1–99.5)	3.6 (2.8–4.6)	0.77 ^E (0.40–1.1)	3.6 (3.1–4.2)	16 ^F (9.0–22)	24 (16–33)
12–19 years							
1 (2007–2009)	980	82.2 (72.1–89.2)	2.9 (2.4–3.6)	<LOD	3.1 (2.4–3.7)	12 (9.3–15)	18 (14–22)
2 (2009–2011)	512	88.1 (84.3–91.0)	3.4 (3.0–3.9)	<LOD	3.1 (2.6–3.7)	16 (11–22)	23 ^F (14–31)
5 (2016–2017)	524	98.6 (97.3–99.3)	2.6 (2.1–3.1)	0.59 ^E (0.33–0.85)	2.7 (2.0–3.4)	9.9 (7.4–12)	17 (12–22)
6 (2018–2019)	505	97.3 (93.7–98.8)	2.7 (2.2–3.4)	0.64 (0.42–0.86)	2.6 (1.8–3.5)	9.7 (6.4–13)	14 (9.3–19)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1163	77.7 (65.9–86.3)	2.1 (1.7–2.6)	<LOD	2.1 (1.8–2.5)	7.8 (6.0–9.6)	12 (8.6–14)
2 (2009–2011)	357	83.1 (75.7–88.6)	2.7 (2.3–3.2)	<LOD	2.6 (2.2–3.0)	9.5 ^E (5.4–14)	20 ^E (7.9–32)
5 (2016–2017)	361	95.7 (89.9–98.2)	2.0 (1.6–2.7)	0.47 (0.31–0.62)	1.8 ^E (1.1–2.5)	10 (7.6–13)	15 ^E (8.9–22)
6 (2018–2019)	332	97.1 (92.1–99.0)	2.2 (1.9–2.6)	0.45 ^E (<LOD–0.64)	2.2 (1.8–2.6)	10 ^E (5.0–15)	15 ^E (6.8–23)
40–59 years							
1 (2007–2009)	1223	75.6 (66.0–83.1)	2.1 (1.8–2.4)	<LOD	2.1 (1.8–2.4)	7.6 (5.9–9.2)	11 (8.2–13)
2 (2009–2011)	360	80.3 (71.6–86.9)	2.5 (2.0–3.1)	<LOD	2.5 (1.9–3.1)	9.5 ^E (5.3–14)	16 ^E (8.6–23)
5 (2016–2017)	348	98.5 (96.0–99.5)	2.0 (1.7–2.3)	0.58 (0.42–0.73)	2.0 (1.6–2.3)	6.8 (5.5–8.0)	8.2 (6.6–9.9)
6 (2018–2019)	343	94.7 (89.5–97.4)	1.8 (1.4–2.3)	0.47 (0.31–0.63)	1.6 (1.1–2.1)	8.9 (5.7–12)	13 ^E (5.6–21)
60–79 years							
1 (2007–2009)	1080	82.4 (74.0–88.5)	2.4 (2.1–2.6)	<LOD	2.3 (2.0–2.7)	8.8 (7.8–9.9)	12 (9.8–13)
2 (2009–2011)	289	80.6 (73.0–86.5)	2.6 (2.0–3.2)	<LOD	2.6 (1.9–3.4)	10 ^E (4.7–16)	16 (12–21)
5 (2016–2017)	350	99.0 (96.8–99.7)	2.1 (1.7–2.5)	0.42 ^E (<LOD–0.57)	1.9 (1.4–2.4)	9.7 (6.5–13)	13 (10–17)
6 (2018–2019)	343	98.1 (93.7–99.5)	1.8 (1.5–2.2)	0.45 (0.35–0.55)	1.8 (1.4–2.3)	7.8 (5.1–11)	10 ^E (4.0–16)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 1, 1, 0.29 and 0.29 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
 b Data are not available, as participants under the age of six years were not included in cycle 1.
 E Use data with caution.

Table 13.1.9

Diethylphosphate (DEP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2546	83.3 (79.1–86.7)	2.7 (2.5–2.9)	<LOD	2.6 (2.3–2.9)	9.5 (8.3–11)	14 (11–17)
5 (2016–2017)	2619	97.8 (95.9–98.8)	2.1 (2.0–2.3)	0.66 (0.52–0.80)	2.1 (1.8–2.3)	7.1 (6.7–7.5)	10 (8.8–11)
6 (2018–2019)	2537	96.7 (94.7–97.9)	2.3 (2.2–2.5)	0.75 (0.65–0.85)	2.2 (2.0–2.4)	8.3 (7.2–9.4)	13 (9.7–16)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1275	85.3 (81.7–88.3)	2.4 (2.1–2.7)	<LOD	2.2 (1.8–2.5)	9.1 (6.9–11)	14 (9.5–18)
5 (2016–2017)	1305	97.9 (95.9–98.9)	1.9 (1.6–2.2)	0.55 (0.40–0.71)	1.8 (1.4–2.1)	7.1 (6.1–8.1)	9.5 (8.1–11)
6 (2018–2019)	1257	96.7 (92.8–98.5)	2.1 (1.9–2.3)	0.67 (0.55–0.79)	1.9 (1.7–2.2)	7.3 (5.1–9.5)	11 ^E (6.4–16)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1271	81.2 (75.4–85.9)	3.1 (2.7–3.5)	<LOD	2.9 (2.5–3.3)	9.9 (7.5–12)	14 (9.9–19)
5 (2016–2017)	1314	97.7 (93.6–99.2)	2.4 (2.1–2.7)	0.80 (0.58–1.0)	2.4 (2.0–2.7)	7.1 (6.5–7.7)	11 (9.1–12)
6 (2018–2019)	1280	96.7 (94.1–98.1)	2.6 (2.3–3.0)	0.85 (0.71–0.99)	2.5 (2.2–2.9)	9.5 (7.0–12)	14 (9.0–18)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	92.9 (89.5–95.3)	8.5 (7.3–9.9)	2.6 (<LOD–3.4)	8.6 (7.2–10)	31 (22–41)	44 (33–55)
5 (2016–2017)	538	98.7 (96.6–99.5)	7.1 (6.3–8.0)	1.9 (1.3–2.5)	7.9 (6.7–9.2)	20 (17–24)	32 (21–43)
6 (2018–2019)	516	99.3 (94.7–99.9)	6.3 (5.3–7.6)	2.1 (1.6–2.6)	6.2 (4.4–7.9)	22 ^E (13–30)	24 (15–33)
6–11 years							
1 (2007–2009)	1026	80.9 (68.2–89.3)	4.4 (3.7–5.2)	<LOD	4.2 (3.5–4.9)	16 (13–20)	24 (19–29)
2 (2009–2011)	513	92.0 (89.5–94.0)	4.8 (4.3–5.3)	<LOD	4.5 (3.9–5.2)	18 (13–22)	24 ^E (11–38)
5 (2016–2017)	507	98.2 (96.5–99.1)	3.7 (3.1–4.4)	1.1 (0.82–1.3)	3.5 (2.8–4.2)	11 (7.4–14)	16 ^E (9.2–24)
6 (2018–2019)	498	96.7 (82.1–99.5)	4.3 (3.5–5.3)	1.0 (0.65–1.4)	3.8 (3.1–4.6)	15 ^E (9.2–20)	27 ^E (<LOD–57)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	978	82.2 (72.1–89.2)	2.6 (2.2–3.1)	<LOD	2.6 (2.1–3.1)	8.7 (7.9–9.5)	12 (10–13)
2 (2009–2011)	510	88.1 (84.3–91.0)	2.6 (2.2–3.0)	<LOD	2.5 (2.0–3.0)	9.9 (7.8–12)	15 ^E (9.6–21)
5 (2016–2017)	520	98.6 (97.3–99.3)	2.0 (1.7–2.3)	0.55 (0.38–0.72)	1.9 (1.6–2.3)	7.5 (5.5–9.4)	9.2 (7.1–11)
6 (2018–2019)	505	97.3 (93.7–98.8)	2.3 (1.9–2.7)	0.79 (0.66–0.93)	2.4 (2.0–2.7)	6.0 (4.6–7.4)	8.0 (5.8–10)
20–39 years							
1 (2007–2009)	1159	77.7 (65.9–86.3)	2.4 (2.0–2.8)	<LOD	2.2 (1.8–2.7)	7.4 (6.6–8.2)	9.9 (8.4–11)
2 (2009–2011)	355	83.1 (75.7–88.6)	2.2 (1.9–2.6)	<LOD	2.0 (1.4–2.6)	7.2 ^E (3.5–11)	13 ^E (<LOD–26)
5 (2016–2017)	358	95.7 (89.9–98.2)	1.8 (1.6–2.1)	0.50 ^E (0.30–0.70)	1.8 (1.4–2.2)	6.3 (5.2–7.4)	7.2 ^E (4.4–10)
6 (2018–2019)	332	97.1 (92.1–99.0)	2.1 (1.9–2.3)	0.73 (<LOD–0.86)	2.0 (1.7–2.3)	6.8 (4.6–9.0)	9.9 ^E (5.5–14)
40–59 years							
1 (2007–2009)	1218	75.6 (66.0–83.1)	2.7 (2.4–3.0)	<LOD	2.9 (2.6–3.2)	8.9 (7.2–11)	11 (10–13)
2 (2009–2011)	358	80.3 (71.6–86.9)	2.5 (2.2–2.8)	<LOD	2.4 (1.9–2.8)	7.9 (5.5–10)	11 (7.5–15)
5 (2016–2017)	347	98.5 (96.0–99.5)	1.8 (1.6–2.1)	0.72 (0.48–0.95)	1.8 (1.5–2.1)	4.5 (3.6–5.4)	6.4 (4.3–8.4)
6 (2018–2019)	343	94.7 (89.5–97.4)	2.2 (1.8–2.6)	0.70 (0.50–0.91)	1.9 (1.4–2.4)	6.9 ^E (4.3–9.5)	14 ^E (8.1–20)
60–79 years							
1 (2007–2009)	1080	82.4 (74.0–88.5)	3.4 (3.0–3.7)	<LOD	3.5 (3.0–4.0)	9.9 (8.9–11)	13 (11–16)
2 (2009–2011)	288	80.6 (73.0–86.5)	3.0 (2.5–3.6)	<LOD	2.9 (2.2–3.6)	9.0 ^E (5.6–12)	13 (9.9–17)
5 (2016–2017)	349	99.0 (96.8–99.7)	2.4 (2.1–2.8)	0.76 (<LOD–0.99)	2.2 (2.0–2.5)	7.3 (6.0–8.6)	9.5 (6.8–12)
6 (2018–2019)	343	98.1 (93.7–99.5)	2.1 (1.9–2.4)	0.64 (0.48–0.79)	2.1 (1.7–2.6)	7.5 (6.0–9.0)	10 (7.3–13)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.1.10

Diethylthiophosphate (DETP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2511	72.7 (68.1–76.8)	0.66 (0.60–0.72)	<LOD	0.60 (0.51–0.70)	2.7 (1.9–3.4)	5.3 ^E (3.2–7.4)
5 (2016–2017)	2610	75.5 (70.3–80.1)	0.37 (0.33–0.42)	<LOD	0.32 (0.27–0.38)	2.6 (2.1–3.2)	4.4 (3.6–5.2)
6 (2018–2019)	2502	68.4 (62.0–74.1)	0.28 (0.24–0.32)	<LOD	0.27 (0.22–0.31)	1.7 (1.2–2.2)	2.5 (2.0–3.0)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1261	73.1 (67.9–77.7)	0.63 (0.57–0.71)	<LOD	0.58 (0.49–0.67)	2.5 (1.9–3.1)	3.5 ^E (1.6–5.5)
5 (2016–2017)	1294	75.7 (66.1–83.3)	0.37 (0.29–0.48)	<LOD	0.33 (0.22–0.45)	2.4 ^E (1.1–3.7)	4.5 (2.9–6.2)
6 (2018–2019)	1239	69.0 (62.0–75.2)	0.28 (0.24–0.34)	<LOD	0.27 (0.22–0.32)	1.5 ^E (0.76–2.2)	2.8 (2.0–3.7)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1250	72.2 (65.9–77.8)	0.68 (0.59–0.79)	<LOD	0.61 (0.46–0.76)	3.0 ^E (0.78–5.2)	5.6 ^E (1.6–9.5)
5 (2016–2017)	1316	75.3 (70.9–79.3)	0.37 (0.29–0.47)	<LOD	0.32 (0.24–0.40)	2.7 ^E (1.4–4.1)	4.3 ^E (1.5–7.1)
6 (2018–2019)	1263	67.8 (58.7–75.7)	0.27 (0.22–0.32)	<LOD	0.26 (0.20–0.33)	1.8 (1.2–2.4)	2.3 (1.9–2.7)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	512	88.2 (83.8–91.5)	1.0 (0.92–1.2)	<LOD	1.0 (0.91–1.1)	4.3 ^E (2.7–6.0)	6.7 ^E (3.4–10)
5 (2016–2017)	539	88.3 (83.0–92.1)	0.68 (0.51–0.91)	<LOD	0.80 ^E (0.47–1.1)	5.2 ^E (2.6–7.8)	7.4 ^E (4.2–11)
6 (2018–2019)	510	87.2 (81.5–91.3)	0.58 (0.47–0.72)	<LOD	0.62 (0.46–0.78)	3.0 (2.0–4.0)	4.2 (2.8–5.6)
6–11 years							
1 (2007–2009)	1029	41.8 (31.7–52.5)	—	<LOD	<LOD	2.9 (2.1–3.7)	4.8 (3.9–5.7)
2 (2009–2011)	508	80.8 (74.7–85.7)	0.85 (0.74–0.98)	<LOD	0.78 (0.68–0.88)	3.4 ^E (2.1–4.6)	5.4 ^E (1.0–9.8)
5 (2016–2017)	511	84.1 (80.2–87.4)	0.54 (0.45–0.65)	<LOD	0.49 (0.32–0.67)	3.2 (2.2–4.2)	5.4 ^E (2.9–7.8)
6 (2018–2019)	491	77.6 (69.4–84.1)	0.46 (0.35–0.60)	<LOD	0.45 (0.35–0.54)	2.7 ^E (1.3–4.1)	6.0 ^E (<LOD–13)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	979	44.6 (34.2–55.4)	—	<LOD	<LOD	2.6 (1.8–3.3)	4.1 (3.1–5.1)
2 (2009–2011)	504	74.6 (66.2–81.4)	0.67 (0.57–0.78)	<LOD	0.59 (0.47–0.71)	2.6 (2.0–3.2)	4.1 ^E (2.5–5.7)
5 (2016–2017)	520	77.1 (66.5–85.2)	0.41 (0.31–0.55)	<LOD	0.35 ^E (0.21–0.49)	3.4 ^E (1.7–5.1)	5.8 ^E (2.9–8.8)
6 (2018–2019)	502	76.0 (68.0–82.5)	0.35 (0.27–0.46)	<LOD	0.32 (0.24–0.39)	2.6 ^E (1.4–3.9)	5.2 ^E (1.9–8.5)
20–39 years							
1 (2007–2009)	1163	36.1 (27.5–45.7)	—	<LOD	<LOD	1.9 (1.5–2.3)	2.9 (1.9–3.8)
2 (2009–2011)	349	67.8 (58.7–75.7)	0.57 (0.48–0.69)	<LOD	0.47 ^E (<LOD–0.64)	2.6 ^E (1.2–3.9)	5.4 ^E (1.6–9.1)
5 (2016–2017)	354	73.3 (60.9–82.9)	0.37 (0.28–0.48)	<LOD	0.31 ^E (0.19–0.43)	3.6 ^E (0.47–6.6)	6.9 ^E (1.8–12)
6 (2018–2019)	328	70.9 (61.2–79.1)	0.26 (0.21–0.32)	<LOD	0.25 (0.19–0.31)	1.7 ^E (0.93–2.6)	2.2 (1.6–2.7)
40–59 years							
1 (2007–2009)	1223	34.1 (27.0–42.0)	—	<LOD	<LOD	2.2 (1.6–2.8)	4.6 ^E (2.8–6.5)
2 (2009–2011)	352	73.6 (64.4–81.2)	0.66 (0.53–0.82)	<LOD	0.65 (0.46–0.84)	2.3 ^E (<LOD–5.1)	4.9 ^E (<LOD–13)
5 (2016–2017)	342	74.5 (67.4–80.6)	0.31 (0.25–0.38)	<LOD	0.29 (0.21–0.37)	2.0 ^E (0.63–3.4)	3.9 ^E (2.3–5.5)
6 (2018–2019)	334	63.3 (47.6–76.6)	0.24 (0.17–0.34)	<LOD	0.24 ^E (0.13–0.35)	1.2 (0.81–1.5)	1.7 (1.2–2.1)
60–79 years							
1 (2007–2009)	1080	40.0 (32.9–47.5)	—	<LOD	<LOD	2.6 (2.2–3.0)	4.1 (3.5–4.7)
2 (2009–2011)	286	71.6 (63.7–78.3)	0.67 (0.55–0.82)	<LOD	0.59 (0.41–0.76)	2.7 ^E (0.76–4.6)	5.1 ^E (0.71–9.4)
5 (2016–2017)	344	74.4 (66.2–81.2)	0.37 (0.28–0.48)	<LOD	0.36 ^E (0.20–0.52)	2.1 (1.5–2.8)	3.1 ^E (1.1–5.1)
6 (2018–2019)	337	62.3 (55.5–68.6)	0.25 (0.20–0.30)	<LOD	0.23 (0.18–0.29)	1.7 ^E (0.73–2.7)	2.6 (1.8–3.4)

CI: onfidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.6, 0.3, 0.13 and 0.13 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.1.11

Diethylthiophosphate (DETP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2501	72.7 (68.1–76.8)	0.60 (0.54–0.66)	<LOD	0.59 (0.50–0.68)	2.8 (2.1–3.4)	4.1 (3.5–4.7)
5 (2016–2017)	2583	75.5 (70.3–80.1)	0.36 (0.32–0.40)	<LOD	0.34 (0.29–0.39)	2.3 (1.7–2.8)	3.8 (2.8–4.7)
6 (2018–2019)	2501	68.4 (62.0–74.1)	0.30 (0.26–0.35)	<LOD	0.26 (0.21–0.32)	1.5 (1.1–1.9)	2.7 (2.3–3.1)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1257	73.1 (67.9–77.7)	0.50 (0.44–0.57)	<LOD	0.44 (0.32–0.55)	2.1 (1.5–2.7)	3.3 (2.2–4.4)
5 (2016–2017)	1284	75.7 (66.1–83.3)	0.32 (0.26–0.40)	<LOD	0.29 (0.19–0.39)	1.9 (1.3–2.4)	3.0 ^E (1.5–4.6)
6 (2018–2019)	1238	69.0 (62.0–75.2)	0.26 (0.22–0.31)	<LOD	0.23 (0.19–0.27)	1.3 (0.86–1.7)	2.3 ^E (1.3–3.4)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1244	72.2 (65.9–77.8)	0.72 (0.60–0.87)	<LOD	0.69 (0.55–0.82)	3.6 (2.8–4.5)	5.2 ^E (2.9–7.5)
5 (2016–2017)	1299	75.3 (70.9–79.3)	0.40 (0.32–0.49)	<LOD	0.36 (0.28–0.44)	2.9 ^E (1.6–4.1)	3.9 ^E (1.9–6.0)
6 (2018–2019)	1263	67.8 (58.7–75.7)	0.34 (0.27–0.42)	<LOD	0.30 (0.19–0.40)	1.8 (1.3–2.4)	2.8 ^E (1.4–4.2)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	511	88.2 (83.8–91.5)	1.7 (1.5–2.0)	<LOD	1.6 (1.3–2.0)	6.7 ^E (4.2–9.2)	9.6 ^E (5.5–14)
5 (2016–2017)	530	88.3 (83.0–92.1)	1.1 ^E (0.79–1.7)	<LOD	1.0 ^E (0.61–1.5)	6.5 ^E (3.7–9.3)	12 ^E (3.9–19)
6 (2018–2019)	509	87.2 (81.5–91.3)	0.97 (0.81–1.2)	<LOD	0.96 (0.77–1.1)	4.7 (3.1–6.4)	5.5 ^E (3.3–7.7)
6–11 years							
1 (2007–2009)	1026	41.8 (31.7–52.5)	—	<LOD	<LOD	4.2 (3.1–5.3)	6.5 (4.5–8.6)
2 (2009–2011)	506	80.8 (74.7–85.7)	0.92 (0.77–1.1)	<LOD	0.89 (0.77–1.0)	3.7 (2.5–4.9)	7.3 ^E (1.9–13)
5 (2016–2017)	502	84.1 (80.2–87.4)	0.64 (0.53–0.77)	<LOD	0.64 (0.45–0.83)	3.5 (2.4–4.6)	5.2 (3.6–6.8)
6 (2018–2019)	491	77.6 (69.4–84.1)	0.55 (0.44–0.68)	<LOD	0.50 (0.37–0.64)	2.7 ^E (1.4–4.0)	5.8 ^E (<LOD–13)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	977	44.6 (34.2–55.4)	—	<LOD	<LOD	1.9 (1.8–2.1)	3.2 (2.2–4.3)
2 (2009–2011)	502	74.6 (66.2–81.4)	0.47 (0.40–0.55)	<LOD	0.48 (0.37–0.59)	1.7 (1.5–2.0)	2.7 ^E (1.4–4.1)
5 (2016–2017)	516	77.1 (66.5–85.2)	0.31 (0.25–0.40)	<LOD	0.27 (0.20–0.34)	1.9 ^E (1.0–2.7)	3.5 ^E (0.71–6.2)
6 (2018–2019)	502	76.0 (68.0–82.5)	0.29 (0.23–0.37)	<LOD	0.28 (0.20–0.37)	1.8 ^E (1.0–2.6)	2.9 ^E (0.71–5.0)
20–39 years							
1 (2007–2009)	1159	36.1 (27.5–45.7)	—	<LOD	<LOD	2.0 (1.5–2.5)	3.7 (2.7–4.7)
2 (2009–2011)	347	67.8 (58.7–75.7)	0.45 (0.39–0.52)	<LOD	0.39 (<LOD–0.49)	2.3 ^E (1.3–3.3)	3.7 ^E (2.3–5.1)
5 (2016–2017)	351	73.3 (60.9–82.9)	0.32 (0.25–0.42)	<LOD	0.28 (0.20–0.36)	2.8 ^E (0.85–4.7)	4.5 ^E (1.6–7.3)
6 (2018–2019)	328	70.9 (61.2–79.1)	0.25 (0.19–0.32)	<LOD	0.21 ^E (0.13–0.29)	1.3 ^E (0.41–2.2)	2.3 ^E (0.86–3.8)
40–59 years							
1 (2007–2009)	1218	34.1 (27.0–42.0)	—	<LOD	<LOD	3.0 (2.5–3.5)	5.4 (3.5–7.4)
2 (2009–2011)	350	73.6 (64.4–81.2)	0.62 (0.48–0.80)	<LOD	0.60 (0.43–0.76)	2.8 ^E (<LOD–4.0)	4.0 ^E (<LOD–6.2)
5 (2016–2017)	341	74.5 (67.4–80.6)	0.28 (0.23–0.35)	<LOD	0.31 (0.21–0.40)	1.4 ^E (0.58–2.2)	2.4 (1.6–3.2)
6 (2018–2019)	334	63.3 (47.6–76.6)	0.28 (0.20–0.40)	<LOD	0.23 ^E (0.080–0.39)	1.1 ^E (0.48–1.7)	1.7 ^E (0.28–3.1)
60–79 years							
1 (2007–2009)	1080	40.0 (32.9–47.5)	—	<LOD	<LOD	2.9 (2.5–3.4)	4.1 (2.7–5.4)
2 (2009–2011)	285	71.6 (63.7–78.3)	0.71 (0.58–0.88)	<LOD	0.69 (0.54–0.85)	3.5 ^E (1.9–5.1)	4.7 ^E (0.41–8.9)
5 (2016–2017)	343	74.4 (66.2–81.2)	0.42 (0.34–0.53)	<LOD	0.38 (0.27–0.49)	2.5 ^E (1.5–3.5)	3.4 (2.3–4.4)
6 (2018–2019)	337	62.3 (55.5–68.6)	0.29 (0.24–0.35)	<LOD	0.27 (0.22–0.31)	1.6 (1.1–2.2)	2.6 ^E (1.5–3.7)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.1.12

Diethyldithiophosphate (DEDTP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2557	3.4 ^E (1.8–6.4)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	2643	5.8 ^E (3.7–9.0)	—	<LOD	<LOD	<LOD	0.072 (<LOD–0.091)
6 (2018–2019)	2536	15.5 ^E (9.7–24.0)	—	<LOD	<LOD	0.079 (<LOD–0.094)	0.11 (0.081–0.13)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1279	5.0 ^E (2.3–10.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1312	5.9 ^E (3.0–11.4)	—	<LOD	<LOD	<LOD	0.074 ^E (<LOD–0.10)
6 (2018–2019)	1257	17.9 ^E (11.8–26.1)	—	<LOD	<LOD	0.083 (0.067–0.098)	0.12 ^E (<LOD–0.19)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1278	1.8 ^E (0.80–4.0)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1331	5.7 (3.9–8.1)	—	<LOD	<LOD	<LOD	0.071 (<LOD–0.081)
6 (2018–2019)	1279	13.2 ^E (6.9–23.7)	—	<LOD	<LOD	0.074 (<LOD–0.091)	0.099 (0.072–0.13)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	524	1.0 ^E (0.50–1.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	547	5.5 ^E (2.6–11.6)	—	<LOD	<LOD	<LOD	0.071 (<LOD–0.093)
6 (2018–2019)	515	11.0 ^E (4.8–22.9)	—	<LOD	<LOD	<LOD	0.080 (<LOD–0.095)
6–11 years							
1 (2007–2009)	1029	3.3 ^E (2.1–5.2)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	516	5.3 ^E (2.0–13.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	514	7.1 ^E (4.8–10.4)	—	<LOD	<LOD	<LOD	0.079 (<LOD–0.095)
6 (2018–2019)	498	13.2 ^E (6.3–25.9)	—	<LOD	<LOD	0.074 (<LOD–0.098)	0.098 (<LOD–0.13)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	980	4.0 ^E (2.8–5.8)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	511	3.5 ^E (1.7–7.1)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	524	9.7 ^E (5.2–17.3)	—	<LOD	<LOD	<LOD	0.10 ^E (<LOD–0.17)
6 (2018–2019)	505	22.7 ^E (12.8–37.0)	—	<LOD	<LOD	0.094 (0.070–0.12)	0.14 ^E (<LOD–0.23)
20–39 years							
1 (2007–2009)	1163	2.4 (1.8–3.3)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	356	3.2 ^E (1.5–6.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	361	5.6 ^E (2.8–11.0)	—	<LOD	<LOD	<LOD	0.083 (<LOD–0.11)
6 (2018–2019)	332	14.8 ^E (6.8–29.3)	—	<LOD	<LOD	0.076 (<LOD–0.095)	0.10 ^E (<LOD–0.15)
40–59 years							
1 (2007–2009)	1223	2.3 ^E (1.1–4.4)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	360	3.3 ^E (0.80–12.0)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	347	4.3 ^E (1.8–9.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	343	16.5 ^E (10.5–25.0)	—	<LOD	<LOD	0.079 (<LOD–0.11)	0.12 ^E (<LOD–0.20)
60–79 years							
1 (2007–2009)	1080	2.4 ^E (1.4–4.0)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	290	3.5 ^E (0.50–19.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	350	6.1 ^E (3.4–10.6)	—	<LOD	<LOD	<LOD	0.071 (<LOD–0.092)
6 (2018–2019)	343	13.5 ^E (8.3–21.2)	—	<LOD	<LOD	0.077 (<LOD–0.092)	0.099 (0.068–0.13)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.3, 0.3, 0.067 and 0.067 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.1.13

Diethyldithiophosphate (DEDTP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2547	3.4 ^E (1.8–6.4)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	2616	5.8 ^E (3.7–9.0)	—	<LOD	<LOD	<LOD	0.13 (<LOD–0.16)
6 (2018–2019)	2535	15.5 ^E (9.7–24.0)	—	<LOD	<LOD	0.13 (<LOD–0.16)	0.19 (0.15–0.24)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1275	5.0 ^E (2.3–10.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1302	5.9 ^E (3.0–11.4)	—	<LOD	<LOD	<LOD	0.12 (<LOD–0.15)
6 (2018–2019)	1256	17.9 ^E (11.8–26.1)	—	<LOD	<LOD	0.12 (0.088–0.16)	0.18 (<LOD–0.25)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1272	1.8 ^E (0.80–4.0)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1314	5.7 (3.9–8.1)	—	<LOD	<LOD	<LOD	0.15 (<LOD–0.17)
6 (2018–2019)	1279	13.2 ^E (6.9–23.7)	—	<LOD	<LOD	0.15 (<LOD–0.18)	0.20 (0.15–0.25)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	523	1.0 ^E (0.50–1.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	538	5.5 ^E (2.6–11.6)	—	<LOD	<LOD	<LOD	0.20 (<LOD–0.25)
6 (2018–2019)	514	11.0 ^E (4.8–22.9)	—	<LOD	<LOD	<LOD	0.19 (<LOD–0.22)
6–11 years							
1 (2007–2009)	1026	3.3 ^E (2.1–5.2)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	514	5.3 ^E (2.0–13.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	505	7.1 ^E (4.8–10.4)	—	<LOD	<LOD	<LOD	0.13 ^E (<LOD–0.18)
6 (2018–2019)	498	13.2 ^E (6.3–25.9)	—	<LOD	<LOD	0.14 ^E (<LOD–0.23)	0.23 ^E (<LOD–0.34)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	978	4.0 ^E (2.8–5.8)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	509	3.5 ^E (1.7–7.1)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	520	9.7 ^E (5.2–17.3)	—	<LOD	<LOD	<LOD	0.13 (<LOD–0.17)
6 (2018–2019)	505	22.7 ^E (12.8–37.0)	—	<LOD	<LOD	0.11 ^E (<LOD–0.21)	0.27 ^E (<LOD–0.50)
20–39 years							
1 (2007–2009)	1159	2.4 (1.8–3.3)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	354	3.2 ^E (1.5–6.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	358	5.6 ^E (2.8–11.0)	—	<LOD	<LOD	<LOD	0.14 ^E (<LOD–0.19)
6 (2018–2019)	332	14.8 ^E (6.8–29.3)	—	<LOD	<LOD	0.13 ^E (<LOD–0.18)	0.17 (<LOD–0.23)
40–59 years							
1 (2007–2009)	1218	2.3 ^E (1.1–4.4)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	358	3.3 ^E (0.80–12.0)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	346	4.3 ^E (1.8–9.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	343	16.5 ^E (10.5–25.0)	—	<LOD	<LOD	0.15 (<LOD–0.21)	0.20 ^E (<LOD–0.28)
60–79 years							
1 (2007–2009)	1080	2.4 ^E (1.4–4.0)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	289	3.5 ^E (0.50–19.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	349	6.1 ^E (3.4–10.6)	—	<LOD	<LOD	<LOD	0.15 (<LOD–0.18)
6 (2018–2019)	343	13.5 ^E (8.3–21.2)	—	<LOD	<LOD	0.13 (<LOD–0.16)	0.18 ^E (0.11–0.26)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

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13.2 PYRETHROIDS

Pyrethrins are naturally occurring compounds found in certain chrysanthemum flowers (ATSDR, 2003). They have been used for their insecticidal properties since the early 1800s in Asia to control ticks and various insects, such as fleas and mosquitoes (ATSDR, 2003). Pyrethroids are synthetic versions of pyrethrins that have been structurally altered to improve their efficacy as pesticides by increasing their stability in the environment and their toxicity (ATSDR, 2003). Many commercial pyrethrin and pyrethroid pesticides are currently registered for use in Canada (HC, 2020).

Pyrethroids enter the environment primarily because of their use as insecticides on agricultural crops; however, they break down rapidly and, as a result, only trace amounts of the chemicals are typically found in air, water, soil and food (ATSDR, 2003). Pyrethroids degrade

to carboxylic and phenoxybenzoic metabolites in the environment; these metabolites have been measured in dust collected from homes and daycare centres (Starr et al., 2008). Pyrethroids bind strongly to soil particles, and thus usually do not leach into the groundwater but rather remain in the soil (ATSDR, 2003).

Pyrethrin and pyrethroid pesticides are used in Canada for insect control on agricultural crops and on turf; in orchards, nurseries and greenhouses; as a general indoor and outdoor residential insecticide for controlling crawling and flying insect pests; for controlling adult mosquitoes around buildings; in cattle ear tags; for controlling mites in bee colonies; and for flea and tick control on pets (HC, 2004; 2020; 2021). The use of pyrethrins and pyrethroids has increased during the past decade with the declining use of organophosphate pesticides, which are more acutely toxic to birds and mammals (EPA, 2020).

Permethrin is the most widely used pyrethroid pesticide in Canada, and is found in more than 350 registered pesticide products (CCME, 2006; HC, 2021). It is used for a variety of agricultural, livestock, forestry and residential insect control applications. In addition to pesticide uses, permethrin is used in medications to treat scabies (HC, 2013). Cyfluthrin and beta-cyfluthrin are used as agricultural and surface insecticides to control crawling and flying insect pests (HC, 2021). Cypermethrin has agricultural, forestry, livestock, and non-crop industrial uses (HC, 2018c). Lambda-cyhalothrin is used for a variety of agricultural, turf, livestock, and structural purposes (HC, 2017). Deltamethrin is used in several agricultural applications, on turf and in greenhouses; it is also used to treat sleeping areas and clothing in malaria-affected countries (HC, 2004; 2018b). D-phenothrin is used primarily in residential settings, whereas fluvalinate-tau is used to control mites in bee colonies (HC, 2016; 2021).

The primary routes of exposure for the general population are through the use of products that contain pyrethroids, such as household insecticides and pet sprays, and through the ingestion of pyrethroid residues in food (EPA, 2009b).

Pyrethroid pesticides are rapidly metabolized and eliminated from the body through hydrolysis, oxidation and conjugation. Following oral ingestion, inhalation or dermal exposure, pyrethroids are metabolized into carboxylic and phenoxybenzoic acids and excreted

in urine and feces (HC, 2020). Pyrethroids and metabolites can be measured in blood and urine, and are reflective of recent exposure to the parent compound or the metabolite (as an environmental degradate) in the environment (ATSDR, 2003; CDC, 2009; Kuhn et al., 1999; Starr et al., 2008). Urinary metabolites of pyrethroids can be specific to 1 pyrethroid or common to several pyrethroids. Table 13.2.1 outlines the pyrethroid metabolites measured as part of the Canadian Health Measures Survey (CHMS) and their corresponding parent compounds that are registered for use in Canada (Barr and Needham, 2002; CDC, 2009; Fortin et al., 2008; HC, 2021; Starr et al., 2008). Other pyrethroid insecticides, such as tetramethrin and bifenthrin, are registered in Canada but are not included in the table, as they do not form the metabolites measured in this survey.

■ Table 13.2.1

Pyrethroid pesticide metabolites measured in the Canadian Health Measures Survey and their parent pesticide compounds

Pyrethroid pesticide (CASRN)	Metabolite (CASRN)
Cypermethrin (52315-07-8) Deltamethrin (52918-63-5) Permethrin (52645-53-1) Lambda-cyhalothrin (91465-08-6) d-Phenothrin (26046-85-5) Fluvalinate-tau (102851-06-9)	3-PBA: 3-phenoxybenzoic acid (3739-38-6)
Cyfluthrin (68359-37-5) Flumethrin (69770-45-2)	4-F-3-PBA: 4-fluoro-3-phenoxybenzoic acid (77279-89-1)
Deltamethrin (52918-63-5)	<i>cis</i> -DBCA: <i>cis</i> -3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid (63597-73-9)
Cyfluthrin (68359-37-5) Permethrin (52645-53-1) Cypermethrin (52315-07-8)	<i>cis</i> -DCCA: <i>cis</i> -3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (55701-05-8)
Cyfluthrin (68359-37-5) Permethrin (52645-53-1) Cypermethrin (52315-07-8)	<i>trans</i> -DCCA: <i>trans</i> -3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (55701-03-6)

Pyrethroids, much like the naturally occurring pyrethrins, primarily affect the nervous systems of insects and mammals (Davies et al., 2007). They act on the axons in the peripheral and central nervous systems by prolonging the opening time of small conductance sodium channels, leading to membrane depolarizations and excess excitability. This action causes paralysis in target insect pests, eventually resulting in death. Pyrethroids are more than 2,000 times more toxic to insects than they are to mammals because insects have higher sodium channel sensitivity, smaller body sizes

and lower body temperatures (Bradberry et al., 2005). Mammals are also able to quickly metabolize pyrethroids into their inactive forms and eliminate them (HC, 2009).

Adverse effects in humans can include dizziness, nausea, headaches, tremor, salivation, involuntary movements and seizures; very high exposures may result in unconsciousness (ATSDR, 2003; CDC, 2005). There is evidence for neurobehavioural effects, such as decreased motor activity, in laboratory animals following oral exposure to pyrethroid pesticides (Wolansky and Harrill, 2008). However, there remains a general lack of evidence concerning long-term exposures to low levels of pyrethroids and neurological and reproductive effects in mammals, which may be due to the rapid metabolism and elimination of these compounds from the body (ATSDR, 2003; Kolaczinski and Curtis, 2004; Saillenfait et al., 2015). Allergic reactions in humans have been reported following exposure to pyrethroids; however, the United States Environmental Protection Agency (EPA) found no clear and consistent pattern of effects reported to indicate conclusively whether there is an association between pyrethroid exposure and asthma and allergies (EPA, 2009a; Moretto, 1991; Salome et al., 2000; Vanden Driessche et al., 2010). According to the International Agency for Research on Cancer, the carcinogenicity of permethrin and deltamethrin to humans is not classifiable because of a lack of evidence (Group 3) (IARC, 1991).

The sale and use of pyrethroid pesticides is regulated in Canada by the Pest Management Regulatory Agency (PMRA) under the *Pest Control Products Act* (Canada, 2002). PMRA evaluates toxicity and potential exposure to determine whether a pesticide should be registered for a specific use. As part of this registration process, PMRA specifies maximum residue limits of pesticides in food. Maximum residue limits exist for several pyrethroid pesticides in food, including cyfluthrin, cypermethrin, deltamethrin, lambda-cyhalothrin, permethrin and pyrethrins (HC, 2012; 2020). PMRA re-evaluates registered pesticides on a cyclical basis. As part of this process, Health Canada has completed a re-evaluation of deltamethrin, cyfluthrin, cypermethrin, d-phenothrin, permethrin and lambda-cyhalothrin and determined that most uses do not present unacceptable risks to humans or the environment when used according to product label directions. As such, these products were granted continued registration (HC, 2016; 2018a; 2018b; 2018c; 2019a). Fluvalinate-tau is listed on PMRA's workplan

for the prioritization and re-evaluation of pesticides extending to 2024 (HC, 2019b).

Pyrethroid metabolite concentrations in urine have been measured in a number of biomonitoring studies conducted in Canada, including the First Nations Biomonitoring Initiative (AFN, 2013).

Five pyrethroid metabolites (see Table 13.2.1) were measured in the urine of CHMS participants aged 6–79 in cycle 1 (2007–2009) and aged 3–79 in cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented as both µg/L and µg/g creatinine (Tables 13.2.2 to 13.2.11). Finding a measurable amount of pyrethroid metabolites in urine is an indicator of exposure to pyrethroid pesticides and does not necessarily mean that an adverse health effect will occur.

Table 13.2.2

3-Phenoxybenzoic acid (3-PBA)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2516	100	0.43 (0.35–0.53)	0.079 (0.066–0.091)	0.36 (0.29–0.43)	2.6 ^E (1.6–3.6)	5.9 ^E (2.2–9.5)
5 (2016–2017)	2706	100 (99.9–100)	0.53 (0.42–0.66)	0.091 (0.065–0.12)	0.46 (0.37–0.55)	3.6 ^E (1.7–5.4)	9.7 ^E (3.6–16)
6 (2018–2019)	2509	100	0.51 (0.42–0.62)	0.10 (0.080–0.12)	0.47 (0.36–0.58)	2.7 (1.9–3.5)	5.2 ^E (3.2–7.3)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1256	100	0.37 (0.30–0.46)	0.073 (0.053–0.092)	0.33 (0.27–0.39)	1.9 ^E (0.85–3.0)	3.3 ^E (0.74–6.0)
5 (2016–2017)	1348	100 (99.9–100)	0.46 (0.37–0.56)	0.074 ^E (0.044–0.10)	0.41 (0.30–0.52)	2.6 (1.7–3.4)	4.3 ^E (2.5–6.1)
6 (2018–2019)	1245	100	0.52 (0.41–0.67)	0.11 (0.080–0.13)	0.46 (0.35–0.58)	2.7 ^E (1.6–3.9)	5.8 ^E (3.1–8.5)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1260	100	0.49 (0.37–0.64)	0.084 (0.069–0.10)	0.38 (0.27–0.48)	3.9 ^E (1.6–6.2)	8.2 ^E (<LOD–23)
5 (2016–2017)	1358	100 (99.7–100)	0.62 (0.46–0.83)	0.096 (0.082–0.11)	0.49 (0.36–0.61)	6.0 ^E (<LOD–13)	15 ^E (6.1–24)
6 (2018–2019)	1264	100	0.50 (0.40–0.62)	0.098 (0.070–0.13)	0.48 (0.32–0.63)	2.6 ^E (1.6–3.6)	4.0 ^E (1.1–6.9)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	99.9 (99.4–100)	0.32 (0.23–0.45)	0.078 (0.057–0.099)	0.27 (0.21–0.33)	1.3 ^E (<LOD–3.7)	3.5 ^E (<LOD–8.8)
5 (2016–2017)	551	100	0.40 (0.30–0.54)	0.079 ^E (0.047–0.11)	0.33 (0.25–0.42)	2.9 ^E (0.80–5.1)	6.3 ^E (3.7–9.0)
6 (2018–2019)	509	100	0.48 (0.37–0.63)	0.10 (0.082–0.13)	0.39 ^E (0.24–0.55)	2.3 ^E (1.0–3.5)	4.0 ^E (<LOD–10)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
6–11 years							
1 (2007–2009)	1025	99.3 (97.9–99.8)	0.21 (0.16–0.28)	0.047 (0.034–0.060)	0.19 (0.14–0.24)	1.1 (0.76–1.4)	1.7 ^E (0.51–2.9)
2 (2009–2011)	515	100	0.30 (0.25–0.35)	0.079 (0.063–0.095)	0.24 (0.19–0.30)	1.2 (0.79–1.6)	1.9 ^E (0.20–3.6)
5 (2016–2017)	534	100	0.47 (0.39–0.57)	0.10 (0.082–0.12)	0.38 (0.30–0.45)	2.7 ^E (1.4–4.0)	5.4 ^E (<LOD–12)
6 (2018–2019)	495	100	0.55 (0.40–0.76)	0.12 (0.089–0.15)	0.46 ^E (0.29–0.64)	3.0 ^E (0.94–5.1)	5.9 ^E (<LOD–15)
12–19 years							
1 (2007–2009)	977	99.8 (98.8–100)	0.28 (0.21–0.38)	0.059 ^E (0.030–0.088)	0.25 (0.18–0.32)	2.0 ^E (1.0–3.0)	3.2 ^E (2.0–4.5)
2 (2009–2011)	509	100	0.36 (0.29–0.45)	0.096 (0.085–0.11)	0.27 (0.20–0.35)	2.3 ^E (1.2–3.4)	5.6 ^E (2.8–8.3)
5 (2016–2017)	533	100	0.45 (0.34–0.60)	0.094 ^E (0.053–0.13)	0.37 (0.28–0.47)	3.0 ^E (1.8–4.2)	5.9 ^E (1.1–11)
6 (2018–2019)	499	100	0.43 (0.33–0.55)	0.094 ^E (0.050–0.14)	0.38 (0.25–0.51)	1.8 ^E (0.63–3.0)	5.0 ^E (2.0–8.1)
20–39 years							
1 (2007–2009)	1159	99.6 (97.5–99.9)	0.25 (0.20–0.32)	0.051 (0.036–0.067)	0.21 (0.16–0.26)	1.4 (1.0–1.8)	2.5 ^E (1.6–3.5)
2 (2009–2011)	345	100	0.61 ^E (0.41–0.91)	0.094 ^E (0.056–0.13)	0.48 ^E (0.28–0.67)	5.7 ^E (0.63–11)	23 ^E (<LOD–54)
5 (2016–2017)	375	100 (99.9–100)	0.61 ^E (0.34–1.1)	0.074 ^E (0.032–0.12)	0.48 ^E (0.29–0.67)	6.1 ^E (<LOD–16)	17 ^E (3.8–31)
6 (2018–2019)	326	100	0.58 (0.43–0.79)	0.11 ^E (0.064–0.16)	0.50 (0.32–0.68)	2.8 ^E (1.0–4.5)	5.3 ^E (1.3–9.4)
40–59 years							
1 (2007–2009)	1216	99.2 (98.4–99.6)	0.27 (0.21–0.34)	0.046 (0.032–0.060)	0.25 (0.18–0.32)	1.7 ^E (0.91–2.5)	3.5 ^E (2.0–5.0)
2 (2009–2011)	346	100	0.40 (0.29–0.55)	0.064 ^E (0.041–0.088)	0.36 (0.24–0.48)	2.4 ^E (1.2–3.5)	4.2 ^E (2.0–6.4)
5 (2016–2017)	359	99.9 (99.5–100)	0.55 (0.41–0.74)	0.12 ^E (0.060–0.19)	0.53 (0.34–0.71)	2.7 ^E (1.5–4.0)	4.9 ^E (0.95–8.9)
6 (2018–2019)	339	100	0.50 (0.36–0.69)	0.10 ^E (0.059–0.15)	0.50 ^E (0.28–0.73)	2.0 ^E (0.88–3.1)	3.6 ^E (1.9–5.3)
60–79 years							
1 (2007–2009)	1073	99.3 (96.8–99.8)	0.24 (0.20–0.29)	0.051 (0.041–0.062)	0.21 (0.17–0.25)	1.3 (0.88–1.7)	2.2 (1.5–2.8)
2 (2009–2011)	279	100	0.36 ^E (0.24–0.54)	0.074 (0.055–0.093)	0.27 ^E (0.14–0.41)	2.4 ^E (0.97–3.8)	3.7 ^E (<LOD–11)
5 (2016–2017)	354	100	0.48 ^E (0.33–0.70)	0.075 ^E (0.041–0.11)	0.41 (0.27–0.54)	3.0 ^E (<LOD–6.3)	9.3 ^E (4.4–14)
6 (2018–2019)	341	100	0.46 (0.34–0.62)	0.086 ^E (0.045–0.13)	0.38 (0.24–0.51)	2.9 ^E (1.3–4.6)	7.0 ^E (3.3–11)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The limits of detection (LODs) for cycles 1, 2, 5 and 6 are 0.01, 0.01, 0.012 and 0.012 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.2.3

3-Phenoxybenzoic acid (3-PBA) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2506	100	0.42 (0.34–0.51)	0.10 (0.093–0.11)	0.33 (0.26–0.39)	2.3 ^E (1.2–3.4)	6.6 ^E (1.1–12)
5 (2016–2017)	2676	100 (99.9–100)	0.52 (0.43–0.62)	0.11 (0.088–0.13)	0.39 (0.33–0.44)	3.2 (2.1–4.2)	8.0 ^E (0.62–15)
6 (2018–2019)	2508	100	0.56 (0.44–0.70)	0.14 (0.11–0.16)	0.44 (0.31–0.57)	2.9 ^E (1.7–4.1)	5.8 ^E (2.0–9.5)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1252	100	0.31 (0.26–0.38)	0.088 (0.072–0.10)	0.26 (0.21–0.32)	1.3 ^E (0.69–1.9)	2.7 ^E (0.77–4.6)
5 (2016–2017)	1333	100 (99.9–100)	0.39 (0.34–0.46)	0.099 (0.083–0.12)	0.29 (0.22–0.36)	2.3 ^E (1.5–3.2)	3.7 (2.9–4.5)
6 (2018–2019)	1244	100	0.49 (0.37–0.64)	0.12 (0.085–0.15)	0.37 (0.26–0.47)	2.5 ^E (1.1–3.8)	5.9 ^E (0.67–11)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1254	100	0.56 (0.44–0.72)	0.11 (0.093–0.13)	0.41 (0.31–0.51)	3.3 ^E (0.13–6.5)	13 ^F (<LOD–23)
5 (2016–2017)	1343	100 (99.7–100)	0.68 (0.53–0.88)	0.15 (0.12–0.17)	0.50 (0.41–0.59)	6.4 ^E (<LOD–12)	18 ^E (6.3–29)
6 (2018–2019)	1264	100	0.64 (0.52–0.78)	0.16 (0.12–0.19)	0.53 (0.38–0.68)	3.4 ^E (1.9–5.0)	5.4 ^E (0.54–10)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	521	99.9 (99.4–100)	0.56 (0.40–0.78)	0.15 (0.10–0.19)	0.46 (0.35–0.57)	2.6 ^E (<LOD–5.2)	6.3 ^E (<LOD–14)
5 (2016–2017)	542	100	0.70 (0.58–0.85)	0.16 ^E (0.081–0.25)	0.53 (0.42–0.65)	4.2 ^E (1.8–6.6)	7.7 ^E (1.5–14)
6 (2018–2019)	508	100	0.79 (0.61–1.0)	0.23 (0.15–0.30)	0.62 (0.42–0.83)	3.5 ^E (1.3–5.7)	6.4 ^E (<LOD–14)
6–11 years							
1 (2007–2009)	1022	99.3 (97.9–99.8)	0.32 (0.26–0.40)	0.099 (0.082–0.12)	0.27 (0.22–0.33)	1.3 ^E (0.72–1.9)	3.0 ^E (1.4–4.6)
2 (2009–2011)	513	100	0.34 (0.29–0.41)	0.12 (0.10–0.14)	0.26 (0.19–0.33)	1.3 (0.89–1.7)	2.7 ^E (1.1–4.2)
5 (2016–2017)	526	100	0.56 (0.47–0.68)	0.15 (0.13–0.18)	0.41 (0.32–0.49)	3.3 ^E (1.6–5.1)	8.7 ^E (<LOD–16)
6 (2018–2019)	495	100	0.66 (0.51–0.85)	0.15 (0.12–0.19)	0.51 ^E (0.31–0.71)	3.1 ^E (1.2–4.9)	7.6 ^E (<LOD–14)
12–19 years							
1 (2007–2009)	975	99.8 (98.8–100)	0.25 (0.19–0.32)	0.067 (0.052–0.082)	0.19 (0.14–0.25)	1.4 ^E (0.83–2.0)	2.9 ^E (1.7–4.0)
2 (2009–2011)	507	100	0.27 (0.22–0.34)	0.081 (0.070–0.092)	0.21 (0.15–0.26)	1.4 ^E (0.89–2.0)	2.6 (2.1–3.1)
5 (2016–2017)	526	100	0.35 (0.28–0.44)	0.087 (0.075–0.098)	0.28 (0.24–0.32)	1.9 ^E (0.54–3.2)	4.9 ^E (1.6–8.1)
6 (2018–2019)	499	100	0.35 (0.30–0.42)	0.097 (0.077–0.12)	0.29 (0.23–0.36)	1.3 ^E (<LOD–3.0)	3.8 ^E (2.4–5.3)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1155	99.6 (97.5–99.9)	0.28 (0.22–0.35)	0.073 (0.052–0.094)	0.23 (0.17–0.29)	1.3 ^E (0.75–1.9)	2.4 (1.5–3.2)
2 (2009–2011)	343	100	0.52 ^E (0.36–0.75)	0.10 (0.083–0.13)	0.35 ^E (0.22–0.48)	3.5 ^E (<LOD–8.5)	18 ^E (<LOD–35)
5 (2016–2017)	371	100 (99.9–100)	0.54 ^E (0.34–0.86)	0.099 (0.081–0.12)	0.37 ^E (0.17–0.56)	5.7 ^E (<LOD–15)	17 ^E (0.64–33)
6 (2018–2019)	326	100	0.56 (0.43–0.74)	0.12 ^E (0.056–0.18)	0.44 (0.31–0.56)	3.7 ^E (2.0–5.4)	4.6 ^E (<LOD–11)
40–59 years							
1 (2007–2009)	1211	99.2 (98.4–99.6)	0.34 (0.28–0.43)	0.084 (0.068–0.10)	0.30 (0.24–0.35)	1.9 ^E (1.1–2.6)	2.9 (2.2–3.7)
2 (2009–2011)	344	100	0.41 (0.33–0.50)	0.10 (0.088–0.12)	0.35 (0.25–0.45)	1.8 ^E (1.2–2.5)	3.4 ^E (1.2–5.6)
5 (2016–2017)	358	99.9 (99.5–100)	0.51 (0.43–0.60)	0.13 (0.11–0.16)	0.39 (0.29–0.49)	3.0 ^E (1.9–4.2)	3.9 ^E (<LOD–9.2)
6 (2018–2019)	339	100	0.60 (0.42–0.85)	0.15 (0.11–0.20)	0.54 ^E (0.32–0.75)	2.6 ^E (0.54–4.8)	5.0 ^E (<LOD–11)
60–79 years							
1 (2007–2009)	1073	99.3 (96.8–99.8)	0.34 (0.28–0.40)	0.090 (0.079–0.10)	0.29 (0.24–0.34)	1.6 ^E (0.94–2.2)	3.0 (1.9–4.1)
2 (2009–2011)	278	100	0.42 ^E (0.29–0.63)	0.092 (0.075–0.11)	0.32 (0.24–0.41)	3.1 ^E (<LOD–8.6)	8.6 ^E (<LOD–18)
5 (2016–2017)	353	100	0.55 (0.40–0.76)	0.11 ^E (0.066–0.15)	0.44 (0.31–0.58)	3.3 ^E (<LOD–5.7)	7.7 ^E (1.2–14)
6 (2018–2019)	341	100	0.54 (0.42–0.71)	0.14 (0.11–0.17)	0.42 (0.31–0.53)	3.2 ^E (1.0–5.3)	9.2 ^E (3.4–15)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.2.4

4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2539	58.6 (53.1–63.9)	—	<LOD	0.0091 (<LOD–0.010)	0.049 ^E (0.028–0.070)	0.11 ^E (0.040–0.17)
5 (2016–2017)	2649	34.5 (28.3–41.4)	—	<LOD	<LOD	0.048 (0.036–0.060)	0.082 (0.055–0.11)
6 (2018–2019)	2521	20.4 (15.7–26.2)	—	<LOD	<LOD	0.038 ^E (0.023–0.054)	0.10 ^E (0.018–0.19)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1268	57.4 (52.0–62.6)	—	<LOD	0.0090 (<LOD–0.012)	0.055 ^E (0.032–0.079)	0.10 ^E (0.044–0.16)
5 (2016–2017)	1319	34.2 (26.0–43.5)	—	<LOD	<LOD	0.049 ^E (0.027–0.072)	0.082 (0.060–0.10)
6 (2018–2019)	1247	20.6 (16.4–25.7)	—	<LOD	<LOD	0.037 ^E (0.022–0.053)	0.094 ^E (0.058–0.13)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1271	59.8 (52.5–66.6)	—	<LOD	0.0092 (0.0083–0.010)	0.049 ^E (0.015–0.082)	0.11 ^E (<LOD–0.25)
5 (2016–2017)	1330	34.9 (28.3–42.1)	—	<LOD	<LOD	0.044 (0.031–0.057)	0.074 ^E (<LOD–0.15)
6 (2018–2019)	1274	20.2 (14.0–28.3)	—	<LOD	<LOD	0.041 ^E (0.013–0.069)	0.17 ^E (<LOD–0.38)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	517	49.6 (41.1–58.2)	—	<LOD	<LOD	0.043 (0.031–0.056)	0.050 (0.032–0.067)
5 (2016–2017)	539	34.5 ^E (20.6–51.7)	—	<LOD	<LOD	0.047 ^E (0.017–0.077)	0.079 ^E (0.040–0.12)
6 (2018–2019)	510	26.7 (20.2–34.4)	—	<LOD	<LOD	0.063 ^E (<LOD–0.30)	0.53 ^E (<LOD–1.2)
6–11 years							
1 (2007–2009)	998	41.5 (36.3–46.8)	—	<LOD	<LOD	0.023 ^E (0.014–0.032)	0.042 ^E (0.011–0.073)
2 (2009–2011)	514	56.7 (48.3–64.8)	—	<LOD	0.0087 (<LOD–0.011)	0.037 (0.026–0.048)	0.056 ^E (0.028–0.085)
5 (2016–2017)	525	38.4 (29.2–48.6)	—	<LOD	<LOD	0.041 ^E (0.018–0.064)	0.072 ^E (0.035–0.11)
6 (2018–2019)	495	23.3 ^E (13.9–36.3)	—	<LOD	<LOD	0.053 ^E (<LOD–0.11)	0.28 ^E (<LOD–0.59)
12–19 years							
1 (2007–2009)	947	50.7 (45.3–56.0)	—	<LOD	<LOD ^E (<LOD–0.0090)	0.035 (0.025–0.045)	0.060 ^E (0.017–0.10)
2 (2009–2011)	510	58.8 (50.5–66.7)	—	<LOD	0.0090 (<LOD–0.011)	0.032 ^E (0.0098–0.054)	0.070 ^E (<LOD–0.14)
5 (2016–2017)	530	30.1 (23.5–37.7)	—	<LOD	<LOD	0.039 ^E (0.013–0.064)	0.071 (0.051–0.090)
6 (2018–2019)	503	17.7 ^E (10.4–28.7)	—	<LOD	<LOD	0.026 ^E (0.015–0.037)	0.047 ^E (<LOD–0.11)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1100	44.7 (36.9–52.8)	—	<LOD	<LOD	0.038 ^E (0.015–0.062)	0.089 ^E (0.030–0.15)
2 (2009–2011)	352	61.3 (49.9–71.6)	—	<LOD	0.0093 (<LOD–0.012)	0.073 ^E (0.018–0.13)	0.11 ^E (0.033–0.19)
5 (2016–2017)	367	32.8 ^E (21.1–47.2)	—	<LOD	<LOD	0.057 ^E (0.031–0.083)	0.078 ^E (<LOD–0.16)
6 (2018–2019)	332	21.2 ^E (13.9–31.1)	—	<LOD	<LOD	0.058 ^E (<LOD–0.15)	0.23 ^E (<LOD–0.54)
40–59 years							
1 (2007–2009)	1161	39.6 (32.2–47.5)	—	<LOD	<LOD	0.037 (0.026–0.048)	0.079 ^E (0.048–0.11)
2 (2009–2011)	357	62.8 (51.5–72.9)	—	<LOD	0.0094 (0.0083–0.010)	0.057 ^E (0.018–0.097)	0.20 ^E (<LOD–0.39)
5 (2016–2017)	345	40.7 (28.2–54.5)	—	<LOD	<LOD	0.046 ^E (0.020–0.073)	0.068 ^E (<LOD–0.13)
6 (2018–2019)	341	20.8 (14.6–28.7)	—	<LOD	<LOD	0.033 ^E (0.020–0.047)	0.074 ^E (0.0069–0.14)
60–79 years							
1 (2007–2009)	1018	38.6 (32.7–44.8)	—	<LOD	<LOD	0.032 ^E (0.014–0.050)	0.069 ^E (0.021–0.12)
2 (2009–2011)	289	48.6 (42.7–54.5)	—	<LOD	<LOD	0.042 ^E (<LOD–0.14)	0.065 ^E (<LOD–0.27)
5 (2016–2017)	343	29.3 (20.8–39.6)	—	<LOD	<LOD	0.040 ^E (<LOD–0.079)	0.099 ^E (<LOD–0.20)
6 (2018–2019)	340	18.1 (13.9–23.2)	—	<LOD	<LOD	0.038 ^E (0.016–0.060)	0.088 ^E (0.017–0.16)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.008, 0.008, 0.0060 and 0.0060 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.2.5

4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2529	58.6 (53.1–63.9)	—	<LOD	0.0099 (<LOD–0.012)	0.048 ^E (0.030–0.066)	0.080 ^E (0.014–0.15)
5 (2016–2017)	2619	34.5 (28.3–41.4)	—	<LOD	<LOD	0.034 (0.026–0.043)	0.084 ^E (0.045–0.12)
6 (2018–2019)	2520	20.4 (15.7–26.2)	—	<LOD	<LOD	0.037 ^E (0.017–0.056)	0.14 ^E (0.035–0.25)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1264	57.4 (52.0–62.6)	—	<LOD	0.0079 (<LOD–0.010)	0.036 ^E (0.019–0.054)	0.061 ^E (<LOD–0.12)
5 (2016–2017)	1304	34.2 (26.0–43.5)	—	<LOD	<LOD	0.036 ^E (0.021–0.052)	0.085 ^E (0.036–0.13)
6 (2018–2019)	1246	20.6 (16.4–25.7)	—	<LOD	<LOD	0.028 ^E (0.016–0.039)	0.069 ^E (0.0070–0.13)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1265	59.8 (52.5–66.6)	—	<LOD	0.0099 (0.0093–0.011)	0.050 ^E (0.024–0.076)	0.094 ^E (<LOD–0.49)
5 (2016–2017)	1315	34.9 (28.3–42.1)	—	<LOD	<LOD	0.032 (0.021–0.044)	0.074 ^E (<LOD–0.16)
6 (2018–2019)	1274	20.2 (14.0–28.3)	—	<LOD	<LOD	0.059 ^E (0.0082–0.11)	0.19 ^E (<LOD–0.46)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	516	49.6 (41.1–58.2)	—	<LOD	<LOD	0.048 ^E (0.030–0.066)	0.091 ^E (0.056–0.12)
5 (2016–2017)	530	34.5 ^E (20.6–51.7)	—	<LOD	<LOD	0.062 ^E (0.036–0.089)	0.11 ^E (<LOD–0.21)
6 (2018–2019)	509	26.7 (20.2–34.4)	—	<LOD	<LOD	0.11 ^E (<LOD–0.30)	0.49 ^E (<LOD–1.0)
6–11 years							
1 (2007–2009)	995	41.5 (36.3–46.8)	—	<LOD	<LOD	0.039 (0.031–0.048)	0.071 ^E (0.044–0.099)
2 (2009–2011)	512	56.7 (48.3–64.8)	—	<LOD	0.0092 (<LOD–0.0097)	0.037 (0.026–0.048)	0.065 ^E (0.024–0.11)
5 (2016–2017)	517	38.4 (29.2–48.6)	—	<LOD	<LOD	0.052 ^E (0.022–0.082)	0.098 ^E (0.043–0.15)
6 (2018–2019)	495	23.3 ^E (13.9–36.3)	—	<LOD	<LOD	0.052 ^E (<LOD–0.10)	0.18 ^E (<LOD–0.33)
12–19 years							
1 (2007–2009)	945	50.7 (45.3–56.0)	—	<LOD	<LOD	0.029 (0.024–0.035)	0.044 ^E (0.015–0.074)
2 (2009–2011)	508	58.8 (50.5–66.7)	—	<LOD	0.0068 (<LOD–0.0083)	0.024 ^E (0.011–0.038)	0.055 ^E (<LOD–0.11)
5 (2016–2017)	523	30.1 (23.5–37.7)	—	<LOD	<LOD	0.028 (0.024–0.031)	0.049 ^E (0.025–0.073)
6 (2018–2019)	503	17.7 ^E (10.4–28.7)	—	<LOD	<LOD	0.022 ^E (<LOD–0.039)	0.057 ^E (<LOD–0.17)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1096	44.7 (36.9–52.8)	—	<LOD	<LOD	0.040 ^E (0.025–0.055)	0.073 ^E (0.014–0.13)
2 (2009–2011)	350	61.3 (49.9–71.6)	—	<LOD	0.0085 (<LOD–0.011)	0.050 ^E (0.020–0.080)	0.076 ^E (<LOD–0.18)
5 (2016–2017)	363	32.8 ^E (21.1–47.2)	—	<LOD	<LOD	0.029 ^E (0.016–0.043)	0.043 ^E (<LOD–0.16)
6 (2018–2019)	332	21.2 ^E (13.9–31.1)	—	<LOD	<LOD	0.037 ^E (<LOD–0.23)	0.55 ^E (<LOD–1.4)
40–59 years							
1 (2007–2009)	1156	39.6 (32.2–47.5)	—	<LOD	<LOD	0.043 (0.032–0.053)	0.081 ^E (0.041–0.12)
2 (2009–2011)	355	62.8 (51.5–72.9)	—	<LOD	0.0095 (0.0083–0.011)	0.051 ^E (0.017–0.084)	0.21 ^E (<LOD–0.41)
5 (2016–2017)	344	40.7 (28.2–54.5)	—	<LOD	<LOD	0.032 ^E (<LOD–0.076)	0.084 ^E (<LOD–0.16)
6 (2018–2019)	341	20.8 (14.6–28.7)	—	<LOD	<LOD	0.030 ^E (0.0063–0.054)	0.14 ^E (0.037–0.24)
60–79 years							
1 (2007–2009)	1018	38.6 (32.7–44.8)	—	<LOD	<LOD	0.038 ^E (0.019–0.058)	0.095 ^E (0.026–0.16)
2 (2009–2011)	288	48.6 (42.7–54.5)	—	<LOD	<LOD	0.041 ^E (<LOD–0.11)	0.056 ^E (<LOD–0.23)
5 (2016–2017)	342	29.3 (20.8–39.6)	—	<LOD	<LOD	0.049 ^E (<LOD–0.090)	0.11 ^E (<LOD–0.30)
6 (2018–2019)	340	18.1 (13.9–23.2)	—	<LOD	<LOD	0.046 ^E (0.018–0.073)	0.099 ^E (0.060–0.14)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.2.6

cis-3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DBCA)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2535	59.6 (52.5–66.3)	0.012 (0.010–0.014)	<LOD	0.0094 (0.0084–0.010)	0.066 (0.045–0.087)	0.15 ^E (0.076–0.23)
5 (2016–2017)	2633	79.5 (73.6–84.3)	0.019 (0.016–0.023)	<LOD	0.019 (0.016–0.021)	0.11 (0.083–0.13)	0.18 (0.13–0.22)
6 (2018–2019)	2491	80.9 (75.6–85.2)	0.019 (0.016–0.022)	<LOD	0.019 (0.015–0.023)	0.098 (0.077–0.12)	0.19 ^E (0.10–0.27)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1272	61.7 (54.5–68.4)	0.012 (0.010–0.015)	<LOD	0.0096 (0.0068–0.012)	0.070 ^E (0.044–0.095)	0.14 ^E (0.048–0.23)
5 (2016–2017)	1305	78.7 (71.6–84.4)	0.019 (0.015–0.023)	<LOD	0.018 (0.015–0.020)	0.12 (0.077–0.15)	0.20 (0.13–0.26)
6 (2018–2019)	1229	80.6 (72.0–87.0)	0.019 (0.015–0.023)	<LOD	0.018 (0.013–0.024)	0.094 (0.073–0.11)	0.17 ^E (0.099–0.23)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1263	57.5 (48.6–66.0)	0.011 (0.0092–0.013)	<LOD	0.0092 (0.0069–0.011)	0.058 ^E (0.0084–0.11)	0.17 ^E (0.041–0.30)
5 (2016–2017)	1328	80.2 (73.3–85.8)	0.020 (0.016–0.024)	<LOD	0.019 (0.016–0.022)	0.10 (0.082–0.12)	0.17 (0.12–0.22)
6 (2018–2019)	1262	81.1 (76.1–85.3)	0.019 (0.016–0.023)	<LOD	0.019 (0.016–0.023)	0.10 ^E (0.046–0.16)	0.20 ^E (<LOD–0.43)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	65.9 (55.6–74.8)	0.014 (0.010–0.018)	<LOD	0.0099 ^E (<LOD–0.020)	0.092 ^E (0.054–0.13)	0.13 ^E (0.0072–0.25)
5 (2016–2017)	544	87.7 (83.9–90.7)	0.030 (0.022–0.041)	<LOD	0.025 (0.017–0.033)	0.23 ^E (0.11–0.35)	0.46 ^E (<LOD–1.1)
6 (2018–2019)	509	89.6 (85.2–92.8)	0.031 (0.024–0.041)	<LOD	0.035 ^E (0.020–0.049)	0.17 ^E (0.062–0.28)	0.41 ^E (0.17–0.64)
6–11 years							
1 (2007–2009)	974	48.0 (39.8–56.4)	—	<LOD	<LOD	0.045 (0.033–0.056)	0.097 (0.064–0.13)
2 (2009–2011)	513	70.6 (57.8–80.8)	0.015 (0.012–0.020)	<LOD	0.010 ^E (<LOD–0.023)	0.098 ^E (0.030–0.17)	0.30 ^E (0.057–0.54)
5 (2016–2017)	526	93.3 (91.1–95.1)	0.035 (0.029–0.042)	0.0077 (0.0059–0.0095)	0.026 (0.020–0.032)	0.23 ^E (0.091–0.37)	0.39 ^E (0.19–0.59)
6 (2018–2019)	488	89.3 (83.0–93.5)	0.028 (0.022–0.035)	<LOD	0.026 (0.020–0.032)	0.13 ^E (0.058–0.20)	0.23 ^E (0.051–0.40)
12–19 years							
1 (2007–2009)	927	56.3 (44.2–67.6)	—	<LOD	0.0072 ^E (<LOD–0.011)	0.048 (0.035–0.060)	0.085 (0.069–0.10)
2 (2009–2011)	507	65.2 (55.6–73.7)	0.014 (0.012–0.017)	<LOD	0.010 ^E (<LOD–0.022)	0.092 (0.062–0.12)	0.19 (0.14–0.24)
5 (2016–2017)	521	85.4 (75.2–91.8)	0.026 (0.020–0.032)	<LOD	0.024 (0.018–0.030)	0.13 (0.10–0.15)	0.18 ^E (0.075–0.29)
6 (2018–2019)	497	88.9 (82.5–93.1)	0.026 (0.021–0.032)	<LOD	0.024 (0.015–0.033)	0.11 ^E (0.045–0.18)	0.21 ^E (0.081–0.33)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1055	47.1 (38.1–56.4)	—	<LOD	<LOD	0.037 (0.025–0.050)	0.085 ^E (0.051–0.12)
2 (2009–2011)	355	58.8 (47.4–69.3)	0.012 (0.0086–0.015)	<LOD	0.0092 ^E (<LOD–0.019)	0.063 ^E (0.015–0.11)	0.14 ^E (0.025–0.26)
5 (2016–2017)	363	79.6 (67.5–88.0)	0.019 (0.014–0.025)	<LOD	0.019 (0.014–0.023)	0.10 ^E (0.056–0.14)	0.15 ^E (0.097–0.21)
6 (2018–2019)	325	81.8 (70.6–89.4)	0.022 (0.016–0.029)	<LOD	0.023 ^E (0.014–0.031)	0.13 ^E (<LOD–0.25)	0.23 ^E (<LOD–0.66)
40–59 years							
1 (2007–2009)	1109	45.4 (37.4–53.6)	—	<LOD	<LOD	0.045 (0.035–0.055)	0.067 (0.056–0.077)
2 (2009–2011)	352	58.2 (47.8–68.0)	—	<LOD	0.0093 (0.0060–0.013)	0.063 ^E (0.016–0.11)	0.13 ^E (0.0092–0.26)
5 (2016–2017)	342	75.4 (59.7–86.4)	0.015 (0.011–0.021)	<LOD	0.015 (0.011–0.019)	0.085 ^E (0.036–0.13)	0.14 ^E (0.082–0.19)
6 (2018–2019)	338	75.7 (66.5–83.1)	0.014 (0.011–0.018)	<LOD	0.016 (0.011–0.021)	0.057 (0.041–0.073)	0.087 ^E (0.046–0.13)
60–79 years							
1 (2007–2009)	957	46.1 (38.4–54.0)	—	<LOD	<LOD	0.042 (0.033–0.052)	0.071 (0.052–0.091)
2 (2009–2011)	286	54.5 (46.5–62.4)	—	<LOD	0.0089 ^E (<LOD–0.013)	0.058 ^E (0.0086–0.11)	0.17 ^E (0.0079–0.33)
5 (2016–2017)	337	76.4 (66.9–83.8)	0.018 (0.013–0.025)	<LOD	0.018 (0.013–0.023)	0.10 ^E (0.017–0.19)	0.22 ^E (0.10–0.35)
6 (2018–2019)	334	78.8 (71.3–84.7)	0.017 (0.013–0.021)	<LOD	0.017 (0.013–0.021)	0.091 ^E (0.041–0.14)	0.23 ^E (0.043–0.41)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.006, 0.006, 0.0059 and 0.0059 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.2.7

cis-3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DBCA) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2525	59.6 (52.5–66.3)	0.011 (0.0097–0.013)	<LOD	0.0099 (0.0091–0.011)	0.060 ^E (0.035–0.085)	0.12 ^E (0.069–0.17)
5 (2016–2017)	2603	79.5 (73.6–84.3)	0.019 (0.016–0.022)	<LOD	0.017 (0.014–0.020)	0.097 (0.076–0.12)	0.16 (0.13–0.19)
6 (2018–2019)	2490	80.9 (75.6–85.2)	0.021 (0.018–0.024)	<LOD	0.019 (0.016–0.022)	0.086 (0.068–0.10)	0.17 ^E (0.10–0.24)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1268	61.7 (54.5–68.4)	0.010 (0.0085–0.012)	<LOD	0.0098 (0.0082–0.011)	0.059 ^E (0.036–0.081)	0.11 ^E (0.043–0.18)
5 (2016–2017)	1290	78.7 (71.6–84.4)	0.016 (0.014–0.019)	<LOD	0.015 (0.012–0.018)	0.079 (0.051–0.11)	0.15 (0.098–0.20)
6 (2018–2019)	1228	80.6 (72.0–87.0)	0.018 (0.014–0.022)	<LOD	0.018 (0.014–0.021)	0.074 (0.059–0.089)	0.12 ^E (0.069–0.17)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1257	57.5 (48.6–66.0)	0.013 (0.011–0.015)	<LOD	0.010 ^E (0.0062–0.014)	0.066 ^E (0.027–0.10)	0.14 ^E (0.071–0.21)
5 (2016–2017)	1313	80.2 (73.3–85.8)	0.021 (0.018–0.026)	<LOD	0.021 (0.017–0.025)	0.098 (0.083–0.11)	0.16 (0.11–0.22)
6 (2018–2019)	1262	81.1 (76.1–85.3)	0.025 (0.022–0.028)	<LOD	0.022 (0.019–0.026)	0.097 ^E (0.027–0.17)	0.23 ^E (<LOD–0.40)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	521	65.9 (55.6–74.8)	0.023 (0.017–0.031)	<LOD	0.020 (<LOD–0.026)	0.13 ^E (0.065–0.19)	0.26 ^E (<LOD–0.53)
5 (2016–2017)	535	87.7 (83.9–90.7)	0.052 ^E (0.035–0.078)	<LOD	0.043 ^E (0.026–0.059)	0.26 (0.17–0.36)	0.64 ^E (<LOD–1.4)
6 (2018–2019)	508	89.6 (85.2–92.8)	0.051 (0.041–0.062)	<LOD	0.047 (0.035–0.058)	0.29 ^E (0.13–0.45)	0.51 ^E (0.26–0.75)
6–11 years							
1 (2007–2009)	971	48.0 (39.8–56.4)	—	<LOD	<LOD	0.065 (0.047–0.082)	0.13 ^E (0.074–0.19)
2 (2009–2011)	511	70.6 (57.8–80.8)	0.018 (0.013–0.024)	<LOD	0.016 ^E (<LOD–0.024)	0.11 ^E (0.033–0.19)	0.21 ^E (<LOD–0.51)
5 (2016–2017)	518	93.3 (91.1–95.1)	0.040 (0.033–0.049)	0.011 (0.0090–0.013)	0.032 (0.027–0.036)	0.21 ^E (0.094–0.32)	0.48 ^E (0.12–0.84)
6 (2018–2019)	488	89.3 (83.0–93.5)	0.034 (0.029–0.039)	<LOD	0.027 (0.022–0.032)	0.14 ^E (0.075–0.21)	0.22 ^E (0.11–0.33)
12–19 years							
1 (2007–2009)	925	56.3 (44.2–67.6)	—	<LOD	0.0077 (<LOD–0.0091)	0.039 (0.034–0.044)	0.071 (0.050–0.092)
2 (2009–2011)	505	65.2 (55.6–73.7)	0.011 (0.0090–0.012)	<LOD	0.0099 (<LOD–0.011)	0.063 ^E (0.033–0.093)	0.12 (0.090–0.16)
5 (2016–2017)	514	85.4 (75.2–91.8)	0.020 (0.016–0.024)	<LOD	0.017 (0.014–0.021)	0.095 (0.066–0.13)	0.15 (0.11–0.19)
6 (2018–2019)	497	88.9 (82.5–93.1)	0.022 (0.018–0.025)	<LOD	0.020 (0.015–0.025)	0.079 ^E (0.050–0.11)	0.13 ^E (0.064–0.19)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1051	47.1 (38.1–56.4)	—	<LOD	<LOD	0.040 (0.028–0.052)	0.083 ^E (0.047–0.12)
2 (2009–2011)	353	58.8 (47.4–69.3)	0.0097 (0.0071–0.013)	<LOD	0.0092 (<LOD–0.012)	0.045 ^E (0.014–0.076)	0.10 ^E (0.014–0.19)
5 (2016–2017)	359	79.6 (67.5–88.0)	0.017 (0.014–0.021)	<LOD	0.015 (0.012–0.017)	0.073 ^E (0.040–0.11)	0.11 (0.080–0.14)
6 (2018–2019)	325	81.8 (70.6–89.4)	0.021 (0.016–0.027)	<LOD	0.019 (0.014–0.024)	0.089 ^E (<LOD–0.22)	0.23 ^E (<LOD–0.45)
40–59 years							
1 (2007–2009)	1104	45.4 (37.4–53.6)	—	<LOD	<LOD	0.047 (0.037–0.058)	0.088 (0.059–0.12)
2 (2009–2011)	350	58.2 (47.8–68.0)	—	<LOD	0.0099 (0.0082–0.012)	0.056 ^E (0.018–0.095)	0.10 ^E (0.039–0.17)
5 (2016–2017)	341	75.4 (59.7–86.4)	0.014 (0.010–0.019)	<LOD	0.015 ^E (0.0093–0.021)	0.063 (0.043–0.083)	0.11 ^E (0.051–0.16)
6 (2018–2019)	338	75.7 (66.5–83.1)	0.017 (0.012–0.023)	<LOD	0.017 (0.013–0.022)	0.059 ^E (0.036–0.083)	0.087 (0.062–0.11)
60–79 years							
1 (2007–2009)	957	46.1 (38.4–54.0)	—	<LOD	<LOD	0.057 (0.046–0.069)	0.081 (0.061–0.10)
2 (2009–2011)	285	54.5 (46.5–62.4)	—	<LOD	0.0099 ^E (<LOD–0.014)	0.073 ^E (0.024–0.12)	0.18 ^E (0.079–0.27)
5 (2016–2017)	336	76.4 (66.9–83.8)	0.021 (0.016–0.028)	<LOD	0.019 ^E (0.010–0.027)	0.11 ^E (0.050–0.16)	0.18 ^E (0.035–0.32)
6 (2018–2019)	334	78.8 (71.3–84.7)	0.020 (0.016–0.025)	<LOD	0.018 (0.012–0.024)	0.096 ^E (0.031–0.16)	0.20 ^E (0.071–0.32)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.2.8

cis-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2553	99.4 (98.0–99.8)	0.12 (0.10–0.15)	0.024 (0.021–0.028)	0.093 (0.076–0.11)	0.85 ^E (0.47–1.2)	2.2 ^E (0.78–3.6)
5 (2016–2017)	2715	100 (99.9–100)	0.18 (0.13–0.24)	0.029 ^E (0.016–0.042)	0.15 (0.11–0.19)	1.1 ^E (0.43–1.8)	3.0 ^E (<LOD–6.0)
6 (2018–2019)	2530	99.8 (99.0–100)	0.19 (0.14–0.25)	0.040 (0.032–0.049)	0.16 (0.12–0.21)	1.0 ^E (0.53–1.5)	2.3 ^E (1.1–3.6)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1277	99.2 (96.8–99.8)	0.10 (0.087–0.13)	0.024 (0.018–0.029)	0.088 (0.068–0.11)	0.55 (0.43–0.68)	1.2 ^E (0.39–2.1)
5 (2016–2017)	1355	100 (99.9–100)	0.16 (0.12–0.22)	0.027 ^E (0.011–0.042)	0.13 (0.089–0.18)	1.1 ^E (0.61–1.5)	2.5 ^E (0.96–4.0)
6 (2018–2019)	1257	99.9 (99.6–100)	0.18 (0.13–0.25)	0.039 (0.026–0.051)	0.16 (0.11–0.21)	1.1 ^E (0.41–1.7)	2.6 ^E (1.2–4.0)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1276	99.6 (97.9–99.9)	0.15 (0.11–0.20)	0.025 (0.020–0.030)	0.099 (0.077–0.12)	1.2 ^E (0.32–2.0)	2.7 ^E (<LOD–7.0)
5 (2016–2017)	1360	99.9 (99.9–100)	0.19 ^E (0.13–0.29)	0.034 ^E (0.021–0.048)	0.17 (0.12–0.22)	1.2 ^E (<LOD–3.0)	4.5 ^E (0.21–8.7)
6 (2018–2019)	1273	99.7 (97.8–100)	0.19 (0.14–0.27)	0.041 (0.035–0.047)	0.16 (0.11–0.21)	1.0 ^E (0.48–1.5)	2.0 ^E (0.53–3.5)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	520	98.2 (93.1–99.6)	0.067 (0.049–0.090)	0.016 (0.011–0.022)	0.065 (0.047–0.082)	0.29 ^E (0.061–0.52)	0.65 ^E (<LOD–1.8)
5 (2016–2017)	553	99.9 (98.7–100)	0.10 (0.077–0.14)	0.023 ^E (0.014–0.031)	0.084 (0.061–0.11)	0.56 ^E (<LOD–1.4)	1.6 ^E (<LOD–4.3)
6 (2018–2019)	512	99.5 (88.7–100)	0.14 (0.11–0.18)	0.036 ^E (0.022–0.050)	0.12 (0.083–0.17)	0.54 ^E (0.17–0.91)	1.4 ^E (0.47–2.3)
6–11 years							
1 (2007–2009)	1026	97.2 (95.0–98.5)	0.054 (0.043–0.067)	0.014 (0.0099–0.018)	0.049 (0.038–0.060)	0.22 (0.15–0.28)	0.38 ^E (0.18–0.57)
2 (2009–2011)	514	99.3 (97.5–99.8)	0.069 (0.059–0.082)	0.018 (0.014–0.022)	0.056 (0.046–0.065)	0.35 ^E (0.22–0.48)	0.60 ^E (<LOD–1.3)
5 (2016–2017)	536	99.9 (99.2–100)	0.12 (0.10–0.14)	0.030 (0.024–0.036)	0.10 (0.090–0.11)	0.77 ^E (0.32–1.2)	1.6 ^E (0.55–2.6)
6 (2018–2019)	498	100	0.15 ^E (0.10–0.23)	0.029 ^E (0.015–0.043)	0.12 (0.084–0.16)	1.1 ^E (0.25–1.9)	2.7 ^E (0.94–4.4)
12–19 years							
1 (2007–2009)	970	98.8 (95.5–99.7)	0.090 (0.067–0.12)	0.019 (0.013–0.025)	0.077 (0.055–0.099)	0.52 ^E (0.20–0.84)	1.0 ^E (0.44–1.6)
2 (2009–2011)	510	99.8 (99.4–99.9)	0.10 (0.083–0.13)	0.026 (0.022–0.030)	0.080 (0.065–0.095)	0.65 ^E (0.36–0.94)	1.7 ^E (0.90–2.4)
5 (2016–2017)	538	99.8 (99.2–100)	0.15 (0.11–0.20)	0.030 ^F (0.018–0.043)	0.11 (0.084–0.14)	0.89 ^F (0.55–1.2)	2.1 ^F (0.19–3.9)
6 (2018–2019)	504	99.7 (94.7–100)	0.14 (0.11–0.18)	0.037 ^E (0.019–0.056)	0.14 (0.10–0.18)	0.62 (0.49–0.74)	0.92 ^E (0.26–1.6)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1151	99.2 (96.0–99.6)	0.086 (0.070–0.11)	0.020 (0.015–0.024)	0.076 (0.057–0.094)	0.45 (0.30–0.60)	0.75 ^E (0.35–1.1)
2 (2009–2011)	359	99.2 (93.7–99.9)	0.18 ^E (0.12–0.28)	0.027 (0.019–0.035)	0.13 (0.092–0.17)	2.0 ^E (<LOD–5.5)	9.1 ^E (<LOD–26)
5 (2016–2017)	376	100 (99.9–100)	0.21 ^E (0.11–0.40)	0.029 ^E (0.0077–0.051)	0.18 ^E (0.11–0.25)	2.4 ^E (<LOD–7.1)	7.0 ^E (0.86–13)
6 (2018–2019)	332	100	0.24 ^E (0.15–0.38)	0.048 (0.036–0.060)	0.20 (0.13–0.26)	1.4 ^E (0.38–2.4)	2.7 ^E (<LOD–11)
40–59 years							
1 (2007–2009)	1208	98.3 (96.4–99.2)	0.092 (0.073–0.12)	0.018 (0.012–0.024)	0.077 (0.054–0.099)	0.60 (0.42–0.78)	1.2 (0.91–1.5)
2 (2009–2011)	359	99.7 (98.7–99.9)	0.12 (0.089–0.16)	0.024 (0.016–0.031)	0.10 ^E (0.054–0.15)	0.64 ^E (0.32–0.96)	1.6 ^E (0.46–2.7)
5 (2016–2017)	360	100	0.19 ^E (0.13–0.27)	0.031 ^E (0.0080–0.054)	0.16 ^E (0.061–0.26)	0.84 ^E (0.089–1.6)	2.2 ^E (<LOD–4.6)
6 (2018–2019)	342	100	0.20 ^E (0.13–0.31)	0.038 ^E (0.017–0.058)	0.19 ^E (0.094–0.29)	0.99 ^E (0.19–1.8)	2.0 ^E (0.34–3.7)
60–79 years							
1 (2007–2009)	1076	99.1 (94.0–99.9)	0.083 (0.066–0.10)	0.019 (0.015–0.024)	0.067 (0.050–0.083)	0.42 ^E (0.25–0.58)	0.75 (0.47–1.0)
2 (2009–2011)	291	98.9 (90.0–99.9)	0.11 ^E (0.072–0.16)	0.021 (0.014–0.029)	0.086 (0.064–0.11)	0.92 ^E (0.37–1.5)	1.2 ^E (<LOD–2.5)
5 (2016–2017)	352	100	0.17 ^E (0.11–0.26)	0.024 ^E (<LOD–0.044)	0.15 (0.11–0.20)	1.5 ^E (0.69–2.3)	2.3 ^E (<LOD–5.0)
6 (2018–2019)	342	99.5 (94.9–99.9)	0.15 (0.11–0.21)	0.033 ^E (0.020–0.046)	0.12 ^E (0.061–0.18)	0.91 ^E (0.38–1.4)	1.8 ^E (0.17–3.4)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.007, 0.007, 0.0045 and 0.0042 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.2.9

cis-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*cis*-DCCA) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2543	99.4 (98.0–99.8)	0.12 (0.10–0.15)	0.028 (0.025–0.031)	0.087 (0.072–0.10)	0.83 ^E (0.42–1.2)	2.3 ^E (0.23–4.3)
5 (2016–2017)	2685	100 (99.9–100)	0.17 (0.13–0.23)	0.036 (0.026–0.045)	0.14 (0.10–0.17)	1.0 (0.71–1.4)	2.3 ^E (<LOD–5.1)
6 (2018–2019)	2529	99.8 (99.0–100)	0.20 (0.14–0.29)	0.046 (0.035–0.057)	0.15 (0.11–0.20)	1.2 ^E (0.65–1.7)	2.8 ^E (1.6–4.0)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1273	99.2 (96.8–99.8)	0.088 (0.075–0.10)	0.026 (0.023–0.029)	0.068 (0.053–0.083)	0.41 ^E (0.23–0.59)	0.96 ^E (0.46–1.5)
5 (2016–2017)	1340	100 (99.9–100)	0.14 (0.10–0.18)	0.029 (0.020–0.038)	0.10 (0.065–0.13)	0.92 ^E (0.55–1.3)	1.8 ^E (1.1–2.5)
6 (2018–2019)	1256	99.9 (99.6–100)	0.17 (0.12–0.24)	0.038 (0.029–0.047)	0.13 (0.087–0.18)	0.99 ^E (0.34–1.6)	2.1 ^E (<LOD–4.3)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1270	99.6 (97.9–99.9)	0.17 (0.13–0.22)	0.034 (0.029–0.039)	0.11 (0.077–0.14)	1.2 ^E (0.056–2.3)	5.0 ^E (<LOD–9.5)
5 (2016–2017)	1345	99.9 (99.9–100)	0.21 (0.15–0.30)	0.051 (0.039–0.062)	0.17 (0.13–0.21)	1.1 ^E (<LOD–2.5)	6.6 ^E (<LOD–14)
6 (2018–2019)	1273	99.7 (97.8–100)	0.25 ^E (0.17–0.37)	0.059 (0.051–0.066)	0.17 ^E (0.10–0.24)	1.4 ^E (<LOD–2.8)	2.8 ^E (0.85–4.8)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	519	98.2 (93.1–99.6)	0.12 (0.085–0.16)	0.031 (0.022–0.040)	0.091 (0.068–0.11)	0.63 ^E (0.19–1.1)	0.97 ^E (<LOD–4.1)
5 (2016–2017)	544	99.9 (98.7–100)	0.18 (0.15–0.22)	0.048 (0.033–0.062)	0.15 (0.12–0.18)	0.73 ^E (<LOD–1.9)	2.0 ^E (<LOD–4.1)
6 (2018–2019)	511	99.5 (88.7–100)	0.23 (0.18–0.28)	0.077 (0.055–0.099)	0.18 (0.14–0.22)	0.83 ^E (0.43–1.2)	1.5 ^E (0.70–2.4)
6–11 years							
1 (2007–2009)	1023	97.2 (95.0–98.5)	0.083 (0.070–0.098)	0.028 (0.023–0.033)	0.071 (0.063–0.079)	0.30 ^E (0.19–0.41)	0.58 ^E (0.21–0.95)
2 (2009–2011)	512	99.3 (97.5–99.8)	0.080 (0.069–0.094)	0.026 (0.022–0.031)	0.059 (0.052–0.066)	0.39 ^E (0.24–0.54)	0.70 ^E (<LOD–1.2)
5 (2016–2017)	528	99.9 (99.2–100)	0.14 (0.12–0.16)	0.045 (0.035–0.056)	0.10 (0.094–0.11)	0.69 ^E (0.29–1.1)	1.7 ^E (0.82–2.5)
6 (2018–2019)	498	100	0.18 (0.13–0.25)	0.048 (0.036–0.059)	0.13 ^E (0.079–0.18)	1.3 ^E (0.35–2.3)	2.4 ^E (1.2–3.6)
12–19 years							
1 (2007–2009)	968	98.8 (95.5–99.7)	0.079 (0.062–0.10)	0.022 (0.018–0.025)	0.061 (0.042–0.080)	0.43 ^E (0.23–0.63)	0.98 ^E (0.55–1.4)
2 (2009–2011)	508	99.8 (99.4–99.9)	0.079 (0.063–0.099)	0.024 (0.020–0.027)	0.060 (0.046–0.074)	0.45 ^E (0.24–0.66)	0.88 ^E (0.54–1.2)
5 (2016–2017)	531	99.8 (99.2–100)	0.11 (0.088–0.14)	0.030 (0.026–0.034)	0.085 (0.062–0.11)	0.60 ^E (0.23–0.98)	1.8 ^E (0.56–3.1)
6 (2018–2019)	504	99.7 (94.7–100)	0.12 (0.096–0.14)	0.037 (0.026–0.048)	0.097 (0.068–0.13)	0.34 ^E (0.18–0.50)	0.83 ^E (0.046–1.6)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1147	98.7 (96.0–99.6)	0.096 (0.080–0.12)	0.026 (0.021–0.031)	0.084 (0.069–0.099)	0.38 ^E (0.23–0.53)	0.82 ^E (0.40–1.2)
2 (2009–2011)	357	99.2 (93.7–99.9)	0.16 ^E (0.10–0.23)	0.028 (0.024–0.033)	0.098 (0.070–0.13)	1.8 ^E (<LOD–4.4)	7.0 ^E (<LOD–15)
5 (2016–2017)	372	100 (99.9–100)	0.18 ^E (0.10–0.32)	0.035 (0.028–0.043)	0.15 ^E (0.073–0.22)	1.4 ^E (<LOD–3.8)	5.3 ^E (<LOD–15)
6 (2018–2019)	332	100	0.22 ^E (0.14–0.37)	0.047 ^E (0.023–0.071)	0.15 ^E (0.089–0.21)	1.5 ^E (0.22–2.8)	2.9 ^E (<LOD–7.3)
40–59 years							
1 (2007–2009)	1203	98.3 (96.4–99.2)	0.12 (0.097–0.14)	0.029 (0.023–0.035)	0.097 (0.080–0.11)	0.64 (0.42–0.86)	1.2 (0.97–1.5)
2 (2009–2011)	357	99.7 (98.7–99.9)	0.12 (0.10–0.15)	0.032 (0.023–0.041)	0.084 ^E (0.050–0.12)	0.62 ^E (0.28–0.96)	1.3 ^E (0.51–2.0)
5 (2016–2017)	359	100	0.17 (0.12–0.23)	0.034 ^E (0.019–0.049)	0.15 (0.10–0.19)	1.0 ^E (0.49–1.5)	1.4 ^E (<LOD–4.3)
6 (2018–2019)	342	100	0.24 ^E (0.15–0.38)	0.056 (0.043–0.069)	0.18 ^E (0.072–0.30)	1.3 ^E (0.20–2.5)	3.1 ^E (0.33–5.8)
60–79 years							
1 (2007–2009)	1076	99.1 (94.0–99.9)	0.12 (0.093–0.14)	0.034 (0.031–0.037)	0.093 (0.073–0.11)	0.48 ^E (0.18–0.79)	1.2 ^E (0.61–1.7)
2 (2009–2011)	290	98.9 (90.0–99.9)	0.12 ^E (0.084–0.19)	0.030 (0.019–0.041)	0.095 (0.071–0.12)	0.80 ^E (<LOD–2.4)	2.2 ^E (<LOD–6.6)
5 (2016–2017)	351	100	0.19 (0.14–0.28)	0.038 ^E (<LOD–0.062)	0.15 ^E (0.093–0.20)	0.99 (0.67–1.3)	2.0 ^E (<LOD–5.2)
6 (2018–2019)	342	99.5 (94.9–99.9)	0.18 (0.13–0.25)	0.041 (0.029–0.052)	0.15 (0.11–0.18)	1.0 ^E (0.19–1.9)	2.7 ^E (1.3–4.1)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

Table 13.2.10

trans-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2558	99.4 (97.8–99.9)	0.29 (0.23–0.36)	0.051 (0.043–0.059)	0.22 (0.17–0.26)	2.0 ^E (0.90–3.2)	6.8 ^E (2.1–11)
5 (2016–2017)	2719	99.6 (98.7–99.9)	0.27 (0.20–0.37)	0.038 ^E (0.023–0.052)	0.23 (0.18–0.28)	2.2 ^E (0.95–3.4)	6.4 ^E (1.6–11)
6 (2018–2019)	2536	99.7 (99.1–99.9)	0.29 (0.21–0.38)	0.049 (0.039–0.058)	0.23 (0.16–0.30)	1.9 ^E (1.0–2.8)	4.8 ^E (2.2–7.4)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1279	99.3 (96.4–99.9)	0.25 (0.20–0.31)	0.048 (0.036–0.060)	0.21 (0.17–0.25)	1.3 ^E (0.82–1.8)	3.5 ^E (0.86–6.1)
5 (2016–2017)	1355	99.7 (99.1–99.9)	0.25 (0.19–0.33)	0.036 ^E (0.0098–0.062)	0.21 (0.16–0.26)	2.1 ^E (1.3–3.0)	4.5 ^E (1.6–7.3)
6 (2018–2019)	1258	99.8 (99.0–100)	0.28 (0.21–0.39)	0.049 (0.035–0.063)	0.23 ^E (0.13–0.32)	1.9 ^E (0.81–2.9)	4.9 ^E (1.6–8.3)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1279	99.6 (97.7–99.9)	0.34 (0.25–0.46)	0.052 (0.040–0.064)	0.22 (0.16–0.28)	3.4 ^E (0.76–6.0)	8.8 ^E (<LOD–25)
5 (2016–2017)	1364	99.5 (96.8–99.9)	0.29 ^E (0.19–0.43)	0.039 (0.029–0.050)	0.24 (0.17–0.31)	2.4 ^E (<LOD–6.2)	9.4 ^E (0.23–18)
6 (2018–2019)	1278	99.6 (98.2–99.9)	0.29 (0.21–0.39)	0.049 (0.037–0.061)	0.23 (0.17–0.29)	2.0 ^E (0.83–3.2)	4.5 ^E (1.9–7.1)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	521	99.4 (95.1–99.9)	0.22 (0.16–0.31)	0.055 (0.038–0.071)	0.19 (0.13–0.25)	1.1 ^E (0.15–2.0)	2.6 ^E (<LOD–7.9)
5 (2016–2017)	553	100 (99.9–100)	0.22 (0.16–0.30)	0.047 ^E (0.029–0.064)	0.18 (0.13–0.23)	1.1 ^E (<LOD–2.5)	2.4 ^E (<LOD–8.1)
6 (2018–2019)	514	99.5 (88.8–100)	0.31 (0.23–0.41)	0.068 (0.046–0.089)	0.24 (0.16–0.32)	1.2 ^E (0.15–2.3)	3.1 ^E (<LOD–8.2)
6–11 years							
1 (2007–2009)	1027	99.9 (99.6–100)	0.17 (0.15–0.21)	0.041 ^E (0.025–0.057)	0.15 (0.12–0.18)	0.82 (0.57–1.1)	1.4 (1.1–1.8)
2 (2009–2011)	516	99.7 (98.1–100)	0.21 (0.18–0.25)	0.048 (0.037–0.059)	0.17 (0.15–0.19)	1.1 (0.80–1.4)	1.9 ^E (<LOD–4.4)
5 (2016–2017)	538	99.4 (95.5–99.9)	0.23 (0.20–0.26)	0.053 (0.039–0.066)	0.20 (0.16–0.24)	1.3 ^E (0.60–2.0)	2.9 ^E (1.2–4.6)
6 (2018–2019)	499	99.8 (97.1–100)	0.32 ^E (0.21–0.49)	0.066 (0.045–0.087)	0.25 ^E (0.14–0.36)	2.1 ^E (0.38–3.8)	5.2 ^E (1.2–9.3)
12–19 years							
1 (2007–2009)	978	99.9 (99.5–100)	0.24 (0.18–0.33)	0.048 ^E (0.030–0.066)	0.20 (0.16–0.24)	1.5 ^E (0.58–2.4)	3.8 ^E (2.0–5.6)
2 (2009–2011)	511	100	0.27 (0.21–0.34)	0.057 (0.048–0.067)	0.20 (0.16–0.25)	1.8 ^E (1.0–2.5)	4.8 ^E (2.1–7.5)
5 (2016–2017)	538	99.4 (98.3–99.8)	0.26 (0.19–0.35)	0.049 ^E (0.020–0.078)	0.21 (0.16–0.26)	1.7 ^E (0.80–2.6)	4.6 ^E (1.5–7.7)
6 (2018–2019)	505	99.7 (94.7–100)	0.24 (0.18–0.30)	0.050 ^E (0.022–0.078)	0.24 ^E (0.15–0.33)	1.1 (0.69–1.4)	2.5 ^E (1.4–3.5)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1158	99.3 (97.3–99.8)	0.20 (0.16–0.24)	0.042 (0.031–0.053)	0.17 (0.14–0.21)	1.0 (0.71–1.4)	2.0 ^E (1.1–2.8)
2 (2009–2011)	359	100	0.41 ^E (0.26–0.66)	0.061 (0.040–0.082)	0.28 ^E (0.12–0.43)	5.7 ^E (<LOD–15)	27 ^E (<LOD–67)
5 (2016–2017)	376	99.3 (93.5–99.9)	0.33 ^E (0.17–0.64)	0.036 ^E (0.012–0.061)	0.24 ^E (0.11–0.37)	4.3 ^E (<LOD–12)	13 ^E (1.1–25)
6 (2018–2019)	332	99.9 (98.7–100)	0.35 ^E (0.22–0.55)	0.059 ^E (0.033–0.085)	0.26 ^E (0.15–0.36)	2.7 ^E (<LOD–5.5)	6.0 ^E (<LOD–27)
40–59 years							
1 (2007–2009)	1216	99.6 (98.8–99.9)	0.21 (0.17–0.26)	0.037 (0.029–0.044)	0.18 (0.13–0.22)	1.6 ^E (0.86–2.3)	3.2 ^E (1.9–4.5)
2 (2009–2011)	360	98.9 (94.4–99.8)	0.27 (0.20–0.35)	0.041 ^E (0.022–0.060)	0.22 (0.15–0.30)	1.8 ^E (1.1–2.5)	3.9 ^E (0.82–7.0)
5 (2016–2017)	360	99.9 (99.3–100)	0.26 ^E (0.17–0.39)	0.042 ^E (0.012–0.072)	0.25 ^E (0.14–0.35)	1.5 ^E (<LOD–3.1)	4.0 ^E (<LOD–8.0)
6 (2018–2019)	343	99.5 (97.9–99.9)	0.30 ^E (0.20–0.46)	0.049 ^E (0.025–0.073)	0.23 ^E (0.061–0.39)	1.6 ^E (0.38–2.8)	4.3 ^E (0.69–8.0)
60–79 years							
1 (2007–2009)	1078	99.6 (98.0–99.9)	0.18 (0.15–0.22)	0.040 (0.032–0.047)	0.15 (0.12–0.18)	1.1 (0.79–1.3)	1.9 ^E (1.1–2.6)
2 (2009–2011)	291	99.0 (93.3–99.9)	0.23 ^E (0.14–0.39)	0.041 ^E (0.026–0.056)	0.17 ^E (0.082–0.25)	2.4 ^E (0.60–4.1)	3.5 ^E (<LOD–9.7)
5 (2016–2017)	354	99.6 (97.7–99.9)	0.23 ^E (0.16–0.34)	0.029 ^E (0.011–0.048)	0.18 (0.11–0.24)	2.5 ^E (1.3–3.7)	5.1 ^E (<LOD–11)
6 (2018–2019)	343	99.5 (94.9–99.9)	0.21 (0.15–0.30)	0.037 ^E (0.020–0.055)	0.17 ^E (0.10–0.23)	1.6 ^E (0.37–2.8)	3.0 ^E (0.60–5.5)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.01, 0.01, 0.0094 and 0.0094 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
 b Data are not available, as participants under the age of six years were not included in cycle 1.
 E Use data with caution.

Table 13.2.11

trans-3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (*trans*-DCCA) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2548	99.4 (97.8–99.9)	0.28 (0.23–0.35)	0.062 (0.054–0.070)	0.19 (0.15–0.24)	1.9 ^E (0.72–3.1)	7.1 ^E (0.93–13)
5 (2016–2017)	2689	99.6 (98.7–99.9)	0.26 (0.20–0.34)	0.050 (0.038–0.062)	0.21 (0.15–0.26)	2.0 ^E (1.1–3.0)	4.3 ^E (<LOD–9.5)
6 (2018–2019)	2535	99.7 (99.1–99.9)	0.31 (0.22–0.43)	0.063 (0.047–0.079)	0.22 (0.15–0.29)	2.0 ^E (0.22–3.8)	5.6 ^E (3.3–7.9)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1275	99.3 (96.4–99.9)	0.21 (0.18–0.25)	0.055 (0.045–0.064)	0.17 (0.13–0.20)	1.0 ^E (0.53–1.5)	2.7 ^E (0.46–5.0)
5 (2016–2017)	1340	99.7 (99.1–99.9)	0.21 (0.17–0.28)	0.045 (0.030–0.060)	0.17 ^E (0.11–0.23)	1.5 ^E (0.60–2.3)	3.5 (2.3–4.8)
6 (2018–2019)	1257	99.8 (99.0–100)	0.26 (0.19–0.37)	0.056 (0.045–0.067)	0.19 (0.14–0.25)	1.5 ^E (0.58–2.4)	5.2 ^E (<LOD–11)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1273	99.6 (97.7–99.9)	0.38 (0.29–0.51)	0.070 (0.058–0.083)	0.24 (0.18–0.30)	3.8 ^E (0.21–7.5)	15 ^E (<LOD–30)
5 (2016–2017)	1349	99.5 (96.8–99.9)	0.32 (0.22–0.45)	0.058 (0.045–0.070)	0.25 (0.20–0.31)	2.4 ^E (<LOD–5.3)	14 ^E (<LOD–29)
6 (2018–2019)	1278	99.6 (98.2–99.9)	0.36 (0.25–0.52)	0.079 (0.060–0.098)	0.26 (0.17–0.34)	2.9 ^E (<LOD–6.0)	5.6 ^E (2.3–8.9)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	520	99.4 (95.1–99.9)	0.39 (0.28–0.54)	0.094 (0.065–0.12)	0.32 (0.22–0.41)	1.8 ^E (0.17–3.5)	3.8 ^E (<LOD–14)
5 (2016–2017)	544	100 (99.9–100)	0.38 (0.31–0.46)	0.087 ^E (0.053–0.12)	0.33 (0.29–0.37)	1.9 ^E (<LOD–3.2)	3.1 ^E (<LOD–6.8)
6 (2018–2019)	513	99.5 (88.8–100)	0.50 (0.40–0.63)	0.16 (0.12–0.19)	0.43 ^E (0.27–0.59)	1.7 ^E (0.095–3.2)	4.3 ^E (<LOD–10)
6–11 years							
1 (2007–2009)	1024	99.9 (99.6–100)	0.27 (0.24–0.31)	0.086 (0.078–0.095)	0.21 (0.19–0.24)	1.0 ^E (0.63–1.4)	2.4 ^E (1.3–3.6)
2 (2009–2011)	514	99.7 (98.1–100)	0.24 (0.21–0.29)	0.077 (0.067–0.087)	0.18 (0.16–0.20)	1.1 ^E (0.64–1.5)	2.5 ^E (<LOD–4.4)
5 (2016–2017)	530	99.4 (95.5–99.9)	0.27 (0.24–0.30)	0.085 (0.071–0.099)	0.20 (0.17–0.23)	1.6 ^E (0.68–2.5)	3.4 ^E (1.5–5.4)
6 (2018–2019)	499	99.8 (97.1–100)	0.38 ^E (0.26–0.55)	0.090 (0.062–0.12)	0.28 (0.18–0.38)	2.1 ^E (0.57–3.6)	5.5 ^E (2.1–8.9)
12–19 years							
1 (2007–2009)	976	99.9 (99.5–100)	0.21 (0.17–0.27)	0.056 (0.047–0.065)	0.15 (0.11–0.20)	1.2 ^E (0.62–1.8)	2.4 ^E (1.2–3.5)
2 (2009–2011)	509	100	0.21 (0.16–0.26)	0.057 (0.049–0.065)	0.15 (0.11–0.19)	1.2 ^E (0.50–1.9)	2.4 ^E (1.2–3.5)
5 (2016–2017)	531	99.4 (98.3–99.8)	0.20 (0.16–0.25)	0.047 (0.040–0.054)	0.14 (0.096–0.18)	1.1 ^E (0.066–2.1)	3.5 ^E (1.2–5.9)
6 (2018–2019)	505	99.7 (94.7–100)	0.20 (0.16–0.24)	0.052 (0.039–0.066)	0.17 (0.13–0.21)	0.70 (0.51–0.90)	1.6 ^E (0.21–2.9)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	1154	99.3 (97.3–99.8)	0.22 (0.19–0.26)	0.058 (0.050–0.067)	0.17 (0.14–0.21)	1.0 (0.75–1.3)	2.3 ^E (1.4–3.3)
2 (2009–2011)	357	100	0.35 ^E (0.23–0.53)	0.059 (0.040–0.078)	0.22 ^E (0.13–0.30)	5.2 ^E (<LOD–12)	24 ^E (<LOD–49)
5 (2016–2017)	372	99.3 (93.5–99.9)	0.29 ^E (0.16–0.52)	0.048 (0.033–0.063)	0.22 ^E (0.11–0.33)	2.7 ^E (<LOD–10)	14 ^E (<LOD–36)
6 (2018–2019)	332	99.9 (98.7–100)	0.33 ^E (0.20–0.53)	0.063 ^E (0.035–0.090)	0.21 (0.14–0.27)	2.4 ^E (<LOD–6.3)	6.0 ^E (<LOD–17)
40–59 years							
1 (2007–2009)	1211	99.6 (98.8–99.9)	0.27 (0.23–0.32)	0.062 (0.057–0.068)	0.20 (0.17–0.23)	1.7 (1.1–2.3)	3.6 (2.9–4.4)
2 (2009–2011)	358	98.9 (94.4–99.8)	0.27 (0.23–0.32)	0.065 (0.051–0.079)	0.19 ^E (0.12–0.27)	1.6 ^E (0.89–2.2)	3.5 ^E (0.74–6.3)
5 (2016–2017)	359	99.9 (99.3–100)	0.24 (0.17–0.32)	0.049 ^E (0.030–0.068)	0.23 ^E (0.14–0.31)	1.5 ^E (<LOD–2.5)	3.5 ^E (<LOD–6.7)
6 (2018–2019)	343	99.5 (97.9–99.9)	0.36 ^E (0.23–0.54)	0.071 ^E (0.044–0.097)	0.27 ^E (0.10–0.43)	2.6 ^E (0.13–5.0)	6.1 ^E (1.3–11)
60–79 years							
1 (2007–2009)	1078	99.6 (98.0–99.9)	0.25 (0.21–0.31)	0.066 (0.060–0.073)	0.20 (0.16–0.24)	1.3 ^E (0.68–1.9)	2.9 ^E (1.7–4.2)
2 (2009–2011)	290	99.0 (93.3–99.9)	0.27 ^E (0.16–0.44)	0.052 (0.035–0.070)	0.18 ^E (0.10–0.27)	1.8 ^E (<LOD–7.5)	10 ^E (<LOD–25)
5 (2016–2017)	353	99.6 (97.7–99.9)	0.27 (0.19–0.37)	0.047 ^E (0.029–0.065)	0.20 (0.13–0.27)	2.1 ^E (1.0–3.2)	3.5 ^E (<LOD–12)
6 (2018–2019)	343	99.5 (94.9–99.9)	0.25 (0.17–0.35)	0.054 (0.035–0.074)	0.21 (0.14–0.27)	1.5 ^E (<LOD–3.3)	5.0 ^E (1.6–8.5)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years were not included in cycle 1.

E Use data with caution.

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13.3 ETHYLENE BISDITHIO-CARBAMATES

Ethylene bisdithiocarbamates (EBDCs) are a group of pesticides used primarily as broad-spectrum organometallic fungicides. Three EBDCs were registered for use in Canada during the Canadian Health Measures Survey (CHMS) cycle 6 sampling period (2018–2019), namely mancozeb, metiram and nabam (HC, 2021). Ethylene thiourea (ETU) (CASRN 96-45-7), also known as 2-imidazolidinethione, is a metabolite, an environmental degradation product and a synthesis contaminant of EBDCs. ETU can also be produced commercially and is used primarily in plastic and rubber production (CDC, 2016; ECCC and HC, 2017; EPA, 2000; IARC, 2001; NTP, 2016).

EBDCs enter the environment as a result of their use as fungicides. They break down rapidly to ETU and other metabolites. Conversely, ETU is moderately persistent and more mobile than the parent fungicides; therefore, it may be present in the water column (NTP, 2016). In soil, ETU is highly mobile, but biodegrades rapidly, while in air, it is photochemically degraded. ETU may also be released to the environment during plastic and rubber production. While the curing of rubber converts ETU to other compounds, residual amounts of ETU may be present (IARC, 1974). Therefore, ETU can potentially migrate from rubber surfaces.

EBDCs are used in a range of applications. Nabam is a broad-spectrum biocide registered for use in Canada to control slime-forming microorganisms in process fluids for a number of industries. As a slime-control agent, it is used in air washers, cooling towers, evaporative condensers, pulp and paper mills, drilling fluids for oil field operations, and secondary and tertiary petroleum recovery (HC, 2012). Mancozeb and metiram are protectant contact fungicides with a multi-site mode of action. Historically they have been used to control a broad spectrum of plant diseases in a variety of food and feed crops. Following a 2018 re-evaluation decision, Health Canada cancelled all uses of metiram with the exception of foliar application in potatoes (HC, 2018). Health Canada has also recently completed a re-evaluation decision for mancozeb. It determined that continued registration is acceptable with additional risk mitigation measures (HC, 2020).

Exposure of the general population may occur from the ingestion of food treated with EBDCs. Other routes of exposure include inhalation during activity in areas adjacent to fields treated with EBDCs. ETU exposure results from its presence as a contaminant in the applied fungicide, the degradation of the parent fungicide, or as a product of heating food contaminated with an EBDC (IARC, 2001). As a result of EBDC use, ETU may also be present as a contaminant in food or drinking water. Cigarette smoke may also be an important source of EBDCs and ETU exposure owing to the use of fungicides on tobacco crops (Houeto et al., 1995; IARC, 2001). Exposure to EBDCs and ETU can also occur through dermal contact with pesticide products; direct ETU exposure may result from dermal contact with rubber that contains ETU (ECCC and HC, 2017; EPA, 2000; HC 2012; 2018; HSDB, 2010).

EBDCs are primarily absorbed by ingestion, and to a lesser extent by inhalation or dermal contact, and are metabolized rapidly in the body to produce ETU and other substances (CDC, 2016; Houeto, 1995). ETU itself is readily absorbed following oral exposure and excreted in urine as unchanged ETU and other oxidative metabolites (CDC, 2016; Houeto et al., 1995). Once absorbed, ETU travels throughout the body, with predominant distribution to the thyroid gland (IARC, 2001). ETU can cross the placental barrier and has been measured in the milk of lactating laboratory animals (CDC, 2016; HSDB, 2010). ETU elimination following EBDC exposure has a reported half-life in humans ranging from 32 to 100 hours (Kurttio and Savolainen, 1990). Animal and human studies report that ETU is rapidly eliminated, mainly through urine, with a small amount excreted in feces (CDC, 2016, Houeto et al., 1995). ETU measured in urine reflects recent exposure to EBDCs or ETU (CDC, 2016).

Potential human health risks from exposure to EBDCs and their metabolite ETU include key effects on the thyroid. Of the EBDC fungicides, nabam has the greatest toxicity, possibly due to its higher water solubility and absorbability (Frakes and Hicks, 1993). Overall, the toxicity of parent EBDC compounds is relatively low; most is attributed to the metabolites, particularly ETU (Frakes and Hicks, 1993). Acute oral exposure to ETU has been reported to result in thyroid gland hyperplasia and reduced thyroid hormone levels, while short-term inhalation exposure may irritate the respiratory tract (EPA, 2000; Houeto et al., 1995). Acute exposure to higher levels of ETU can result

in symptoms ranging from nausea and sweating to pulmonary edema leading to death. Animal studies show that the target organ for chronic ETU toxicity is the thyroid gland; consequently, several symptoms associated with reduced thyroid hormone may be observed, such as myxedema and goiter. Damage to the liver, kidneys or pituitary gland may also occur (HSDB, 2010).

Experimental animal studies have also shown that ETU is a potential endocrine disruptor, given that it interferes with the synthesis of thyroid hormones; and that it is teratogenic, with effects such as musculoskeletal and central nervous system abnormalities reported in laboratory animals (CDC, 2016; EPA, 1991; Hurley, 1998). Evidence suggests that ETU may be weakly genotoxic. Exposure in laboratory animals has resulted in liver tumours and benign pituitary tumours by a less understood mode of action (IARC, 2001; NTP, 2016). Studies suggest that ETU is carcinogenic; exposed animals have been shown to develop thyroid tumours with a clear non-genotoxic mode of action. According to the International Agency for Research on Cancer (IARC) the carcinogenicity of ETU to humans is not classifiable (Group 3) (IARC, 2001). To date, IARC has not assessed the EBDC fungicides registered for use in Canada for their carcinogenic potential.

The sale and use of EBDC fungicides are regulated in Canada by the Pest Management Regulatory Agency (PMRA) under the *Pest Control Products Act* (Canada, 2002). PMRA evaluates toxicity and potential exposure in order to determine whether a pesticide should be registered for a specific use. As part of this registration process, PMRA specifies maximum residue limits (MRLs) of pesticides in food. MRLs exist for EBDCs, including mancozeb and metiram (HC, 2020). PMRA

re-evaluates registered pesticides on a cyclical basis. As part of this process, Health Canada has completed a re-evaluation of nabam, metiram and mancozeb, and granted these products continued registration for certain specified uses (HC, 2012; 2018; 2020).

The Government of Canada conducted a science-based screening assessment of a group of substances known as the Heterocycles Group under the Chemicals Management Plan that determined whether ETU presents or may present a risk to the environment or human health as per the criteria set out in section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; ECCC and HC, 2017). The draft assessment proposed to conclude that ETU does not meet any of the criteria for being considered toxic under CEPA 1999 (ECCC and HC, 2017). However, ETU was removed from the screening assessment group prior to the final assessment as work was ongoing with the presence of ETU as a metabolite and residual in select pesticides; it will be assessed under CEPA at a later date in a separate screening assessment. The concentration of ETU in specific foods is managed by Health Canada under the Food and Drug Regulations (Canada, 1978). ETU is currently listed in Part 1 of the List of Contaminants and Other Adulterating Substances in Foods, which sets out the prohibitions for certain substances in foods.

Total ETU was analyzed in the urine of CHMS participants aged 3–79 in cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented as both µg/L and µg/g creatinine. Finding a measurable amount of ETU in urine is an indicator of exposure to ETU or an EBDC fungicide and does not necessarily mean that an adverse health effect will occur.

Table 13.3.1

Total ethylene thiourea (ETU)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2704	97.0 (93.5–98.6)	0.42 (0.35–0.51)	0.074 ^E (0.043–0.11)	0.44 (0.36–0.51)	2.0 (1.6–2.5)	3.5 ^E (2.0–4.9)
6 (2018–2019)	2508	98.9 (97.4–99.5)	0.40 (0.36–0.45)	0.085 (0.074–0.096)	0.39 (0.34–0.45)	1.7 (1.3–2.0)	2.7 (2.1–3.2)
Males, 3–79 years							
5 (2016–2017)	1354	96.8 (91.7–98.8)	0.43 (0.33–0.54)	0.074 ^E (<LOD–0.12)	0.46 (0.38–0.53)	2.1 ^E (1.1–3.0)	3.9 ^E (1.9–5.9)
6 (2018–2019)	1242	99.5 (97.8–99.9)	0.47 (0.41–0.53)	0.099 (0.088–0.11)	0.44 (0.37–0.51)	1.9 (1.4–2.5)	2.9 ^E (0.84–4.9)
Females, 3–79 years							
5 (2016–2017)	1350	97.2 (93.6–98.8)	0.41 (0.34–0.49)	0.075 ^E (0.047–0.10)	0.41 (0.34–0.49)	1.9 (1.4–2.4)	2.7 (1.7–3.6)
6 (2018–2019)	1266	98.3 (96.2–99.2)	0.34 (0.30–0.40)	0.071 (0.051–0.092)	0.35 (0.27–0.42)	1.4 (1.1–1.7)	2.2 (1.6–2.9)
3–5 years							
5 (2016–2017)	553	99.0 (87.7–99.9)	0.54 (0.42–0.70)	0.11 ^E (0.050–0.18)	0.47 ^E (0.29–0.66)	2.7 (2.0–3.4)	3.7 (3.0–4.4)
6 (2018–2019)	507	98.9 (96.0–99.7)	0.67 (0.54–0.83)	0.14 (0.11–0.16)	0.84 (0.54–1.1)	2.2 (1.7–2.6)	3.8 (2.9–4.8)
6–11 years							
5 (2016–2017)	534	96.9 (85.9–99.4)	0.50 (0.40–0.61)	0.094 (0.067–0.12)	0.53 (0.36–0.70)	2.1 (1.7–2.5)	3.7 (2.5–4.9)
6 (2018–2019)	494	98.8 (92.4–99.8)	0.54 (0.45–0.66)	0.098 ^E (0.039–0.16)	0.56 (0.48–0.65)	2.3 (1.8–2.8)	3.1 (2.2–4.0)
12–19 years							
5 (2016–2017)	537	96.8 (88.9–99.1)	0.49 (0.36–0.68)	0.075 ^E (0.034–0.12)	0.53 (0.34–0.72)	2.4 (1.5–3.3)	3.7 (2.8–4.7)
6 (2018–2019)	498	96.7 (87.9–99.2)	0.48 (0.34–0.68)	0.080 ^E (0.040–0.12)	0.55 ^E (0.33–0.77)	2.6 ^E (1.6–3.6)	4.3 (2.8–5.8)
20–39 years							
5 (2016–2017)	375	97.9 (89.3–99.6)	0.41 (0.32–0.53)	0.076 ^E (0.040–0.11)	0.41 (0.31–0.51)	2.1 ^E (0.99–3.1)	3.4 ^E (0.80–6.1)
6 (2018–2019)	327	99.5 (81.9–100)	0.39 (0.32–0.49)	0.099 (0.068–0.13)	0.36 (0.29–0.43)	1.4 ^E (0.86–1.9)	2.3 ^E (0.79–3.8)
40–59 years							
5 (2016–2017)	355	95.3 (85.0–98.6)	0.38 (0.29–0.49)	0.072 ^E (<LOD–0.11)	0.42 (0.27–0.57)	1.5 (0.95–2.0)	2.7 ^E (0.56–4.9)
6 (2018–2019)	343	99.6 (98.0–99.9)	0.37 (0.29–0.46)	0.073 (0.062–0.084)	0.33 ^E (0.20–0.46)	1.5 (1.1–2.0)	2.4 ^E (0.41–4.4)
60–79 years							
5 (2016–2017)	350	97.9 (93.7–99.3)	0.42 (0.31–0.56)	0.076 ^E (<LOD–0.12)	0.43 (0.32–0.55)	2.1 ^E (1.2–3.0)	3.8 ^E (1.8–5.8)
6 (2018–2019)	339	98.1 (94.9–99.3)	0.36 (0.30–0.44)	0.076 (0.056–0.096)	0.40 (0.31–0.48)	1.4 (0.98–1.9)	2.2 ^E (1.3–3.2)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.033 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 13.3.2

Total ethylene thiourea (ETU) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2677	97.0 (93.5–98.6)	0.41 (0.34–0.50)	0.075 (0.054–0.096)	0.46 (0.37–0.55)	2.0 (1.5–2.5)	3.4 (2.6–4.1)
6 (2018–2019)	2507	98.9 (97.4–99.5)	0.44 (0.38–0.50)	0.10 (0.086–0.11)	0.43 (0.36–0.51)	1.7 (1.4–2.1)	2.6 (1.9–3.3)
Males, 3–79 years							
5 (2016–2017)	1340	96.8 (91.7–98.8)	0.37 (0.29–0.48)	0.073 ^E (<LOD–0.10)	0.40 (0.28–0.52)	2.0 ^E (1.2–2.7)	3.5 (2.6–4.4)
6 (2018–2019)	1241	99.5 (97.8–99.9)	0.44 (0.38–0.50)	0.10 (0.089–0.12)	0.40 (0.34–0.46)	1.6 (1.3–1.9)	2.7 ^E (1.0–4.4)
Females, 3–79 years							
5 (2016–2017)	1337	97.2 (93.6–98.8)	0.45 (0.37–0.54)	0.086 ^E (0.050–0.12)	0.50 (0.43–0.57)	2.0 (1.4–2.5)	3.3 (2.4–4.3)
6 (2018–2019)	1266	98.3 (96.2–99.2)	0.44 (0.37–0.52)	0.089 (0.071–0.11)	0.46 (0.35–0.57)	1.8 (1.3–2.4)	2.5 (1.9–3.2)
3–5 years							
5 (2016–2017)	543	99.0 (87.7–99.9)	0.91 (0.65–1.3)	0.20 ^E (0.11–0.29)	0.81 ^E (0.47–1.2)	4.2 (3.4–5.0)	5.7 (4.1–7.3)
6 (2018–2019)	506	98.9 (96.0–99.7)	1.1 (0.93–1.4)	0.24 ^E (0.15–0.33)	1.2 (1.1–1.4)	4.2 (3.3–5.0)	6.8 (4.8–8.7)
6–11 years							
5 (2016–2017)	529	96.9 (85.9–99.4)	0.59 (0.46–0.74)	0.13 ^E (0.079–0.19)	0.58 (0.39–0.78)	2.5 (2.0–3.1)	3.3 (2.2–4.3)
6 (2018–2019)	494	98.8 (92.4–99.8)	0.65 (0.54–0.79)	0.14 (0.11–0.18)	0.71 (0.45–0.96)	2.5 (2.0–3.0)	3.5 (2.7–4.2)
12–19 years							
5 (2016–2017)	531	96.8 (88.9–99.1)	0.38 (0.29–0.49)	0.073 ^E (0.028–0.12)	0.42 (0.29–0.56)	1.7 (1.4–2.0)	2.1 (1.8–2.3)
6 (2018–2019)	498	96.7 (87.9–99.2)	0.39 (0.31–0.51)	0.063 ^E (0.038–0.089)	0.44 (0.29–0.60)	1.8 (1.2–2.4)	3.0 ^E (1.7–4.3)
20–39 years							
5 (2016–2017)	371	97.9 (89.3–99.6)	0.37 (0.28–0.49)	0.083 ^E (0.051–0.12)	0.37 ^E (0.23–0.51)	1.8 ^E (0.67–3.0)	3.1 ^E (0.73–5.5)
6 (2018–2019)	327	99.5 (81.9–100)	0.37 (0.30–0.46)	0.10 (0.078–0.13)	0.37 (0.28–0.45)	1.4 (0.97–1.7)	1.7 (1.3–2.1)
40–59 years							
5 (2016–2017)	354	95.3 (85.0–98.6)	0.34 (0.26–0.46)	0.055 ^E (<LOD–0.094)	0.47 (0.31–0.63)	1.3 ^E (0.70–1.9)	2.9 ^E (1.1–4.7)
6 (2018–2019)	343	99.6 (98.0–99.9)	0.44 (0.33–0.57)	0.10 (0.073–0.13)	0.45 (0.29–0.61)	2.1 (1.4–2.7)	2.8 ^E (1.3–4.4)
60–79 years							
5 (2016–2017)	349	97.9 (93.7–99.3)	0.48 (0.36–0.63)	0.090 (<LOD–0.12)	0.51 (0.34–0.68)	2.9 ^E (1.4–4.3)	3.8 (2.9–4.6)
6 (2018–2019)	339	98.1 (94.9–99.3)	0.43 (0.35–0.53)	0.089 (0.066–0.11)	0.42 (0.31–0.54)	1.5 ^E (0.84–2.2)	2.6 ^E (0.89–4.2)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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13.4 *ortho*-PHENYLPHENOL

ortho-Phenylphenol (OPP) (CASRN 90-43-7), also known as 2-phenylphenol or biphenyl-2-ol, is a synthetic phenol compound that has the appearance of white- to pink-coloured flaky crystals under ambient conditions (ANSES, 2014; IARC, 1999). OPP can be synthesized by a number of chemical processes. For example, it can be produced from cyclohexanone using a catalyst (ANSES, 2014). OPP and its salts are registered for use in Canada in controlling fungal and bacterial growth on pears (HC 2008b). Sodium *ortho*-phenylphenate (SOPP) is used as a material preservative agent and active ingredient and formulant in registered pest control products (ECCC and HC, 2020). SOPP is also used in Canada in building and construction materials, products available to consumers (such as tire and rubber lubricants), food packaging, cleaning products, natural health products and non-prescription drugs (ECC and HC, 2020).

OPP, which does not occur naturally, is released into the environment from anthropogenic sources. Entry into the environment may occur when emissions from manufacturing and processing facilities are released into air or water (IARC, 1999). OPP may also potentially be released into the environment from the use of commercial or residential products.

Exposure of the general population to OPP and its salts can occur through environmental media, such as outdoor and indoor air, and through products available to consumers, such as disinfectants and tire and rubber lubricants (CDC, 2017; ECCC and HC, 2020). Children may be exposed via ingestion after touching floors or textiles treated with OPP (HC, 2008a). Exposure can also occur through ingestion of treated food (Appel, 2000; CDC, 2017).

While no human studies of absorption via oral exposure or inhalation were identified, occupational studies have shown that OPP is readily absorbed through dermal contact (Bomhard et al., 2002; INRS, 2016; IARC, 1999; European Commission, 2015). Experimental animal studies have demonstrated absorption following oral and inhalation exposures (ANSES, 2014; INRS, 2016). OPP is rapidly distributed throughout the body following absorption (ANSES, 2014; INRS, 2016). Some evidence from human and animal studies suggests that OPP does not accumulate in the body;

this is supported by its short elimination half-life (0.8 hours) (ANSES, 2014; Bomhard et al., 2002; CDC, 2017; European Commission, 2002). In vivo and in vitro studies demonstrate that OPP is metabolized extensively by cytochrome p450. The main metabolic pathways are conjugation of OPP with glucuronide or sulphate (European Commission, 2002). The 2 major metabolites, OPP-glucuronide and OPP-sulfate, are inactive compounds; in vitro studies also demonstrate that multiple metabolic pathways can produce a variety of OPP metabolites, including active compounds such as phenylhydroquinone and phenylbenzoquinone (ANSES, 2014; Brusick, 2005; INRS, 2016). Elimination is rapid and occurs mainly through urine (90%), but also through feces (5%). Experimental animal studies have shown that 99% of OPP is eliminated as metabolites after 48 hours. Urinary levels of OPP reflect recent exposure (CDC, 2017).

Experimental animal studies have reported minimal toxicity following acute oral and inhalation exposure to OPP; however, OPP is a strong skin irritant and moderate eye irritant (Bomhard et al., 2002; CDC, 2017; Stouten, 1998). No human data evaluating chronic toxicity were identified, but animal studies have reported systemic toxicity following chronic oral exposure to OPP or SOPP, including anemia, weight loss, increased weight of several organs, and detrimental kidney effects (ANSES, 2014; CDC, 2017; ECCC and HC, 2020). Long-term exposure via skin contact showed only local toxicity (skin lesions), but no systemic effects (Stouten, 2018). High doses of OPP and SOPP in animal studies have been associated with bladder and kidney tumours; this finding is supported by in vitro studies reporting mutagenic effects (Bomhard et al., 2002; ECCC and HC, 2020; IARC 1999). According to the International Agency for Research on Cancer, OPP is not classifiable as to its carcinogenicity to humans (Group 3) based on inadequate evidence in humans and limited evidence in experimental animals; however, SOPP is possibly carcinogenic to humans (Group 2B) based on inadequate evidence in humans and sufficient evidence in experimental animals (IARC, 1999).

The sale and use of OPP as a pesticide is regulated in Canada by Health Canada's Pest Management Regulatory Agency (PMRA) under the *Pest Control Products Act* (Canada, 2006). The PMRA registration process also recognizes the maximum residue limits (MRLs) for OPP in food, established under the *Food*

and Drugs Act; the act prohibits the sale of foods containing pesticides that exceed the established MRLs. OPP is currently registered in Canada as a post-harvest treatment for pears and as a material preservative in a wide range of products (HC, 2008b). In 2008, the PMRA re-evaluated OPP and determined that these uses do not present unacceptable risks to humans or the environment when used according to product label directions; it granted them continued registration.

The Government of Canada conducted a science-based screening assessment under the Chemicals Management Plan to determine whether SOPP presents or may present a risk to the environment or human health as per the criteria set out in section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; ECCC and HC, 2020). The draft assessment proposed to conclude that SOPP does not

meet any of the criteria for being considered toxic under CEPA 1999 (ECCC and HC, 2020).

Hard-surface disinfectants are regulated as drugs and subject to the requirements of the *Food and Drugs Act* and its regulations. In 2014, Health Canada issued guidelines on labelling and the use of products intended for use as hard-surface disinfectants, including OPP (HC, 2014).

Two metabolites of OPP (*ortho*-phenylphenol-glucuronide and *ortho*-phenylphenol-sulfate) were analyzed in the urine of Canadian Health Measure Survey participants aged 3–79 in cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented as both µg/L and µg/g creatinine. Finding a measurable amount of OPP metabolites in urine can be an indicator of exposure to OPP and does not necessarily mean that an adverse health effect will occur.

Table 13.4.1

ortho-Phenylphenol-glucuronide (OPP-glucuronide)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2620	12.4 (9.3–16.3)	—	<LOD	<LOD	0.18 ^E (<LOD–0.27)	0.38 ^E (0.18–0.58)
6 (2018–2019)	2488	6.9 (5.4–8.8)	—	<LOD	<LOD	<LOD	0.24 ^E (0.15–0.32)
Males, 3–79 years							
5 (2016–2017)	1303	15.9 (11.1–22.3)	—	<LOD	<LOD	0.25 ^E (<LOD–0.36)	0.43 ^E (0.18–0.67)
6 (2018–2019)	1235	7.5 ^E (5.0–11.0)	—	<LOD	<LOD	<LOD	0.24 ^E (0.15–0.34)
Females, 3–79 years							
5 (2016–2017)	1317	8.8 ^E (5.8–13.1)	—	<LOD	<LOD	<LOD	0.29 ^E (<LOD–0.60)
6 (2018–2019)	1253	6.3 (4.4–9.0)	—	<LOD	<LOD	<LOD	0.22 ^E (<LOD–0.34)
3–5 years							
5 (2016–2017)	531	14.3 ^E (8.0–24.3)	—	<LOD	<LOD	0.21 ^E (<LOD–0.50)	0.46 ^E (<LOD–1.3)
6 (2018–2019)	488	15.0 ^E (9.8–23.9)	—	<LOD	<LOD	0.31 ^E (<LOD–0.62)	1.0 ^E (0.19–1.9)
6–11 years							
5 (2016–2017)	521	12.3 ^E (7.4–19.7)	—	<LOD	<LOD	0.18 ^E (<LOD–0.36)	0.44 ^E (0.17–0.71)
6 (2018–2019)	491	10.5 ^E (6.5–16.5)	—	<LOD	<LOD	<LOD	0.38 ^E (<LOD–0.73)
12–19 years							
5 (2016–2017)	507	12.6 (8.8–17.8)	—	<LOD	<LOD	0.22 (0.15–0.28)	0.37 (0.28–0.46)
6 (2018–2019)	500	10.8 ^E (5.7–19.3)	—	<LOD	<LOD	<LOD ^E (<LOD–0.22)	0.23 ^E (<LOD–0.37)
20–39 years							
5 (2016–2017)	361	10.2 ^E (4.6–21.2)	—	<LOD	<LOD	<LOD ^E (<LOD–0.55)	0.63 ^E (<LOD–1.1)
6 (2018–2019)	330	7.2 ^E (4.6–10.9)	—	<LOD	<LOD	<LOD	0.24 ^E (<LOD–0.36)
40–59 years							
5 (2016–2017)	351	17.5 ^E (9.7–29.6)	—	<LOD	<LOD	0.25 ^E (<LOD–0.40)	0.44 ^E (<LOD–0.74)
6 (2018–2019)	339	5.2 ^E (2.0–13.1)	—	<LOD	<LOD	<LOD	<LOD ^E (<LOD–0.40)
60–79 years							
5 (2016–2017)	349	7.6 ^E (4.3–13.0)	—	<LOD	<LOD	<LOD	0.21 ^E (<LOD–0.30)
6 (2018–2019)	340	4.7 ^E (2.0–10.6)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.15 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 13.4.2

ortho-Phenylphenol-glucuronide (OPP-glucuronide) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2599	12.4 (9.3–16.3)	—	<LOD	<LOD	0.29 (<LOD–0.34)	0.39 (0.31–0.47)
6 (2018–2019)	2487	6.9 (5.4–8.8)	—	<LOD	<LOD	<LOD	0.38 (0.34–0.42)
Males, 3–79 years							
5 (2016–2017)	1293	15.9 (11.1–22.3)	—	<LOD	<LOD	0.28 (<LOD–0.34)	0.36 (0.31–0.42)
6 (2018–2019)	1234	7.5 ^E (5.0–11.0)	—	<LOD	<LOD	<LOD	0.32 (0.22–0.43)
Females, 3–79 years							
5 (2016–2017)	1306	8.8 ^E (5.8–13.1)	—	<LOD	<LOD	<LOD	0.42 ^E (<LOD–0.65)
6 (2018–2019)	1253	6.3 (4.4–9.0)	—	<LOD	<LOD	<LOD	0.40 (<LOD–0.46)
3–5 years							
5 (2016–2017)	524	14.3 ^E (8.0–24.3)	—	<LOD	<LOD	0.46 (<LOD–0.58)	0.74 ^E (<LOD–1.6)
6 (2018–2019)	487	15.6 ^E (9.8–23.9)	—	<LOD	<LOD	0.80 ^E (<LOD–1.4)	1.6 ^E (0.63–2.6)
6–11 years							
5 (2016–2017)	516	12.3 ^E (7.4–19.7)	—	<LOD	<LOD	0.27 (<LOD–0.31)	0.43 (0.30–0.56)
6 (2018–2019)	491	10.5 ^E (6.5–16.5)	—	<LOD	<LOD	<LOD	0.66 (<LOD–0.89)
12–19 years							
5 (2016–2017)	503	12.6 (8.8–17.8)	—	<LOD	<LOD	0.23 (0.17–0.29)	0.33 (0.26–0.41)
6 (2018–2019)	500	10.8 ^E (5.7–19.3)	—	<LOD	<LOD	<LOD	0.39 ^E (<LOD–0.67)
20–39 years							
5 (2016–2017)	358	10.2 ^E (4.6–21.2)	—	<LOD	<LOD	<LOD	0.39 ^E (<LOD–0.70)
6 (2018–2019)	330	7.2 ^E (4.6–10.9)	—	<LOD	<LOD	<LOD	0.35 (<LOD–0.46)
40–59 years							
5 (2016–2017)	350	17.5 ^E (9.7–29.6)	—	<LOD	<LOD	0.30 (<LOD–0.40)	0.36 ^E (<LOD–0.64)
6 (2018–2019)	339	5.2 ^E (2.0–13.1)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	348	7.6 ^E (4.3–13.0)	—	<LOD	<LOD	<LOD	0.35 (<LOD–0.41)
6 (2018–2019)	340	4.7 ^E (2.0–10.6)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 13.4.3

ortho-Phenylphenol-sulfate (OPP-sulfate)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2694	99.8 (99.1–100)	1.7 (1.5–2.0)	0.42 (0.31–0.53)	1.6 (1.4–1.8)	7.0 (4.8–9.1)	13 ^E (7.8–18)
6 (2018–2019)	2507	99.5 (98.7–99.8)	1.4 (1.3–1.6)	0.35 (0.28–0.42)	1.4 (1.2–1.6)	5.5 (4.6–6.3)	7.7 (5.8–9.5)
Males, 3–79 years							
5 (2016–2017)	1345	99.7 (98.1–99.9)	2.0 (1.6–2.4)	0.51 ^E (0.31–0.71)	1.7 (1.3–2.1)	8.9 ^E (5.1–13)	14 ^E (8.6–19)
6 (2018–2019)	1243	99.9 (99.7–100)	1.6 (1.4–1.8)	0.41 (0.34–0.49)	1.6 (1.4–1.8)	5.8 (5.1–6.4)	7.7 (5.0–10)
Females, 3–79 years							
5 (2016–2017)	1349	100 (99.8–100)	1.6 (1.3–1.8)	0.39 (0.31–0.47)	1.5 (1.2–1.8)	6.2 (4.3–8.2)	9.6 ^E (0.27–19)
6 (2018–2019)	1264	99.1 (97.4–99.7)	1.3 (1.1–1.4)	0.32 (0.25–0.39)	1.2 (1.0–1.4)	4.7 (3.6–5.7)	7.5 (5.5–9.4)
3–5 years							
5 (2016–2017)	550	100	1.7 (1.3–2.3)	0.48 (0.30–0.65)	1.5 (1.2–1.8)	6.2 ^E (1.0–11)	11 ^E (<LOD–22)
6 (2018–2019)	509	100	1.9 (1.5–2.5)	0.52 (0.41–0.63)	1.6 (1.2–2.1)	8.5 ^E (0.50–17)	23 ^E (6.5–40)
6–11 years							
5 (2016–2017)	535	100	1.7 (1.6–1.9)	0.58 (0.50–0.67)	1.6 (1.3–1.9)	5.5 (4.1–6.8)	9.3 ^E (5.3–13)
6 (2018–2019)	498	97.8 (83.9–99.7)	1.6 (1.3–2.0)	0.56 ^E (0.33–0.79)	1.6 (1.4–1.8)	6.1 ^E (2.8–9.5)	10 (6.6–13)
12–19 years							
5 (2016–2017)	532	99.8 (99.2–100)	1.9 (1.7–2.1)	0.67 (0.52–0.82)	1.7 (1.5–1.9)	5.2 (4.5–6.0)	8.7 (5.7–12)
6 (2018–2019)	502	98.4 (95.0–99.5)	1.6 (1.3–2.0)	0.41 ^E (0.24–0.58)	1.8 (1.4–2.1)	6.3 (5.1–7.6)	9.0 (5.8–12)
20–39 years							
5 (2016–2017)	371	100 (99.7–100)	1.7 (1.2–2.4)	0.39 ^E (<LOD–0.71)	1.6 (1.1–2.2)	6.2 ^E (<LOD–13)	14 ^E (<LOD–29)
6 (2018–2019)	325	99.8 (83.2–100)	1.5 (1.3–1.8)	0.38 (0.27–0.49)	1.6 (1.1–2.1)	5.6 (4.7–6.5)	8.6 (5.6–12)
40–59 years							
5 (2016–2017)	352	99.6 (95.5–100)	2.0 (1.4–2.7)	0.42 ^E (0.23–0.61)	1.7 (1.1–2.2)	9.7 ^E (5.1–14)	15 ^E (7.3–23)
6 (2018–2019)	337	100	1.4 (1.1–1.7)	0.34 (0.25–0.44)	1.3 (0.92–1.7)	4.7 (3.2–6.3)	6.8 ^E (4.3–9.4)
60–79 years							
5 (2016–2017)	354	99.8 (98.4–100)	1.5 (1.3–1.7)	0.36 (0.24–0.47)	1.5 (1.3–1.6)	5.5 ^E (3.2–7.8)	8.7 (6.9–10)
6 (2018–2019)	336	99.5 (93.8–100)	1.1 (0.89–1.4)	0.27 ^E (0.16–0.37)	0.99 (0.76–1.2)	3.9 (2.9–5.0)	6.2 ^E (3.5–8.9)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.092 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 13.4.4

ortho-Phenylphenol-sulfate (OPP-sulfate) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2673	99.8 (99.1–100)	1.7 (1.5–1.9)	0.62 (0.53–0.71)	1.4 (1.2–1.6)	5.4 (4.3–6.5)	8.3 ^E (5.0–12)
6 (2018–2019)	2506	99.5 (98.7–99.8)	1.6 (1.4–1.7)	0.61 (0.56–0.66)	1.4 (1.3–1.5)	4.6 (3.7–5.5)	7.6 ^E (4.1–11)
Males, 3–79 years							
5 (2016–2017)	1335	99.7 (98.1–99.9)	1.7 (1.5–1.9)	0.59 (0.48–0.69)	1.5 (1.3–1.8)	5.4 (4.1–6.7)	7.2 ^E (4.1–10)
6 (2018–2019)	1242	99.9 (99.7–100)	1.5 (1.3–1.7)	0.59 (0.51–0.67)	1.3 (1.1–1.6)	4.0 (3.1–4.9)	5.6 ^E (1.3–9.9)
Females, 3–79 years							
5 (2016–2017)	1338	100 (99.8–100)	1.7 (1.5–1.9)	0.65 (0.53–0.77)	1.4 (1.2–1.5)	5.3 (3.6–6.9)	9.7 ^E (<LOD–21)
6 (2018–2019)	1264	99.1 (97.4–99.7)	1.6 (1.4–1.8)	0.64 (0.58–0.70)	1.4 (1.2–1.6)	5.3 (3.9–6.6)	9.0 ^E (3.9–14)
3–5 years							
5 (2016–2017)	543	100	2.9 (2.4–3.6)	1.1 (0.77–1.4)	2.4 (1.9–2.9)	9.5 (7.2–12)	13 ^E (<LOD–33)
6 (2018–2019)	508	100	3.1 (2.5–3.9)	1.0 (0.74–1.3)	2.3 (1.9–2.7)	16 ^E (4.4–28)	30 ^E (11–48)
6–11 years							
5 (2016–2017)	530	100	2.0 (1.8–2.2)	0.85 (0.76–0.95)	1.8 (1.5–2.0)	5.3 (3.7–6.9)	7.5 (5.2–9.9)
6 (2018–2019)	498	97.8 (83.9–99.7)	1.9 (1.7–2.2)	0.76 (0.56–0.95)	1.6 (1.3–1.9)	7.5 ^E (4.5–10)	10 ^E (5.9–15)
12–19 years							
5 (2016–2017)	528	99.8 (99.2–100)	1.4 (1.2–1.6)	0.56 (0.45–0.68)	1.3 (1.1–1.5)	3.9 (2.8–5.1)	5.8 (4.8–6.7)
6 (2018–2019)	502	98.4 (95.0–99.5)	1.4 (1.2–1.5)	0.59 (0.49–0.68)	1.2 (1.1–1.3)	3.6 (2.5–4.8)	5.4 ^E (3.3–7.5)
20–39 years							
5 (2016–2017)	368	100 (99.7–100)	1.5 (1.2–1.9)	0.63 (<LOD–0.79)	1.3 (1.0–1.6)	3.4 ^E (<LOD–6.0)	10 ^E (<LOD–19)
6 (2018–2019)	325	99.8 (83.2–100)	1.5 (1.3–1.8)	0.64 (0.53–0.75)	1.3 (1.1–1.5)	5.1 ^E (2.7–7.4)	7.8 ^E (3.6–12)
40–59 years							
5 (2016–2017)	351	99.6 (95.5–100)	1.8 (1.4–2.3)	0.60 (0.46–0.75)	1.4 (1.0–1.7)	5.9 (4.0–7.8)	7.3 ^E (<LOD–16)
6 (2018–2019)	337	100	1.7 (1.4–1.9)	0.64 (0.50–0.77)	1.5 (1.2–1.8)	4.5 ^E (2.3–6.8)	7.7 ^E (<LOD–16)
60–79 years							
5 (2016–2017)	353	99.8 (98.4–100)	1.7 (1.5–2.0)	0.58 (0.48–0.69)	1.4 (1.2–1.7)	5.8 (4.5–7.1)	8.5 ^E (5.2–12)
6 (2018–2019)	336	99.5 (93.8–100)	1.3 (1.1–1.5)	0.50 (0.40–0.61)	1.2 (0.92–1.4)	3.2 (2.1–4.4)	5.1 (3.4–6.8)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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SUMMARIES AND RESULTS FOR PLASTICIZERS

14

14.1 PHTHALATES

Diesters of phthalic acid, commonly called phthalates, are a class of high-production volume industrial chemicals that are used in the manufacture of a variety

of products available to consumers and industrial products. Table 14.1.1 lists phthalates commonly found in commerce and their major metabolites measured in the Canadian Health Measures Survey (CHMS).

Table 14.1.1

Phthalate metabolites measured in the Canadian Health Measures Survey and their parent phthalate compounds

Phthalate	CASRN	Metabolite	CASRN
Dimethyl phthalate (DMP)	131-11-3	Monomethyl phthalate (MMP)	4376-18-5
Diethyl-phthalate (DEP)	84-66-2	Monoethyl phthalate (MEP)	2306-33-4
Di- <i>n</i> -butyl phthalate (<i>Dn</i> BP)	84-74-2	Mono- <i>n</i> -butyl phthalate (<i>Mn</i> BP)	131-70-4
		Mono-3-hydroxy- <i>n</i> -butyl phthalate (3OH-MBP)	—
Diisobutyl phthalate (DiBP)	84-69-5	Monoisobutyl phthalate (MiBP)	30833-53-5
Dicyclohexyl phthalate (DCHP)	84-61-7	Monocyclohexyl phthalate (MCHP)	7517-36-4
Benzyl butyl phthalate (BBP)	85-68-7	Monobenzyl phthalate (MBzP) (some <i>Mn</i> BP)	2528-16-7
Di-2-ethylhexyl phthalate (DEHP)	117-81-7	Mono[2-(carboxymethyl)hexyl] phthalate (MCMHP)	82975-93-7
		Mono(2-ethylhexyl) phthalate (MEHP)	4376-20-9
		Mono(2-ethyl-5-carboxypentyl) phthalate (MECPP)	40809-41-4
		Mono(2-ethyl-5-oxohexyl) phthalate (MEOHP)	40321-98-0
		Mono(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP)	40321-99-1

Phthalate	CASRN	Metabolite	CASRN
Di- <i>n</i> -octyl phthalate (DOP)	117-84-0	Mono(3-carboxypropyl) phthalate (MCP)	66851-46-5
		Mono-carboxy- <i>n</i> -heptyl phthalate (MCHpP)	—
		Mono- <i>n</i> -octyl phthalate (MOP)	5393-19-1
Diisononyl phthalate (DINP)	28553-12-0, 68515-48-0	Mono(carboxyisooctyl) phthalate (MCiOP)	898544-09-7
		Monoisonyl phthalate (MiNP)	519056-28-1
		Monooxoisonyl phthalate (MOiNP)	—
		Monohydroxyisonyl phthalate (MHiNP)	—
Di-isodecyl phthalate (DIDP)	26761-40-0	Monocarboxyisononyl phthalate (MCiNP)	—
		Monohydroxyisodecyl phthalate (MHiDP)	—
		Monoisodecyl phthalate (MiDP)	—
		Monooxisodecyl phthalate (MOiDP)	—

Phthalates are primarily used as plasticizers to impart flexibility and resilience to plastics (Frederiksen et al., 2007; Graham, 1973; HC, 2020). They are also used as solvents in household products, including self-care products, construction and renovation products, and textiles (HC, 2020). In particular, BBP, D*n*BP, DMP and DEP are found in self-care products such as cosmetics (e.g., hair-care products and fragrance) and non-prescription drugs (Cosmetic Ingredient Review Expert Panel, 2005; ECCC and HC, 2020; EC and HC, 2000; 2015e). DINP, DiBP, DCHP, D*n*BP, BBP and DEHP are used in construction and renovation products, such as lubricants and greases, adhesives and sealants, paints and coatings, and building materials (ECCC and HC, 2020; EC and HC, 2000; 2015b; 2015d; HC, 2020). DOP, BBP, DMP, D*n*BP, DIDP, DiBP and DINP are used in electrical items and electronics (ECCC and HC, 2020; EC and HC, 2015b; 2015c; 2015d; 2015e; HC, 2020). Phthalates are also used in the automotive sector (e.g., BBP, DEHP, DiBP and DCHP), in printing ink (e.g., DINP and BBP), and in the formulation of pesticides (e.g., BBP) (ECCC and HC, 2020; EC and HC, 2015d; HC, 2020). Finally, certain phthalates, including BBP, DEHP, DIDP and DMP, can be found in food-packaging materials (ECCC and HC, 2020; EC and HC, 2015c; 2015e; HC, 2020). Prior to restrictions enacted in 2010 (see below), phthalates, namely BBP, D*n*BP, DINP and DEHP, were used in Canada as plasticizers in soft vinyl toys and childcare articles.

There are no known natural sources of phthalates. Releases to the environment are associated with

anthropogenic activities (ECCC and HC, 2020). Releases may occur during the manufacture, processing, transportation and storage of phthalates as well as during the production, use and disposal of products that contain phthalates (ECCC and HC, 2020). Although release into air may occur, water is expected to be the primary receiving medium for phthalates through wastewater effluents from industrial sources and disperse releases from products available to consumers (ECCC and HC, 2020; EC and HC, 2015d).

Phthalates have been detected in food, water, air, soil and dust (Clark, 2003; ECCC and HC, 2020). The general population can be exposed through the inhalation of indoor air; through the ingestion of water, food, beverages, soil and dust; and through the use of products available to consumers (HC, 2020). Other potential sources of exposure are breast milk and the mouthing of children's toys and articles (ECCC and HC, 2020).

In laboratory animals, phthalates have been observed to undergo rapid absorption following oral exposure and generally slow absorption following dermal exposure (ATSDR, 1995; 1997; 2001). Phthalate diesters are converted to their corresponding monoesters in the gastrointestinal tract or saliva prior to absorption (ATSDR, 1995; 1997; 2001; NRC, 2008). Phthalates are rapidly metabolized in the body to form hydrolytic and oxidative monoesters, which can either be excreted in the urine and feces unchanged or can undergo phase II biotransformation to produce glucuronide conjugates with increased water solubility and, as a

result, increased urinary excretion (Hauser and Calafat, 2005; Samandar et al., 2009). Although the metabolism and excretion of monoester phthalates varies based on a number of factors, they are generally characterized by rapid metabolism and short biological half-lives (ATSDR, 1995; 1997; 2001; Hauser and Calafat, 2005). Phthalates do not bioaccumulate in humans (CDC, 2009). Measurement of phthalate metabolites in urine has become the most common approach to assessing phthalate exposure in humans, and reflects relatively recent exposure (Blount et al., 2000; Calafat and McKee, 2006).

In laboratory animals, exposure to some phthalates adversely affects the male reproductive system. In particular, prenatal exposure to phthalates, such as DBP, BBP, DEHP, DCHP and DINP, has been shown to disrupt the androgen-mediated development of the male reproductive tract (David, 2006; EC and HC, 2015b; 2015d; Foster, 2005; Gray et al., 2000; Howdeshell et al., 2007; Main et al., 2006; Mariana et al., 2016; Wine et al., 1997). This response, termed “rat phthalate syndrome,” is characterized by malformations of the epididymis, vas deferens, seminal vesicles, prostate and external genitalia, among other effects (Lioy et al., 2015). Adverse effects on the testes have also been observed in mature laboratory animals, although these effects occurred at higher doses (David, 2006; Foster, 2005). There is also evidence from animal studies that phthalates exert adverse effects on the ovaries (EC and HC, 2015b; Hannon and Flaws, 2015; Mariana et al., 2016). Other target organs identified in animal studies include the liver and kidneys, where phthalate exposure may lead to increased organ weights and peroxisome proliferation in the liver (David and Gans, 2003; EC and HC, 2015b; 2015c; 2015d; 2015e; Howdeshell et al., 2007; Main et al., 2006; Wine et al., 1997).

Numerous studies demonstrate exposure to phthalates in the human population, including prenatal exposure (Becker et al., 2009; Blount et al., 2000; HC, 2018a; 2018b; Lioy et al., 2015; Marsee et al., 2006; NTP-CERHR, 2003a; 2003b; 2003c; 2003d; 2003e; 2003f; 2006; Praveena et al., 2018; Silva et al., 2003; Wittassek et al., 2011). An evaluation by Health Canada of 134 epidemiologic studies of phthalates and health outcomes in categories including hormonal effects, growth and development, and reproductive parameters (HC, 2018a)—as well as a Health Canada evaluation of 125 epidemiologic studies of phthalates and health outcomes in categories including behaviour and neurodevelopment, cardiovascular function, oxidative

stress, breast cancer, obesity, allergy (inflammation of the airways and skin) and metabolic disorders (HC, 2018b)—determined that no health outcome had sufficient evidence of an association with any assessed phthalate or its metabolite (HC, 2018a; 2018b). The International Agency for Research on Cancer has classified DEHP as possibly carcinogenic to humans (Group 2B) and has determined that BBP’s carcinogenicity to humans is not classifiable (Group 3) (IARC, 1999; 2013).

Environment Canada and Health Canada assessed 4 phthalates (DBP, BBP, DEHP and DOP) on an individual basis as part of the First and Second Priority Substances Lists (PSL1 and PSL2) (EC and HC, 1993; 1994a; 1994b; 2000). DBP and BBP were determined not to present a risk to the environment or to human health. DOP was found not to present a risk to the environment; however, at the time of the assessment, the available information was not sufficient to allow a conclusion in terms of human health. A subsequent report concluded that DOP did not pose a risk to human health (EC and HC, 2003). DEHP was determined to present a risk to human health in Canada; however, there was insufficient information to conclude on the potential for risk to the environment at the time of the assessment. State of the Science reports were published in 2015 for the short-chain phthalate DMP, medium-chain phthalates (including DCHP and DiBP), long-chain phthalates (including DIDP) and DINP (EC and HC, 2015b; 2015c; 2015d; 2015e). A screening assessment concluded that the 14 substances in the Phthalate Substance Grouping (including DMP, DiBP, DINP and DIDP) are not harmful to the environment or to human health as set out in section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999), but that DEHP, previously assessed under the Priority Substances Assessment Program, is harmful to the environment as set out in section 64(a) of CEPA 1999 (Canada, 1999; ECCC and HC, 2020). In addition, a cumulative risk assessment using a conservative, lower-tiered hazard index approach indicated no concern for potential cumulative risk of medium-chain phthalates for the general Canadian population, specifically the more sensitive subpopulations (pregnant women, women of child-bearing age, infants and children) at current exposure levels (EC and HC, 2015a; ECCC and HC, 2020).

Health Canada has developed and implemented the Phthalates Regulations under the *Canada Consumer Product Safety Act* concerning the use of 6 phthalates

(DEHP, D n BP, BBP, DINP, DIDP and DOP) in soft vinyl children's toys and childcare articles (Canada, 2010). Phthalates used in children's toys and childcare articles are also regulated in the United States and the European Union. DEHP is on the List of Ingredients that are Prohibited for Use in Cosmetic Products (HC, 2019).

Phthalate metabolite concentrations in urine have been measured in a number of biomonitoring studies conducted in Canada, including the Maternal–Infant Research on Environmental Chemicals study (Arbuckle et al., 2014), the First Nations Biomonitoring Initiative (AFN, 2013), and the Canadian Healthy Infant Longitudinal Development (CHILD) study (Navaranjan et al., 2020).

Eleven phthalate metabolites (*Mn*BP, MEP, MBzP, MCHP, MEHP, MOP, MiNP, MMP, MCP, MEHHP and MEOHP) were measured in the urine of CHMS participants aged 6–49 in cycle 1 (2007–2009) and aged 3–79 in cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019). MiBP was measured in the urine of CHMS participants aged 3–79 in cycles 2, 5 and 6. MCMHP, MECPP, MCiNP, MHiDP, MiDP, MOiDP, MCiOP, MHiNP, MOiNP, 3OH-MBP and MCHpP were measured in the urine of CHMS participants aged 3–79 in cycles 5 and 6. Data from these cycles are presented as both $\mu\text{g/L}$ and $\mu\text{g/g}$ creatinine (Tables 14.1.2 to 14.1.47). Finding a measurable amount of phthalate metabolites in urine is an indicator of exposure to parent phthalates and does not necessarily mean that an adverse health effect will occur.

Table 14.1.2

Monomethyl phthalate (MMP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2559	27.8 (24.8–31.1)	—	<LOD	<LOD	8.4 (7.9–8.8)	15 ^F (6.4–23)
5 (2016–2017)	2677	95.9 (93.0–97.6)	2.0 (1.8–2.3)	0.56 (0.38–0.74)	2.2 (1.8–2.5)	6.8 (5.4–8.1)	9.9 (7.6–12)
6 (2018–2019)	2462	93.2 (90.6–95.2)	1.7 (1.5–1.8)	0.36 (0.26–0.47)	1.9 (1.7–2.1)	6.3 (5.6–7.1)	9.2 (7.6–11)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1280	35.3 (29.7–41.4)	—	<LOD	<LOD	8.7 (6.0–11)	17 ^F (<LOD–33)
5 (2016–2017)	1335	96.2 (91.1–98.5)	2.1 (1.8–2.5)	0.64 ^E (0.32–0.95)	2.2 (1.7–2.7)	7.1 (5.2–8.9)	9.9 (7.5–12)
6 (2018–2019)	1215	92.9 (88.2–95.8)	1.9 (1.7–2.1)	0.37 ^E (<LOD–0.53)	2.1 (1.7–2.5)	6.5 (5.5–7.5)	10 ^F (5.8–14)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1279	20.4 (17.3–23.8)	—	<LOD	<LOD	7.6 (6.2–9.0)	9.9 ^F (<LOD–22)
5 (2016–2017)	1342	95.6 (92.1–97.6)	1.9 (1.7–2.2)	0.53 (0.34–0.73)	2.1 (1.7–2.5)	6.2 (4.4–8.0)	9.9 ^F (5.3–15)
6 (2018–2019)	1247	93.6 (88.9–96.4)	1.5 (1.3–1.7)	0.34 ^E (<LOD–0.51)	1.7 (1.3–2.1)	6.2 (4.8–7.7)	8.3 (6.4–10)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	523	58.4 (51.9–64.7)	—	<LOD	<LOD (<LOD–5.9)	20 ^F (11–28)	29 ^F (6.9–52)
5 (2016–2017)	549	100 (99.9–100)	3.6 (3.1–4.1)	1.1 ^F (0.66–1.6)	3.7 (3.2–4.2)	10 (9.1–11)	13 (9.9–16)
6 (2018–2019)	501	99.3 (95.7–99.9)	3.8 (3.2–4.5)	1.2 (0.94–1.5)	3.8 (2.7–4.8)	10 (7.6–12)	14 ^F (4.0–25)
6–11 years							
1 (2007–2009)	1037	34.0 (26.7–42.2)	—	<LOD	<LOD	14 ^F (5.2–22)	25 ^F (15–34)
2 (2009–2011)	515	64.1 (54.9–72.3)	—	<LOD	<LOD (<LOD–6.5)	23 (17–29)	34 ^F (19–49)
5 (2016–2017)	533	99.7 (99.0–99.9)	3.7 (3.3–4.3)	1.1 (0.86–1.4)	3.7 (3.1–4.4)	12 (9.2–15)	16 (13–19)
6 (2018–2019)	491	99.6 (98.8–99.9)	3.4 (2.9–3.9)	0.97 ^E (0.61–1.3)	3.3 (2.5–4.0)	11 (7.8–14)	18 (15–20)
12–19 years							
1 (2007–2009)	991	32.5 (25.4–40.5)	—	<LOD	<LOD	9.3 (8.7–9.9)	11 (6.8–14)
2 (2009–2011)	512	46.0 (38.4–53.8)	—	<LOD	<LOD	8.6 (7.6–9.7)	17 ^F (9.1–25)
5 (2016–2017)	533	99.3 (97.4–99.8)	3.1 (2.8–3.6)	0.85 (0.61–1.1)	3.1 (2.8–3.4)	9.0 (7.1–11)	13 ^F (4.4–22)
6 (2018–2019)	490	98.7 (93.5–99.8)	2.7 (2.1–3.4)	0.72 ^E (0.35–1.1)	2.9 (2.2–3.7)	8.0 (6.1–9.8)	11 ^F (6.0–16)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	730	17.0 ^E (10.8–25.7)	—	<LOD	<LOD	6.9 ^E (<LOD–9.4)	9.4 (8.1–11)
2 (2009–2011)	359	26.4 (20.3–33.4)	—	<LOD	<LOD	7.7 (6.2–9.1)	8.9 ^E (<LOD–17)
5 (2016–2017)	370	97.1 (93.7–98.7)	2.1 (1.7–2.7)	0.54 ^E (<LOD–0.94)	2.3 (1.7–2.9)	6.5 ^E (4.1–9.0)	9.9 ^E (6.1–14)
6 (2018–2019)	325	93.0 (85.8–96.7)	1.8 (1.5–2.2)	0.49 ^E (<LOD–0.89)	2.1 (1.8–2.5)	6.2 (4.6–7.8)	7.4 (6.0–8.8)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	360	17.7 (12.4–24.6)	—	<LOD	<LOD	8.1 ^E (<LOD–13)	9.0 ^E (<LOD–51)
5 (2016–2017)	350	94.2 (85.9–97.7)	1.6 (1.3–2.1)	0.45 ^E (<LOD–0.78)	1.7 (1.3–2.2)	4.8 (3.3–6.3)	7.1 ^E (2.8–11)
6 (2018–2019)	330	90.4 (80.8–95.5)	1.3 (1.0–1.6)	0.24 ^E (<LOD–0.45)	1.6 ^E (0.98–2.2)	5.1 (3.4–6.8)	8.2 ^E (5.0–11)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	290	17.8 (13.6–23.0)	—	<LOD	<LOD	6.8 (5.3–8.3)	8.5 (7.5–9.4)
5 (2016–2017)	342	93.1 (89.4–95.6)	1.5 (1.4–1.7)	0.50 ^E (0.31–0.69)	1.5 (1.2–1.7)	4.9 (3.6–6.1)	7.8 ^E (4.1–12)
6 (2018–2019)	325	91.8 (85.4–95.5)	1.2 (0.99–1.5)	0.26 ^E (<LOD–0.42)	1.1 (0.84–1.4)	4.2 ^E (2.6–5.7)	7.2 ^E (2.4–12)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 5, 5, 0.21 and 0.21 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
 b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.
 E Use data with caution.

Table 14.1.3

Monomethyl phthalate (MMP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2549	27.8 (24.8–31.1)	—	<LOD	<LOD	10 (9.6–10)	19 (17–22)
5 (2016–2017)	2645	95.9 (93.0–97.6)	2.0 (1.8–2.1)	0.66 (0.54–0.78)	1.9 (1.7–2.0)	6.2 (5.5–7.0)	9.1 (7.6–11)
6 (2018–2019)	2461	93.2 (90.6–95.2)	1.8 (1.6–1.9)	0.56 (0.48–0.64)	1.7 (1.5–2.0)	6.0 (4.9–7.2)	8.8 (7.4–10)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1276	35.3 (29.7–41.4)	—	<LOD	<LOD	9.7 (7.6–12)	19 ^F (<LOD–28)
5 (2016–2017)	1320	96.2 (91.1–98.5)	1.8 (1.6–2.2)	0.65 ^E (0.37–0.94)	1.7 (1.5–1.9)	5.6 (4.0–7.1)	9.5 ^E (5.9–13)
6 (2018–2019)	1214	92.9 (88.2–95.8)	1.7 (1.6–1.8)	0.52 (<LOD–0.65)	1.6 (1.5–1.7)	5.0 (3.7–6.3)	8.4 ^E (4.3–12)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1273	20.4 (17.3–23.8)	—	<LOD	<LOD	10 (8.4–12)	19 (<LOD–22)
5 (2016–2017)	1325	95.6 (92.1–97.6)	2.1 (1.9–2.3)	0.68 ^E (0.43–0.93)	2.0 (1.8–2.2)	6.8 (5.8–7.9)	8.8 (7.4–10)
6 (2018–2019)	1247	93.6 (88.9–96.4)	1.9 (1.6–2.3)	0.58 (<LOD–0.75)	1.8 (1.4–2.3)	6.3 (4.8–7.7)	8.7 (6.4–11)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	58.4 (51.9–64.7)	—	<LOD	<LOD	30 (23–37)	49 ^F (21–77)
5 (2016–2017)	538	100 (99.9–100)	6.2 (5.8–6.6)	2.5 (2.1–3.0)	6.1 (5.6–6.5)	14 (11–17)	22 ^E (14–30)
6 (2018–2019)	500	99.3 (95.7–99.9)	6.2 (5.3–7.3)	2.3 (1.5–3.1)	6.0 (5.2–6.8)	15 ^F (8.0–22)	22 ^E (11–32)
6–11 years							
1 (2007–2009)	1034	34.0 (26.7–42.2)	—	<LOD	<LOD	23 (16–30)	38 (25–50)
2 (2009–2011)	513	64.1 (54.9–72.3)	—	<LOD	<LOD	26 ^F (16–36)	32 ^E (13–51)
5 (2016–2017)	525	99.7 (99.0–99.9)	4.3 (3.9–4.8)	1.9 (1.6–2.1)	3.8 (3.2–4.4)	11 (8.4–13)	18 (12–24)
6 (2018–2019)	491	99.6 (98.8–99.9)	4.0 (3.7–4.4)	1.6 (1.4–1.7)	3.6 (3.4–3.8)	12 (9.1–15)	16 (12–20)
12–19 years							
1 (2007–2009)	989	32.5 (25.4–40.5)	—	<LOD	<LOD	9.2 (8.8–9.7)	10 ^F (5.7–14)
2 (2009–2011)	510	46.0 (38.4–53.8)	—	<LOD	<LOD	9.0 (7.0–11)	12 (9.0–15)
5 (2016–2017)	526	99.3 (97.4–99.8)	2.4 (2.2–2.6)	1.0 (0.88–1.1)	2.2 (1.9–2.5)	6.1 (4.9–7.4)	8.2 ^F (4.1–12)
6 (2018–2019)	490	98.7 (93.5–99.8)	2.2 (1.8–2.7)	0.87 (0.71–1.0)	2.0 (1.7–2.4)	5.3 (3.8–6.8)	7.0 ^F (3.3–11)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	728	17.0 ^E (10.8–25.7)	—	<LOD	<LOD	9.1 (<LOD–9.8)	19 ^E (8.6–29)
2 (2009–2011)	357	26.4 (20.3–33.4)	—	<LOD	<LOD	7.4 ^E (4.4–10)	9.9 ^E (<LOD–25)
5 (2016–2017)	366	97.1 (93.7–98.7)	1.9 (1.6–2.3)	0.77 ^E (<LOD–1.1)	1.8 (1.6–2.1)	5.7 (3.7–7.8)	8.3 ^E (4.8–12)
6 (2018–2019)	325	93.0 (85.8–96.7)	1.7 (1.4–2.0)	0.74 ^E (<LOD–1.0)	1.6 (1.3–1.9)	6.0 ^E (3.5–8.5)	8.5 ^E (4.9–12)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	358	17.7 (12.4–24.6)	—	<LOD	<LOD	9.6 (<LOD–13)	18 ^E (<LOD–31)
5 (2016–2017)	349	94.2 (85.9–97.7)	1.5 (1.2–1.8)	0.46 (<LOD–0.60)	1.5 (1.2–1.8)	3.9 (2.7–5.2)	7.0 ^E (4.0–10)
6 (2018–2019)	330	90.4 (80.8–95.5)	1.5 (1.2–1.8)	0.46 (<LOD–0.62)	1.5 (1.1–2.0)	4.1 (2.9–5.3)	6.2 (4.5–7.8)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	289	17.8 (13.6–23.0)	—	<LOD	<LOD	9.6 (6.6–13)	18 ^E (8.6–28)
5 (2016–2017)	341	93.1 (89.4–95.6)	1.7 (1.5–1.9)	0.64 (0.49–0.80)	1.7 (1.5–2.0)	5.5 (4.9–6.1)	7.5 (5.8–9.1)
6 (2018–2019)	325	91.8 (85.4–95.5)	1.4 (1.2–1.7)	0.47 ^E (<LOD–0.69)	1.4 (1.2–1.5)	4.0 (3.0–4.9)	6.8 ^E (<LOD–15)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.4

Monoethyl phthalate (MEP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2561	100	44 (36–54)	7.6 (6.0–9.2)	42 (35–50)	250 ^E (150–340)	470 ^E (<LOD–960)
5 (2016–2017)	2712	99.2 (95.9–99.8)	22 (19–25)	3.8 (2.9–4.7)	19 (16–22)	150 (98–210)	280 ^E (100–450)
6 (2018–2019)	2526	99.4 (97.8–99.8)	17 (15–20)	3.1 (2.3–4.0)	16 (12–19)	98 (70–130)	180 (130–230)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1282	100	45 (35–59)	8.8 (7.3–10)	38 (25–50)	270 ^E (130–400)	510 ^E (<LOD–1100)
5 (2016–2017)	1350	99.5 (98.6–99.9)	21 (17–26)	3.7 ^E (2.1–5.3)	19 (15–22)	110 ^E (40–190)	240 ^E (100–370)
6 (2018–2019)	1253	99.0 (95.8–99.8)	16 (13–20)	3.3 (2.3–4.3)	14 (10–18)	73 ^E (41–110)	140 ^E (<LOD–550)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1279	100	43 (36–53)	6.9 (5.0–8.7)	45 (35–54)	230 ^E (98–350)	420 ^E (<LOD–900)
5 (2016–2017)	1362	98.8 (92.5–99.8)	23 (19–27)	3.9 (3.0–4.9)	19 (15–24)	180 ^E (120–250)	350 ^E (<LOD–700)
6 (2018–2019)	1273	99.7 (98.9–99.9)	18 (15–22)	2.9 (2.0–3.9)	17 (12–22)	120 ^E (66–160)	190 (140–240)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	523	100	21 (18–24)	6.8 (5.4–8.2)	19 (16–23)	80 (58–100)	120 (92–140)
5 (2016–2017)	553	100	13 (10–17)	3.5 ^E (2.1–4.9)	12 (11–13)	50 (37–63)	85 ^E (8.9–160)
6 (2018–2019)	509	99.7 (99.0–99.9)	12 (9.6–15)	3.5 (2.8–4.1)	11 (8.7–13)	32 ^E (<LOD–67)	67 ^E (39–94)
6–11 years							
1 (2007–2009)	1037	100 (96.5–100)	26 (21–32)	6.3 (4.5–8.0)	23 (19–28)	120 (80–160)	200 ^E (120–290)
2 (2009–2011)	516	100	29 (23–37)	6.6 (4.4–8.8)	25 ^E (14–36)	120 ^E (60–180)	240 ^E (110–380)
5 (2016–2017)	536	99.5 (98.8–99.8)	18 (14–23)	4.0 (3.2–4.8)	15 (13–18)	110 ^E (34–190)	240 ^E (<LOD–520)
6 (2018–2019)	498	99.9 (99.5–100)	16 (13–20)	4.5 (3.6–5.5)	14 (11–17)	71 ^E (26–120)	130 (83–170)
12–19 years							
1 (2007–2009)	991	100	65 (55–77)	14 (9.7–18)	60 (47–73)	340 (300–390)	550 ^E (320–780)
2 (2009–2011)	512	100	51 (43–61)	10 (7.1–14)	47 (38–57)	230 (150–310)	490 ^E (270–710)
5 (2016–2017)	537	99.0 (95.3–99.8)	25 (19–32)	5.4 (4.0–6.8)	21 (15–28)	130 ^E (61–200)	320 ^E (59–580)
6 (2018–2019)	504	100 (97.0–100)	20 (14–27)	3.8 ^E (2.2–5.5)	20 ^E (13–28)	89 ^E (41–140)	180 ^E (84–270)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	730	100	62 (51–75)	11 (7.3–14)	51 (35–68)	440 ^E (130–740)	920 ^E (<LOD–1900)
2 (2009–2011)	359	100	48 ^E (31–73)	7.6 (4.8–10)	45 ^E (25–65)	320 ^E (120–520)	520 ^E (<LOD–1300)
5 (2016–2017)	374	97.9 (83.7–99.8)	20 ^E (13–32)	3.1 ^E (<LOD–6.1)	17 ^E (11–24)	190 ^E (77–300)	250 ^E (<LOD–500)
6 (2018–2019)	332	98.3 (93.8–99.6)	17 (13–22)	2.5 ^E (1.2–3.8)	17 (11–23)	88 ^E (51–120)	180 ^E (59–310)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	360	100	44 ^E (29–69)	6.9 ^E (3.1–11)	43 ^E (27–60)	240 ^E (<LOD–690)	330 ^E (<LOD–1400)
5 (2016–2017)	359	99.9 (99.4–100)	23 ^E (15–33)	3.6 ^E (2.1–5.0)	20 (15–26)	160 ^E (23–300)	290 ^E (<LOD–640)
6 (2018–2019)	341	100	18 (14–22)	3.2 (2.2–4.3)	13 ^E (8.0–18)	160 ^E (76–250)	250 ^E (<LOD–960)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	291	100	49 (38–62)	9.1 (6.8–11)	44 (33–56)	240 ^E (82–390)	920 ^E (110–1700)
5 (2016–2017)	353	99.8 (98.7–100)	25 (20–31)	5.6 (3.9–7.3)	20 (14–26)	110 ^E (31–180)	270 ^E (<LOD–580)
6 (2018–2019)	342	99.5 (93.9–100)	17 (13–22)	3.4 ^E (2.0–4.8)	16 (12–21)	78 (52–100)	120 (100–140)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.5, 0.3, 0.98 and 0.76 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.
E Use data with caution.

Table 14.1.5

Monoethyl phthalate (MEP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2551	100	44 (38–52)	10 (8.5–12)	37 (30–44)	220 ^E (120–320)	410 ^E (<LOD–620)
5 (2016–2017)	2680	99.2 (95.9–99.8)	21 (19–23)	5.3 (4.6–6.0)	16 (14–18)	110 (88–140)	200 (140–270)
6 (2018–2019)	2525	99.4 (97.8–99.8)	18 (16–22)	4.8 (4.0–5.7)	15 (13–18)	86 (65–110)	140 ^E (66–210)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1278	100	39 (31–49)	9.4 (8.0–11)	30 (23–38)	220 ^E (110–330)	390 ^E (<LOD–600)
5 (2016–2017)	1335	99.5 (98.6–99.9)	18 (15–21)	4.9 (3.8–6.0)	14 (12–16)	86 ^E (45–130)	140 ^E (67–220)
6 (2018–2019)	1252	99.0 (95.8–99.8)	15 (12–18)	4.3 (3.5–5.1)	12 (8.9–15)	53 ^E (27–78)	120 ^E (<LOD–360)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1273	100	50 (41–60)	14 (11–17)	43 (38–49)	230 ^E (43–410)	410 ^E (<LOD–950)
5 (2016–2017)	1345	98.8 (92.5–99.8)	25 (22–29)	5.6 (4.8–6.4)	20 (17–24)	130 ^E (79–170)	230 ^E (<LOD–320)
6 (2018–2019)	1273	99.7 (98.9–99.9)	23 (19–28)	5.8 (4.8–6.9)	20 (15–24)	110 (79–140)	170 ^E (61–270)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	100	36 (32–41)	14 (12–16)	30 (25–35)	110 (82–140)	180 (120–230)
5 (2016–2017)	542	100	23 (19–28)	7.6 (5.7–9.6)	18 (13–22)	72 ^E (28–120)	170 (110–230)
6 (2018–2019)	508	99.7 (99.0–99.9)	19 (16–24)	8.4 (6.3–10)	16 (13–19)	47 ^E (<LOD–78)	77 ^E (11–140)
6–11 years							
1 (2007–2009)	1034	100 (96.5–100)	40 (33–48)	14 (12–17)	33 (27–38)	130 ^E (80–190)	210 ^E (97–320)
2 (2009–2011)	514	100	34 (27–42)	10 (8.2–12)	27 (20–35)	130 ^E (60–200)	230 ^E (130–330)
5 (2016–2017)	528	99.5 (98.8–99.8)	21 (17–27)	6.9 (6.2–7.6)	15 (12–18)	93 ^E (<LOD–220)	310 ^E (<LOD–570)
6 (2018–2019)	498	99.9 (99.5–100)	19 (14–25)	6.7 (5.5–7.8)	14 (11–17)	88 ^E (46–130)	120 ^E (64–180)
12–19 years							
1 (2007–2009)	989	100	55 (49–62)	14 (13–16)	49 (41–57)	250 (200–300)	420 (350–480)
2 (2009–2011)	510	100	39 (34–45)	10 (8.7–12)	33 (26–39)	160 ^E (100–220)	300 ^E (190–410)
5 (2016–2017)	530	99.0 (95.3–99.8)	19 (15–23)	6.1 (5.2–7.0)	13 (11–16)	85 ^E (38–130)	180 ^E (<LOD–390)
6 (2018–2019)	504	100 (97.0–100)	16 (13–21)	4.9 (4.2–5.6)	13 (9.2–17)	87 ^E (45–130)	120 ^E (54–200)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	728	100	65 (55–75)	14 (13–16)	54 (45–64)	340 ^E (190–490)	840 ^E (<LOD–1600)
2 (2009–2011)	357	100	42 (30–59)	9.9 (7.2–13)	34 ^E (16–52)	210 ^E (12–410)	370 ^E (<LOD–770)
5 (2016–2017)	370	97.9 (83.7–99.8)	18 (14–24)	3.8 ^E (<LOD–5.4)	15 (11–19)	100 ^E (58–140)	150 ^E (<LOD–240)
6 (2018–2019)	332	98.3 (93.8–99.6)	16 (13–20)	4.0 (3.1–5.0)	12 ^E (6.6–17)	75 (48–100)	140 ^E (<LOD–310)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	358	100	45 (32–64)	9.7 ^E (5.4–14)	39 (27–50)	280 ^E (<LOD–540)	410 ^E (<LOD–990)
5 (2016–2017)	358	99.9 (99.4–100)	21 (16–27)	5.4 (4.3–6.4)	15 (10–20)	120 ^E (62–190)	200 ^E (<LOD–340)
6 (2018–2019)	341	100	21 (17–26)	5.0 (3.7–6.3)	16 (12–20)	110 ^E (65–150)	250 ^E (<LOD–710)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	290	100	57 (47–70)	14 (9.7–18)	47 (33–62)	280 ^E (61–500)	570 ^E (220–910)
5 (2016–2017)	352	99.8 (98.7–100)	28 (24–34)	7.4 (5.4–9.4)	23 (18–27)	130 ^E (65–190)	230 ^E (<LOD–410)
6 (2018–2019)	342	99.5 (93.9–100)	20 (17–23)	5.4 (3.5–7.3)	17 (14–20)	66 ^E (33–99)	130 (110–160)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.6

Mono(3-carboxypropyl) phthalate (MCPP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2543	98.1 (95.7–99.2)	1.9 (1.8–2.1)	0.45 (0.36–0.54)	2.0 (1.7–2.2)	7.0 (6.1–7.8)	11 (9.0–12)
5 (2016–2017)	2670	90.5 (86.8–93.3)	0.73 (0.61–0.86)	0.15 ^E (<LOD–0.20)	0.75 (0.63–0.88)	2.8 (2.2–3.4)	4.5 (3.4–5.5)
6 (2018–2019)	2455	89.2 (87.4–90.8)	0.60 (0.55–0.65)	<LOD	0.62 (0.56–0.68)	2.2 (1.7–2.7)	3.8 (2.6–5.0)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1273	98.6 (95.2–99.6)	2.1 (1.8–2.5)	0.53 ^E (0.33–0.72)	2.0 (1.6–2.4)	7.8 (5.1–10)	12 (9.0–15)
5 (2016–2017)	1331	92.2 (88.4–94.9)	0.72 (0.60–0.85)	0.16 (<LOD–0.20)	0.75 (0.58–0.92)	2.7 (1.8–3.6)	4.1 (2.9–5.4)
6 (2018–2019)	1226	90.9 (87.8–93.3)	0.66 (0.58–0.76)	0.15 ^E (<LOD–0.21)	0.73 (0.62–0.83)	2.1 ^E (1.3–2.9)	3.4 ^E (1.0–5.7)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1270	97.7 (92.9–99.3)	1.7 (1.5–2.0)	0.39 (0.26–0.53)	1.9 (1.6–2.2)	6.7 (5.2–8.2)	8.6 (6.4–11)
5 (2016–2017)	1339	88.8 (83.2–92.8)	0.74 (0.58–0.95)	<LOD	0.75 (0.58–0.92)	3.2 (2.3–4.2)	5.1 ^E (0.74–9.5)
6 (2018–2019)	1229	87.4 (84.2–90.0)	0.54 (0.48–0.61)	<LOD	0.55 (0.46–0.63)	2.3 (1.6–3.0)	3.9 (2.7–5.0)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	517	99.8 (99.4–100)	3.2 (2.8–3.7)	0.94 (0.63–1.2)	3.1 (2.6–3.6)	9.3 (6.5–12)	14 ^E (8.5–19)
5 (2016–2017)	550	97.2 (91.8–99.1)	1.3 ^E (0.92–1.9)	0.37 ^E (0.22–0.51)	1.3 ^E (0.66–2.0)	4.2 ^E (1.2–7.2)	6.4 ^E (3.1–9.8)
6 (2018–2019)	502	98.9 (96.4–99.7)	1.2 (1.1–1.4)	0.41 (0.35–0.47)	1.2 (0.97–1.4)	3.9 ^E (2.2–5.6)	5.6 (4.1–7.1)
6–11 years							
1 (2007–2009)	1037	97.3 (94.9–98.6)	2.7 (2.2–3.2)	0.70 ^E (0.41–0.99)	3.1 (2.5–3.7)	8.8 (7.5–10)	12 (9.8–15)
2 (2009–2011)	515	99.6 (98.3–99.9)	3.3 (2.8–4.0)	1.0 (0.80–1.2)	3.4 (2.9–3.9)	11 ^E (7.0–15)	15 (11–19)
5 (2016–2017)	531	97.4 (94.7–98.8)	1.3 (1.1–1.6)	0.40 (0.26–0.54)	1.3 (1.1–1.6)	4.0 (3.3–4.7)	6.3 ^E (3.4–9.2)
6 (2018–2019)	494	95.7 (85.7–98.8)	1.1 (0.93–1.4)	0.31 ^E (<LOD–0.50)	1.2 (0.92–1.4)	3.5 (2.6–4.3)	4.9 (3.6–6.2)
12–19 years							
1 (2007–2009)	991	96.2 (94.7–97.2)	2.2 (1.9–2.6)	0.40 ^E (<LOD–0.60)	2.6 (2.3–2.9)	8.0 (6.4–9.6)	11 ^E (6.5–15)
2 (2009–2011)	509	99.7 (98.8–99.9)	2.6 (2.2–3.1)	0.65 ^E (0.33–0.98)	2.5 (2.2–2.8)	9.6 (6.3–13)	16 ^E (8.0–24)
5 (2016–2017)	532	92.0 (88.3–94.6)	0.88 (0.73–1.0)	0.17 ^E (<LOD–0.26)	0.94 (0.84–1.0)	3.0 (2.4–3.5)	4.1 ^E (<LOD–10)
6 (2018–2019)	497	91.8 (84.8–95.8)	0.69 (0.54–0.88)	<LOD ^E (<LOD–0.21)	0.71 (0.47–0.96)	2.4 (1.6–3.2)	3.8 (2.6–5.0)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	730	96.8 (86.3–93.5)	1.3 (1.1–1.6)	<LOD	1.5 (1.2–1.8)	5.6 (4.1–7.2)	8.4 (5.8–11)
2 (2009–2011)	359	96.8 (91.4–98.9)	1.9 (1.5–2.5)	0.43 ^E (0.19–0.66)	2.0 (1.3–2.7)	7.1 (5.2–9.0)	10 (6.9–13)
5 (2016–2017)	365	92.0 (80.4–97.0)	0.70 (0.50–0.97)	<LOD	0.71 (0.49–0.93)	2.3 ^E (0.89–3.8)	4.3 ^E (2.4–6.2)
6 (2018–2019)	317	89.5 (84.8–92.9)	0.57 (0.44–0.75)	<LOD	0.55 (0.37–0.73)	1.8 ^E (0.20–3.5)	5.0 ^E (<LOD–9.8)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	359	98.2 (95.1–99.4)	1.6 (1.4–1.9)	0.42 ^E (0.20–0.64)	1.8 (1.4–2.1)	5.3 ^E (2.9–7.7)	8.7 ^E (3.4–14)
5 (2016–2017)	348	86.8 (76.3–93.1)	0.66 (0.48–0.90)	<LOD	0.69 ^E (0.41–0.97)	2.7 (2.1–3.3)	4.0 ^E (<LOD–8.6)
6 (2018–2019)	321	86.3 (79.9–90.8)	0.50 (0.39–0.64)	<LOD	0.58 (0.46–0.70)	1.7 ^E (0.73–2.8)	2.9 ^E (1.7–4.0)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	284	98.3 (94.4–99.5)	1.5 (1.2–1.7)	0.39 ^E (0.24–0.54)	1.5 (1.3–1.7)	5.1 ^E (2.7–7.5)	8.7 ^E (5.5–12)
5 (2016–2017)	344	89.5 (83.7–93.4)	0.61 (0.50–0.73)	<LOD	0.64 (0.52–0.76)	2.6 (2.0–3.3)	4.4 (2.9–5.9)
6 (2018–2019)	324	87.4 (81.4–91.7)	0.53 (0.44–0.64)	<LOD	0.51 (0.39–0.63)	1.9 (1.6–2.3)	2.9 ^E (1.3–4.6)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.2, 0.2, 0.14 and 0.14 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.
E Use data with caution.

Table 14.1.7

Mono(3-carboxypropyl) phthalate (MCPP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2533	98.1 (95.7–99.2)	1.9 (1.7–2.0)	0.66 (0.58–0.74)	1.7 (1.6–1.9)	5.9 (4.8–7.0)	9.1 (7.3–11)
5 (2016–2017)	2639	90.5 (86.8–93.3)	0.70 (0.62–0.78)	0.22 (<LOD–0.25)	0.62 (0.54–0.70)	2.3 (1.6–3.0)	4.1 (3.1–5.2)
6 (2018–2019)	2454	89.2 (87.4–90.8)	0.64 (0.59–0.70)	<LOD	0.56 (0.49–0.64)	2.1 (1.7–2.4)	3.2 ^E (1.7–4.7)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1269	98.6 (95.2–99.6)	1.8 (1.6–2.0)	0.60 (0.48–0.71)	1.6 (1.3–1.9)	6.4 (4.7–8.2)	9.9 (6.6–13)
5 (2016–2017)	1317	92.2 (88.4–94.9)	0.61 (0.54–0.70)	0.20 (<LOD–0.24)	0.58 (0.51–0.65)	1.9 (1.6–2.3)	3.2 ^E (1.9–4.5)
6 (2018–2019)	1225	90.9 (87.8–93.3)	0.61 (0.54–0.69)	0.21 (<LOD–0.25)	0.55 (0.46–0.65)	1.9 (1.3–2.5)	2.9 ^E (1.7–4.1)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1264	97.7 (92.9–99.3)	1.9 (1.7–2.2)	0.69 (0.57–0.82)	1.9 (1.7–2.2)	5.5 (4.4–6.6)	8.4 (7.0–9.9)
5 (2016–2017)	1322	88.8 (83.2–92.8)	0.79 (0.65–0.96)	<LOD	0.71 (0.56–0.87)	2.8 ^E (1.2–4.5)	5.8 ^E (3.0–8.7)
6 (2018–2019)	1229	87.4 (84.2–90.0)	0.67 (0.61–0.74)	<LOD	0.60 (0.53–0.66)	2.3 (1.7–3.0)	3.8 ^E (0.78–6.8)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	516	99.8 (99.4–100)	5.6 (4.8–6.4)	2.4 (2.0–2.8)	5.5 (4.6–6.4)	13 (10–17)	21 ^E (12–30)
5 (2016–2017)	539	97.2 (91.8–99.1)	2.3 (1.8–3.0)	0.94 (0.70–1.2)	2.2 (1.7–2.8)	5.6 ^E (3.2–8.0)	8.7 ^E (4.0–13)
6 (2018–2019)	501	98.9 (96.4–99.7)	2.0 (1.8–2.3)	0.87 ^E (0.54–1.2)	1.9 (1.7–2.1)	5.4 (4.0–6.8)	6.9 (5.2–8.6)
6–11 years							
1 (2007–2009)	1034	97.3 (94.9–98.6)	4.1 (3.6–4.6)	1.4 (1.1–1.7)	3.9 (3.4–4.3)	12 (8.6–15)	16 (11–20)
2 (2009–2011)	513	99.6 (98.3–99.9)	3.8 (3.4–4.3)	1.5 (1.1–1.8)	3.7 (3.3–4.1)	10 ^E (6.3–14)	15 (11–20)
5 (2016–2017)	523	97.4 (94.7–98.8)	1.5 (1.3–1.9)	0.67 (0.57–0.76)	1.4 (1.2–1.7)	3.7 (2.6–4.8)	6.0 ^E (3.6–8.4)
6 (2018–2019)	494	95.7 (85.7–98.8)	1.3 (1.2–1.5)	0.56 (<LOD–0.71)	1.2 (1.1–1.4)	3.3 (2.6–4.1)	5.1 (3.4–6.8)
12–19 years							
1 (2007–2009)	989	96.2 (94.7–97.2)	1.9 (1.7–2.1)	0.69 (<LOD–0.81)	1.7 (1.6–1.9)	5.5 (4.3–6.7)	8.3 (5.3–11)
2 (2009–2011)	507	99.7 (98.8–99.9)	2.0 (1.8–2.3)	0.79 (0.59–0.99)	1.7 (1.5–1.9)	6.1 ^E (3.5–8.7)	11 ^E (4.0–18)
5 (2016–2017)	526	92.0 (88.3–94.6)	0.66 (0.54–0.82)	0.22 (<LOD–0.28)	0.58 (0.41–0.76)	1.8 (1.3–2.3)	3.0 ^E (<LOD–6.6)
6 (2018–2019)	497	91.8 (84.8–95.8)	0.56 (0.47–0.68)	<LOD	0.56 (0.41–0.71)	1.6 ^E (0.90–2.2)	2.3 (1.6–3.1)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	728	90.5 (86.3–93.5)	1.4 (1.2–1.6)	<LOD	1.3 (1.1–1.5)	4.2 (2.9–5.4)	5.5 ^E (3.5–7.5)
2 (2009–2011)	357	96.8 (91.4–98.9)	1.6 (1.4–1.9)	0.58 (0.43–0.73)	1.4 (1.1–1.8)	5.3 ^E (2.9–7.7)	7.8 ^E (3.4–12)
5 (2016–2017)	361	92.0 (80.4–97.0)	0.63 (0.54–0.73)	<LOD	0.62 (0.44–0.79)	1.8 ^E (1.1–2.4)	2.5 ^E (0.89–4.1)
6 (2018–2019)	317	89.5 (84.8–92.9)	0.54 (0.43–0.67)	<LOD	0.48 (0.41–0.56)	1.1 ^E (<LOD–2.1)	2.7 ^E (<LOD–6.1)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	357	98.2 (95.1–99.4)	1.6 (1.5–1.8)	0.60 (0.47–0.73)	1.7 (1.4–2.0)	4.4 (3.8–5.0)	7.0 ^E (3.7–10)
5 (2016–2017)	347	86.8 (76.3–93.1)	0.59 (0.47–0.74)	<LOD	0.54 (0.45–0.64)	1.9 ^E (<LOD–4.7)	4.1 ^E (<LOD–6.0)
6 (2018–2019)	321	86.3 (79.9–90.8)	0.58 (0.47–0.72)	<LOD	0.52 (0.43–0.61)	1.9 (1.3–2.6)	2.8 ^E (<LOD–5.6)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	283	98.3 (94.4–99.5)	1.7 (1.5–1.9)	0.68 ^E (0.37–0.99)	1.6 (1.3–1.9)	5.0 (3.9–6.2)	6.1 ^E (3.2–9.0)
5 (2016–2017)	343	89.5 (83.7–93.4)	0.68 (0.58–0.81)	<LOD	0.58 (0.47–0.70)	2.0 (1.5–2.5)	4.6 ^E (1.3–7.9)
6 (2018–2019)	324	87.4 (81.4–91.7)	0.63 (0.54–0.74)	<LOD	0.61 (0.49–0.72)	1.9 ^E (1.1–2.8)	3.2 ^E (1.6–4.9)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.8

Mono-*n*-butyl phthalate (MnBP)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2555	100	20 (18–22)	5.7 (4.3–7.1)	20 (18–22)	67 (57–77)	87 (74–100)
5 (2016–2017)	2711	99.9 (97.9–100)	12 (11–14)	3.7 (2.7–4.6)	12 (10–14)	38 (31–44)	54 (36–71)
6 (2018–2019)	2505	99.7 (97.6–100)	12 (11–13)	3.3 (2.5–4.1)	12 (10–14)	37 (31–43)	49 (36–63)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1279	100	21 (18–24)	6.4 (4.7–8.1)	21 (18–24)	69 (49–90)	96 (70–120)
5 (2016–2017)	1350	99.7 (95.9–100)	12 (10–15)	3.6 (2.3–4.8)	12 (9.1–14)	39 (27–51)	59 ^E (26–92)
6 (2018–2019)	1241	99.4 (94.9–99.9)	13 (11–14)	4.0 ^E (2.5–5.5)	13 (11–14)	41 (33–48)	50 (35–64)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1276	100	19 (17–22)	5.2 ^E (3.3–7.2)	19 (16–22)	64 (50–78)	86 (70–100)
5 (2016–2017)	1361	100	13 (11–14)	3.7 (2.9–4.6)	13 (11–15)	36 (32–41)	54 (47–60)
6 (2018–2019)	1264	99.9 (99.4–100)	11 (9.6–13)	2.8 (2.3–3.4)	11 (8.9–14)	33 (25–40)	48 ^E (30–67)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	100	32 (28–37)	11 (8.0–14)	30 (26–34)	110 (75–150)	130 (110–150)
5 (2016–2017)	555	100	20 (16–25)	5.9 (4.4–7.4)	19 (14–25)	66 ^E (36–95)	85 (67–100)
6 (2018–2019)	509	100	19 (16–22)	6.1 (4.7–7.6)	19 (16–22)	52 (39–64)	72 (51–94)
6–11 years							
1 (2007–2009)	1037	100	33 (29–38)	8.6 (6.4–11)	32 (27–38)	110 (89–130)	160 (130–200)
2 (2009–2011)	515	100	36 (30–43)	9.7 (7.7–12)	32 (26–37)	110 ^E (<LOD–240)	220 ^E (<LOD–540)
5 (2016–2017)	536	100	20 (18–23)	6.9 (5.7–8.1)	19 (16–22)	65 (47–84)	84 (71–98)
6 (2018–2019)	492	100	19 (16–22)	5.9 ^E (3.7–8.1)	21 (17–25)	49 (35–63)	72 (56–87)
12–19 years							
1 (2007–2009)	991	100	32 (29–35)	9.1 (7.4–11)	33 (29–36)	98 (81–120)	140 (130–140)
2 (2009–2011)	512	100	28 (25–33)	9.1 (7.0–11)	28 (23–33)	77 (67–88)	110 (81–130)
5 (2016–2017)	537	100	16 (14–18)	4.6 (3.5–5.7)	18 (16–20)	39 (33–46)	58 (37–79)
6 (2018–2019)	500	99.8 (99.1–100)	14 (11–17)	3.8 ^E (1.7–5.9)	15 (12–19)	40 (30–51)	60 ^E (37–83)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	730	99.9 (99.6–100)	22 (20–25)	6.0 (4.2–7.8)	22 (18–27)	69 (48–90)	100 ^E (34–170)
2 (2009–2011)	358	100	20 (16–25)	6.3 ^E (3.9–8.7)	21 (16–26)	54 (47–61)	77 (56–99)
5 (2016–2017)	372	99.6 (93.2–100)	12 (9.4–15)	3.3 ^E (1.1–5.5)	11 (7.7–14)	44 (29–58)	58 ^E (17–99)
6 (2018–2019)	327	98.9 (92.0–99.9)	12 (9.7–14)	3.6 (2.3–4.8)	12 (9.4–15)	35 (24–47)	49 (38–60)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	357	100	17 (14–21)	4.0 ^E (1.8–6.2)	17 (15–20)	61 ^E (31–91)	83 (57–110)
5 (2016–2017)	358	100	11 (8.8–14)	3.3 ^E (1.9–4.7)	12 (8.5–15)	30 (23–37)	39 ^E (15–64)
6 (2018–2019)	340	100	9.9 (8.1–12)	2.3 ^E (1.3–3.3)	11 (7.9–13)	29 ^E (18–40)	43 ^E (9.8–75)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	291	100	17 (14–21)	5.3 (3.6–7.0)	16 (12–19)	63 (48–79)	81 ^E (34–130)
5 (2016–2017)	353	100	11 (9.8–12)	3.5 (3.0–4.1)	10 (9.5–11)	28 (22–35)	41 (29–54)
6 (2018–2019)	337	100	11 (9.2–14)	3.7 (2.9–4.5)	10 (6.9–13)	36 (27–46)	45 (32–58)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.4, 0.2, 0.60 and 0.60 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
 b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.
 E Use data with caution.

Table 14.1.9

Mono-*n*-butyl phthalate (MnBP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2545	100	20 (18–21)	8.7 (7.7–9.8)	17 (15–19)	48 (42–55)	78 (65–91)
5 (2016–2017)	2679	99.9 (97.9–100)	12 (11–13)	5.1 (4.4–5.9)	11 (9.8–12)	31 (26–35)	41 (35–47)
6 (2018–2019)	2504	99.7 (97.6–100)	13 (11–14)	5.4 (4.6–6.3)	11 (10–12)	31 (25–38)	45 (37–53)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1275	100	18 (16–20)	7.6 (6.9–8.3)	15 (13–17)	46 (38–54)	73 (60–86)
5 (2016–2017)	1335	99.7 (95.9–100)	11 (9.3–12)	4.4 (3.5–5.3)	9.9 (8.9–11)	27 (21–34)	39 (29–49)
6 (2018–2019)	1240	99.4 (94.9–99.9)	12 (11–13)	4.6 (3.7–5.4)	10 (9.2–11)	28 (21–35)	42 ^E (25–59)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1270	100	22 (19–24)	9.9 (8.8–11)	19 (16–22)	52 (41–63)	83 (64–100)
5 (2016–2017)	1344	100	14 (13–15)	6.5 (5.8–7.3)	12 (10–14)	33 (28–39)	45 (40–51)
6 (2018–2019)	1264	99.9 (99.4–100)	14 (12–16)	6.6 (5.9–7.3)	12 (10–14)	33 (23–42)	47 (38–56)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	521	100	56 (49–63)	26 (23–30)	52 (45–59)	120 (88–150)	170 (110–220)
5 (2016–2017)	544	100	35 (31–40)	16 (15–17)	33 (27–40)	80 (65–95)	110 ^E (58–160)
6 (2018–2019)	508	100	30 (26–35)	14 (8.9–19)	29 (24–34)	67 (48–85)	91 (63–120)
6–11 years							
1 (2007–2009)	1034	100	51 (46–56)	22 (19–25)	45 (40–51)	120 (110–140)	210 (140–270)
2 (2009–2011)	513	100	42 (36–48)	16 (14–19)	35 (30–39)	110 ^E (<LOD–260)	220 ^E (<LOD–600)
5 (2016–2017)	528	100	23 (22–25)	11 (9.4–13)	23 (21–25)	50 (41–60)	63 (55–72)
6 (2018–2019)	492	100	22 (20–25)	10 (9.8–11)	22 (21–23)	47 (30–63)	66 (43–88)
12–19 years							
1 (2007–2009)	989	100	27 (25–30)	12 (11–13)	25 (23–27)	68 ^E (42–93)	99 (89–110)
2 (2009–2011)	510	100	22 (19–25)	10 (8.8–11)	19 (16–22)	48 (38–58)	62 (49–75)
5 (2016–2017)	530	100	12 (11–14)	5.6 (4.8–6.4)	11 (8.5–13)	26 (17–35)	33 ^E (20–46)
6 (2018–2019)	500	99.8 (99.1–100)	12 (10–13)	5.2 (4.0–6.3)	11 (9.1–12)	28 (21–35)	35 (27–43)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	728	99.9 (99.6–100)	23 (21–26)	9.9 (8.5–11)	21 (19–22)	56 (41–70)	95 ^E (25–170)
2 (2009–2011)	356	100	17 (15–20)	8.5 (7.2–9.8)	14 (11–17)	36 (29–43)	47 ^E (16–77)
5 (2016–2017)	368	99.6 (93.2–100)	11 (9.7–12)	4.7 (3.8–5.5)	10 (9.1–11)	24 (16–32)	32 ^E (20–44)
6 (2018–2019)	327	98.9 (92.0–99.9)	11 (9.7–12)	4.8 (3.8–5.9)	9.9 (9.0–11)	22 (18–27)	32 ^E (11–52)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	355	100	17 (15–19)	7.3 (5.9–8.7)	16 (13–18)	36 (26–46)	55 ^E (18–92)
5 (2016–2017)	357	100	10 (8.6–12)	4.9 (3.6–6.2)	9.9 (8.6–11)	21 (14–28)	33 ^E (18–48)
6 (2018–2019)	340	100	12 (10–14)	5.0 (3.2–6.8)	10 (8.7–12)	27 ^E (15–38)	40 ^E (25–55)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	290	100	20 (17–23)	9.3 (7.6–11)	18 (13–22)	51 (33–68)	71 (61–81)
5 (2016–2017)	352	100	12 (11–14)	5.9 (4.8–6.9)	11 (10–13)	27 (21–34)	36 (26–46)
6 (2018–2019)	337	100	14 (11–16)	6.6 (5.1–8.0)	12 (9.5–14)	31 (23–39)	40 ^E (23–56)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.10

Monoisobutyl phthalate (MiBP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2547	99.9 (99.6–100)	14 (12–16)	3.5 (2.7–4.4)	14 (12–16)	43 (33–54)	64 (50–79)
5 (2016–2017)	2715	99.7 (97.4–100)	10 (8.6–12)	2.7 (2.2–3.2)	10 (9.1–11)	35 (25–45)	51 (37–64)
6 (2018–2019)	2513	98.9 (96.3–99.7)	8.5 (7.6–9.5)	2.0 (1.8–2.2)	9.1 (7.6–10)	27 (23–32)	43 (32–54)
Males, 3–79 years							
2 (2009–2011)	1275	100	14 (12–17)	3.7 ^E (2.2–5.1)	15 (12–17)	49 (32–67)	67 (43–90)
5 (2016–2017)	1353	99.5 (92.4–100)	10 (8.6–12)	2.8 (2.0–3.6)	10 (8.8–11)	31 (22–41)	46 ^E (29–64)
6 (2018–2019)	1248	98.5 (92.3–99.7)	9.1 (7.8–11)	2.1 (1.5–2.8)	9.9 (8.2–12)	28 ^E (18–39)	49 (33–64)
Females, 3–79 years							
2 (2009–2011)	1272	99.9 (99.3–100)	13 (12–15)	3.5 (2.5–4.5)	13 (11–16)	39 (33–46)	58 (42–73)
5 (2016–2017)	1362	99.9 (99.7–100)	10 (8.2–12)	2.5 (1.9–3.0)	11 (8.6–12)	39 (26–52)	51 (36–66)
6 (2018–2019)	1265	99.3 (97.8–99.8)	8.0 (7.0–9.1)	1.9 (1.7–2.2)	8.3 (6.6–10)	27 (23–32)	37 (29–46)
3–5 years							
2 (2009–2011)	517	100	22 (19–25)	6.9 (5.0–8.9)	22 (18–26)	63 ^E (38–88)	96 (68–120)
5 (2016–2017)	555	100	16 (13–19)	4.2 ^E (2.4–6.1)	16 (13–19)	54 (36–72)	77 (49–110)
6 (2018–2019)	509	100	15 (11–19)	4.4 (3.0–5.8)	13 (9.3–17)	49 ^E (3.8–95)	120 ^E (<LOD–250)
6–11 years							
2 (2009–2011)	515	100	22 (18–27)	6.6 (5.0–8.3)	22 (18–26)	67 ^E (40–93)	120 ^E (67–160)
5 (2016–2017)	536	99.9 (99.2–100)	15 (13–17)	5.3 (3.9–6.8)	14 (12–17)	48 (39–57)	74 (50–97)
6 (2018–2019)	494	99.8 (97.9–100)	13 (10–17)	3.9 ^E (2.2–5.7)	13 (9.8–16)	44 (33–55)	65 ^E (31–99)
12–19 years							
2 (2009–2011)	508	100	18 (16–21)	5.6 (4.0–7.2)	18 (16–20)	49 (34–64)	83 ^E (38–130)
5 (2016–2017)	538	99.9 (99.5–100)	13 (11–15)	3.7 (2.6–4.8)	13 (11–15)	37 (29–44)	51 ^E (32–70)
6 (2018–2019)	503	100	11 (8.8–14)	2.9 ^E (1.8–4.1)	11 (8.5–14)	31 (23–38)	39 ^E (21–58)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
2 (2009–2011)	359	99.8 (98.8–100)	15 (13–18)	3.2 ^E (1.7–4.7)	18 (15–20)	51 (40–63)	65 (49–81)
5 (2016–2017)	374	99.1 (90.4–99.9)	10 (7.5–14)	2.5 ^E (<LOD–4.8)	10 (7.0–14)	41 ^E (15–66)	57 ^E (28–86)
6 (2018–2019)	332	98.1 (93.4–99.5)	8.5 (7.3–10)	2.3 (1.7–2.9)	9.9 (6.4–13)	25 (18–32)	43 ^E (26–60)
40–59 years							
2 (2009–2011)	359	100	12 (9.7–15)	3.0 ^E (1.4–4.7)	12 (8.3–15)	36 ^E (20–51)	47 ^E (18–75)
5 (2016–2017)	359	100	9.2 (7.3–12)	2.5 (1.9–3.0)	10 (6.9–14)	31 ^E (17–46)	45 (29–62)
6 (2018–2019)	340	98.5 (93.7–99.7)	7.1 (6.0–8.5)	1.7 (1.3–2.2)	8.0 (6.7–9.3)	25 (20–31)	36 ^E (16–56)
60–79 years							
2 (2009–2011)	289	100	9.7 (7.6–12)	2.4 ^E (1.4–3.4)	9.3 (7.5–11)	35 (23–47)	42 (29–55)
5 (2016–2017)	353	99.9 (99.1–100)	8.0 (7.3–8.9)	2.4 (2.0–2.8)	7.7 (6.3–9.1)	23 (18–28)	33 (23–44)
6 (2018–2019)	335	99.7 (98.5–99.9)	7.6 (5.8–9.9)	2.0 (1.4–2.5)	7.7 (5.8–9.7)	26 (20–32)	39 ^E (13–65)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 2, 5 and 6 are 0.1, 0.57 and 0.57 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.11

Monoisobutyl phthalate (MiBP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
2 (2009–2011)	2537	99.9 (99.6–100)	13 (12–15)	5.4 (4.7–6.1)	13 (12–14)	34 (28–40)	47 (37–58)
5 (2016–2017)	2683	99.7 (97.4–100)	9.8 (8.8–11)	4.0 (3.7–4.3)	8.8 (7.6–9.9)	25 (19–31)	38 (26–50)
6 (2018–2019)	2512	98.9 (96.3–99.7)	9.2 (8.4–10)	4.0 (3.7–4.3)	8.5 (7.6–9.3)	21 (18–24)	32 (26–38)
Males, 3–79 years							
2 (2009–2011)	1271	100	12 (11–14)	4.9 (3.8–6.0)	11 (9.7–12)	34 (26–42)	46 (34–58)
5 (2016–2017)	1338	99.5 (92.4–100)	8.7 (8.0–9.5)	3.8 (3.3–4.3)	7.5 (7.0–8.1)	23 (19–27)	33 (27–40)
6 (2018–2019)	1247	98.5 (92.3–99.7)	8.4 (7.5–9.5)	3.7 (3.3–4.1)	7.7 (6.5–8.8)	21 (16–25)	32 (22–41)
Females, 3–79 years							
2 (2009–2011)	1266	99.9 (99.3–100)	15 (13–17)	6.2 (5.1–7.2)	14 (12–16)	34 (27–42)	49 (33–65)
5 (2016–2017)	1345	99.9 (99.7–100)	11 (9.6–13)	4.5 (3.8–5.1)	10 (9.1–11)	29 (19–40)	49 ^F (26–72)
6 (2018–2019)	1265	99.3 (97.8–99.8)	10 (9.1–11)	4.7 (4.1–5.2)	9.3 (8.3–10)	22 (17–26)	33 (24–41)
3–5 years							
2 (2009–2011)	516	100	37 (33–42)	16 (13–18)	34 (29–38)	87 (65–110)	120 (86–150)
5 (2016–2017)	544	100	27 (23–32)	11 (8.4–13)	24 (20–28)	79 (62–95)	98 ^F (51–150)
6 (2018–2019)	508	100	24 (19–30)	9.5 (6.3–13)	23 (18–27)	61 ^E (23–98)	110 ^E (<LOD–290)
6–11 years							
2 (2009–2011)	513	100	26 (22–30)	11 (8.8–13)	23 (19–27)	63 (45–80)	94 ^F (40–150)
5 (2016–2017)	528	99.9 (99.2–100)	17 (16–19)	8.1 (7.1–9.1)	15 (13–17)	39 (31–47)	59 (40–77)
6 (2018–2019)	494	99.8 (97.9–100)	16 (14–18)	7.3 (6.2–8.3)	13 (11–15)	38 (24–51)	63 ^E (37–89)
12–19 years							
2 (2009–2011)	506	100	14 (12–16)	7.1 (6.1–8.1)	12 (11–14)	30 (23–38)	41 ^F (18–64)
5 (2016–2017)	531	99.9 (99.5–100)	9.8 (8.3–11)	4.7 (3.8–5.6)	8.8 (7.2–10)	21 (17–25)	29 ^F (18–41)
6 (2018–2019)	503	100	9.1 (7.6–11)	3.9 (3.0–4.9)	8.7 (6.9–11)	20 (14–25)	34 (23–44)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
2 (2009–2011)	357	99.8 (98.8–100)	13 (12–14)	5.4 (4.3–6.5)	13 (11–14)	33 (23–42)	44 ^E (26–62)
5 (2016–2017)	370	99.1 (90.4–99.9)	9.4 (7.7–11)	3.9 (<LOD–4.2)	8.7 (7.4–9.9)	24 ^E (8.4–40)	46 ^E (14–79)
6 (2018–2019)	332	98.1 (93.4–99.5)	8.1 (7.4–8.8)	3.9 (3.0–4.8)	7.9 (6.8–9.0)	16 (14–18)	20 (16–25)
40–59 years							
2 (2009–2011)	357	100	12 (11–14)	5.2 (4.5–6.0)	12 (9.8–13)	24 ^E (15–33)	32 (22–41)
5 (2016–2017)	358	100	8.4 (7.3–9.8)	3.9 (3.3–4.4)	7.6 (6.2–9.0)	21 (17–25)	26 (19–33)
6 (2018–2019)	340	98.5 (93.7–99.7)	8.5 (7.6–9.4)	4.0 (3.2–4.8)	7.9 (6.8–9.0)	20 (16–24)	27 ^E (14–41)
60–79 years							
2 (2009–2011)	288	100	11 (9.0–14)	4.5 (3.0–6.1)	11 (7.8–13)	30 (23–37)	37 (27–46)
5 (2016–2017)	352	99.9 (99.1–100)	9.2 (8.4–10)	3.9 (3.1–4.6)	8.2 (7.5–9.0)	23 (17–30)	39 ^E (22–55)
6 (2018–2019)	335	99.7 (98.5–99.9)	8.9 (7.3–11)	3.8 (3.0–4.7)	7.9 (6.3–9.6)	21 ^E (13–29)	29 ^E (1.8–57)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.12

Mono-3-hydroxy-*n*-butyl phthalate (3OH-MBP)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2644	98.9 (97.3–99.5)	1.7 (1.4–1.9)	0.42 (0.32–0.52)	1.7 (1.4–2.0)	5.9 (5.0–6.8)	9.2 (7.0–11)
6 (2018–2019)	2448	98.1 (96.1–99.1)	1.5 (1.4–1.7)	0.45 (0.39–0.51)	1.6 (1.4–1.7)	5.3 (4.6–6.1)	7.3 (6.0–8.5)
Males, 3–79 years							
5 (2016–2017)	1309	99.0 (96.9–99.7)	1.6 (1.3–1.9)	0.37 ^E (0.23–0.52)	1.6 (1.3–1.9)	6.1 (4.7–7.6)	10 ^F (5.8–14)
6 (2018–2019)	1217	97.3 (93.6–98.9)	1.6 (1.4–1.9)	0.51 (0.33–0.68)	1.6 (1.4–1.9)	6.3 (5.2–7.4)	8.3 (6.2–10)
Females, 3–79 years							
5 (2016–2017)	1335	98.8 (96.0–99.6)	1.7 (1.5–1.9)	0.49 (0.41–0.57)	1.8 (1.4–2.2)	5.5 (4.6–6.5)	8.6 (7.2–10)
6 (2018–2019)	1231	98.9 (97.8–99.5)	1.4 (1.2–1.7)	0.44 (0.36–0.52)	1.5 (1.3–1.8)	4.9 (4.0–5.8)	6.7 (5.8–7.7)
3–5 years							
5 (2016–2017)	538	99.8 (97.9–100)	3.8 (3.2–4.5)	1.0 (0.69–1.3)	3.9 (3.1–4.7)	12 (8.5–15)	15 (11–20)
6 (2018–2019)	491	99.7 (98.0–99.9)	3.4 (2.8–4.1)	0.97 ^E (0.55–1.4)	3.4 (2.8–4.1)	11 (9.0–13)	13 (8.6–18)
6–11 years							
5 (2016–2017)	525	99.9 (99.2–100)	3.4 (3.0–4.0)	1.1 (0.73–1.5)	3.3 (2.7–3.9)	10 (7.0–13)	15 ^F (6.9–22)
6 (2018–2019)	483	98.3 (91.0–99.7)	2.9 (2.3–3.7)	0.81 ^E (0.39–1.2)	3.4 (2.6–4.2)	9.0 (6.7–11)	12 (9.0–14)
12–19 years							
5 (2016–2017)	525	99.7 (98.8–99.9)	2.4 (2.0–2.7)	0.57 ^E (0.30–0.84)	2.5 (2.3–2.8)	7.5 (5.9–9.1)	10 (7.2–14)
6 (2018–2019)	495	99.6 (98.6–99.9)	2.1 (1.7–2.5)	0.61 (0.41–0.81)	2.3 (1.7–2.8)	6.1 (4.6–7.5)	9.4 (7.4–11)
20–39 years							
5 (2016–2017)	363	97.4 (92.5–99.1)	1.5 (1.2–2.1)	0.37 ^E (0.12–0.61)	1.8 ^E (0.92–2.7)	6.1 (4.1–8.1)	9.0 ^F (3.7–14)
6 (2018–2019)	317	97.7 (91.2–99.4)	1.5 (1.3–1.7)	0.51 (0.40–0.62)	1.5 (1.3–1.8)	5.3 (3.7–6.9)	6.9 (5.9–8.0)
40–59 years							
5 (2016–2017)	351	99.5 (98.1–99.9)	1.4 (1.1–1.8)	0.37 (0.26–0.47)	1.4 (1.1–1.7)	5.1 (3.6–6.6)	6.3 ^F (2.9–9.7)
6 (2018–2019)	330	97.6 (89.9–99.5)	1.2 (0.91–1.6)	0.32 ^E (0.17–0.48)	1.2 (0.78–1.6)	4.0 (2.9–5.1)	5.6 ^F (3.0–8.2)
60–79 years							
5 (2016–2017)	342	99.2 (97.9–99.7)	1.3 (1.2–1.5)	0.45 (0.35–0.56)	1.3 (1.1–1.5)	3.5 (2.4–4.6)	5.2 ^F (2.8–7.6)
6 (2018–2019)	332	98.5 (95.9–99.5)	1.4 (1.1–1.7)	0.42 (0.33–0.50)	1.5 (1.2–1.7)	4.4 (3.0–5.8)	6.8 (4.8–8.8)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 5 and 6 are 0.079 and 0.068 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.13

Mono-3-hydroxy-*n*-butyl phthalate (3OH-MBP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2613	98.9 (97.3–99.5)	1.6 (1.5–1.7)	0.60 (0.53–0.66)	1.5 (1.4–1.6)	4.7 (4.2–5.1)	6.8 (6.0–7.5)
6 (2018–2019)	2447	98.1 (96.1–99.1)	1.6 (1.5–1.8)	0.63 (0.53–0.73)	1.5 (1.2–1.8)	4.7 (3.8–5.7)	6.7 (5.4–7.9)
Males, 3–79 years							
5 (2016–2017)	1294	99.0 (96.9–99.7)	1.3 (1.2–1.5)	0.54 (0.42–0.66)	1.2 (1.1–1.4)	4.0 (3.0–5.0)	6.5 (4.8–8.1)
6 (2018–2019)	1216	97.3 (93.6–98.9)	1.5 (1.3–1.7)	0.56 (0.46–0.66)	1.3 (1.2–1.5)	4.7 (3.4–6.0)	6.7 (5.0–8.4)
Females, 3–79 years							
5 (2016–2017)	1319	98.8 (96.0–99.6)	1.9 (1.7–2.0)	0.72 (0.57–0.88)	1.7 (1.5–1.9)	4.9 (4.4–5.4)	7.1 (6.2–8.0)
6 (2018–2019)	1231	98.9 (97.8–99.5)	1.8 (1.5–2.1)	0.73 (0.59–0.88)	1.7 (1.4–2.0)	4.9 (3.7–6.1)	6.8 (5.4–8.1)
3–5 years							
5 (2016–2017)	527	99.8 (97.9–100)	6.5 (5.7–7.4)	2.4 (1.9–3.0)	6.7 (5.9–7.6)	15 (11–19)	25 ^E (14–37)
6 (2018–2019)	490	99.7 (98.0–99.9)	5.5 (4.5–6.8)	2.3 (1.5–3.0)	5.3 (4.5–6.2)	14 (12–17)	16 ^E (8.2–23)
6–11 years							
5 (2016–2017)	517	99.9 (99.2–100)	4.0 (3.5–4.5)	1.5 (1.1–1.8)	3.9 (3.4–4.4)	8.1 (7.1–9.0)	10 (7.2–14)
6 (2018–2019)	483	98.3 (91.0–99.7)	3.5 (2.8–4.3)	1.4 (0.91–1.9)	3.7 (3.5–4.0)	8.7 (6.3–11)	11 (8.0–14)
12–19 years							
5 (2016–2017)	519	99.7 (98.8–99.9)	1.8 (1.5–2.0)	0.77 (0.68–0.87)	1.7 (1.5–1.9)	3.9 (2.9–4.9)	5.0 ^E (3.1–6.9)
6 (2018–2019)	495	99.6 (98.6–99.9)	1.6 (1.4–1.8)	0.73 (0.59–0.86)	1.6 (1.4–1.8)	3.7 (2.9–4.5)	4.9 (3.8–6.1)
20–39 years							
5 (2016–2017)	359	97.4 (92.5–99.1)	1.4 (1.2–1.7)	0.54 ^E (0.27–0.81)	1.3 (1.1–1.6)	3.5 ^E (2.2–4.8)	4.8 (3.7–5.9)
6 (2018–2019)	317	97.7 (91.2–99.4)	1.4 (1.2–1.6)	0.55 (0.41–0.69)	1.3 (1.2–1.5)	3.2 (2.4–4.1)	5.4 ^E (2.7–8.2)
40–59 years							
5 (2016–2017)	350	99.5 (98.1–99.9)	1.3 (1.1–1.5)	0.56 (0.48–0.64)	1.2 (1.0–1.4)	2.9 (2.1–3.6)	3.7 ^E (2.1–5.4)
6 (2018–2019)	330	97.6 (89.9–99.5)	1.4 (1.1–1.8)	0.59 (0.42–0.76)	1.3 (0.96–1.7)	3.6 (2.4–4.7)	5.4 (3.7–7.2)
60–79 years							
5 (2016–2017)	341	99.2 (97.9–99.7)	1.5 (1.3–1.7)	0.61 (0.48–0.74)	1.5 (1.2–1.7)	3.6 (2.7–4.5)	4.8 (3.8–5.8)
6 (2018–2019)	332	98.5 (95.9–99.5)	1.6 (1.3–2.0)	0.70 (0.59–0.81)	1.5 (1.1–1.8)	4.3 (2.9–5.7)	5.8 (4.2–7.5)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.14

Monocyclohexyl phthalate (MCHP)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2551	26.0 (19.8–33.3)	—	<LOD	<LOD	0.24 ^E (0.15–0.32)	0.47 ^E (0.28–0.67)
5 (2016–2017)	2706	3.4 ^E (1.9–6.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2524	2.0 ^F (1.0–4.1)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1278	26.6 (19.2–35.5)	—	<LOD	<LOD	0.25 ^F (0.15–0.34)	0.57 ^E (0.29–0.84)
5 (2016–2017)	1348	3.9 ^E (1.9–7.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1253	2.9 ^F (1.1–7.4)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1273	25.3 ^F (17.3–35.5)	—	<LOD	<LOD	0.22 ^E (0.11–0.34)	0.44 (0.30–0.59)
5 (2016–2017)	1358	2.9 ^E (1.5–5.4)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1271	1.1 ^E (0.60–1.9)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	30.9 (23.2–39.8)	—	<LOD	<LOD	0.74 ^E (0.21–1.3)	4.2 ^E (0.29–8.1)
5 (2016–2017)	555	4.6 ^F (2.8–7.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	511	0.90 ^F (0.30–2.9)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
1 (2007–2009)	1037	15.1 (11.0–20.5)	—	<LOD	<LOD	0.43 ^F (<LOD–0.73)	1.1 ^F (0.48–1.7)
2 (2009–2011)	516	33.8 (25.6–43.0)	—	<LOD	<LOD	0.49 ^F (0.28–0.71)	1.3 ^F (0.46–2.0)
5 (2016–2017)	535	5.6 ^F (1.6–18.0)	—	<LOD	<LOD	<LOD	0.33 ^F (<LOD–0.46)
6 (2018–2019)	496	0.90 ^F (0.40–2.3)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
1 (2007–2009)	991	13.3 (9.5–18.3)	—	<LOD	<LOD	0.28 ^F (<LOD–0.43)	1.1 ^F (0.58–1.6)
2 (2009–2011)	507	25.5 (19.4–32.8)	—	<LOD	<LOD	0.30 (0.20–0.40)	0.64 ^E (<LOD–1.5)
5 (2016–2017)	538	3.6 ^F (1.4–8.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	504	0.20 ^F (0–7.5)	—	<LOD	<LOD	<LOD	<LOD

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	730	11.8 (8.2–16.7)	—	<LOD	<LOD	0.31 ^E (<LOD–0.61)	0.86 ^E (0.45–1.3)
2 (2009–2011)	359	25.4 (17.7–35.0)	—	<LOD	<LOD	0.18 ^E (<LOD–0.29)	0.33 ^E (0.19–0.47)
5 (2016–2017)	372	4.3 ^E (1.6–11.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	331	1.9 ^E (0.50–6.9)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	358	23.0 ^E (15.3–33.0)	—	<LOD	<LOD	0.20 ^E (<LOD–0.35)	0.40 ^E (<LOD–0.77)
5 (2016–2017)	356	1.4 ^E (0.40–4.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	342	3.3 ^E (1.2–9.0)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	289	28.6 (20.3–38.5)	—	<LOD	<LOD	0.23 (0.16–0.30)	0.39 ^E (0.10–0.67)
5 (2016–2017)	350	4.0 ^E (2.1–7.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	340	1.6 ^E (0.70–4.0)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.2, 0.1, 0.25 and 0.25 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
 b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.
 E Use data with caution.

Table 14.1.15

Monocyclohexyl phthalate (MCHP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2541	26.0 (19.8–33.3)	—	<LOD	<LOD	0.29 (0.24–0.35)	0.56 ^E (0.33–0.80)
5 (2016–2017)	2674	3.4 ^E (1.9–6.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2523	2.0 ^F (1.0–4.1)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1274	26.6 (19.2–35.5)	—	<LOD	<LOD	0.29 (0.20–0.38)	0.59 (0.38–0.79)
5 (2016–2017)	1333	3.9 ^E (1.9–7.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1252	2.9 ^F (1.1–7.4)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1267	25.3 ^F (17.3–35.5)	—	<LOD	<LOD	0.30 (0.20–0.39)	0.54 ^E (0.12–0.96)
5 (2016–2017)	1341	2.9 ^E (1.5–5.4)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1271	1.1 ^E (0.60–1.9)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	521	30.9 (23.2–39.8)	—	<LOD	<LOD	1.0 ^E (<LOD–2.0)	3.2 ^F (<LOD–10)
5 (2016–2017)	544	4.6 ^F (2.8–7.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	510	0.90 ^F (0.30–2.9)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
1 (2007–2009)	1034	15.1 (11.0–20.5)	—	<LOD	<LOD	0.90 ^F (<LOD–1.4)	2.0 ^F (1.1–2.9)
2 (2009–2011)	514	33.8 (25.6–43.0)	—	<LOD	<LOD	0.51 ^E (0.23–0.79)	1.3 ^F (0.35–2.2)
5 (2016–2017)	527	5.6 ^F (1.6–18.0)	—	<LOD	<LOD	<LOD	0.48 (<LOD–0.61)
6 (2018–2019)	496	0.90 ^F (0.40–2.3)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
1 (2007–2009)	989	13.3 (9.5–18.3)	—	<LOD	<LOD	0.40 ^F (<LOD–0.55)	0.82 ^E (0.40–1.2)
2 (2009–2011)	505	25.5 (19.4–32.8)	—	<LOD	<LOD	0.28 ^F (0.15–0.40)	0.47 ^E (<LOD–1.0)
5 (2016–2017)	531	3.6 ^F (1.4–8.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	504	0.20 ^F (0–7.5)	—	<LOD	<LOD	<LOD	<LOD

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	728	11.8 (8.2–16.7)	—	<LOD	<LOD	0.54 (<LOD–0.72)	0.89 (0.68–1.1)
2 (2009–2011)	357	25.4 (17.7–35.0)	—	<LOD	<LOD	0.20 ^E (<LOD–0.31)	0.31 ^E (<LOD–0.58)
5 (2016–2017)	368	4.3 ^E (1.6–11.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	331	1.9 ^E (0.50–6.9)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	356	23.0 ^E (15.3–33.0)	—	<LOD	<LOD	0.30 ^E (<LOD–0.55)	0.46 ^E (<LOD–1.3)
5 (2016–2017)	355	1.4 ^E (0.40–4.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	342	3.3 ^E (1.2–9.0)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	288	28.6 (20.3–38.5)	—	<LOD	<LOD	0.29 (0.21–0.37)	0.42 ^E (0.19–0.65)
5 (2016–2017)	349	4.0 ^E (2.1–7.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	340	1.6 ^E (0.70–4.0)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.16

Monobenzyl phthalate (MBzP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2559	100	7.5 (6.6–8.6)	1.7 (1.3–2.2)	7.1 (6.1–8.1)	32 (25–38)	57 (48–65)
5 (2016–2017)	2714	96.3 (92.6–98.2)	3.9 (3.1–4.7)	0.82 (0.61–1.0)	3.6 (3.0–4.3)	21 (17–24)	32 (23–40)
6 (2018–2019)	2516	98.3 (96.9–99.1)	2.6 (2.1–3.2)	0.51 (0.38–0.64)	2.6 (2.0–3.2)	13 (11–16)	21 ^F (13–30)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1281	100	8.0 (6.9–9.2)	2.1 (1.5–2.7)	7.5 (6.2–8.9)	33 (26–40)	54 (42–65)
5 (2016–2017)	1353	95.9 (89.6–98.4)	3.8 (2.9–5.0)	0.74 (0.48–1.0)	3.5 (2.6–4.3)	21 (17–26)	29 (23–35)
6 (2018–2019)	1250	98.5 (96.1–99.4)	2.8 (2.2–3.5)	0.50 ^E (0.28–0.72)	2.9 (2.2–3.6)	15 (11–19)	24 (16–33)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1278	100	7.1 (5.7–8.7)	1.5 ^E (0.89–2.0)	6.7 (4.8–8.6)	30 (20–40)	58 (41–75)
5 (2016–2017)	1361	96.8 (94.0–98.3)	3.9 (3.2–4.7)	0.91 (0.66–1.2)	3.8 (3.2–4.4)	19 (13–26)	36 ^F (22–49)
6 (2018–2019)	1266	98.2 (94.7–99.4)	2.4 (2.0–3.0)	0.52 (0.36–0.67)	2.5 (1.9–3.0)	12 (8.7–15)	18 ^F (7.2–28)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	100	17 (14–20)	4.1 ^F (2.6–5.7)	16 (13–18)	59 ^E (25–92)	120 (86–150)
5 (2016–2017)	555	97.0 (90.5–99.1)	7.7 ^E (4.3–14)	1.3 ^E (0.38–2.2)	7.8 ^F (4.9–11)	42 ^E (<LOD–100)	86 ^F (<LOD–210)
6 (2018–2019)	511	99.1 (95.1–99.8)	5.9 ^E (3.9–8.8)	1.1 ^F (0.66–1.5)	5.9 ^F (3.0–8.8)	39 ^F (22–56)	49 (44–54)
6–11 years							
1 (2007–2009)	1037	100	21 (17–25)	4.8 (3.2–6.3)	21 (17–25)	91 (74–110)	120 (98–150)
2 (2009–2011)	516	100	19 (15–23)	4.9 (3.5–6.4)	20 (15–24)	76 ^F (45–110)	100 (72–140)
5 (2016–2017)	537	99.4 (98.4–99.8)	10 (8.3–12)	2.2 ^E (1.3–3.2)	9.6 (7.0–12)	42 (34–50)	58 (37–79)
6 (2018–2019)	496	99.9 (99.1–100)	6.3 ^E (4.2–9.3)	1.3 ^E (0.23–2.3)	6.1 ^E (3.5–8.8)	32 ^E (14–49)	46 ^F (26–67)
12–19 years							
1 (2007–2009)	991	100	19 (16–22)	4.4 (3.1–5.7)	20 (16–24)	74 (56–93)	99 (86–110)
2 (2009–2011)	512	100	12 (10–15)	3.3 (2.2–4.4)	12 (8.9–15)	42 (33–50)	59 (43–75)
5 (2016–2017)	538	99.1 (98.1–99.6)	5.3 (4.2–6.7)	1.0 (0.69–1.3)	5.2 ^F (3.3–7.2)	24 (15–32)	41 (28–54)
6 (2018–2019)	502	99.5 (98.0–99.9)	3.8 (2.7–5.4)	0.66 ^E (0.32–1.0)	3.8 ^F (2.1–5.4)	16 ^F (8.1–23)	26 ^F (3.2–50)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	730	100	10 (8.1–13)	2.0 (1.5–2.5)	9.9 (7.0–13)	51 (38–64)	77 (50–100)
2 (2009–2011)	359	100	7.3 (5.5–9.7)	1.8 ^E (0.78–2.7)	7.0 (5.2–8.7)	30 ^E (12–48)	60 (39–80)
5 (2016–2017)	374	93.8 (80.2–98.2)	3.7 ^E (2.3–6.0)	0.83 ^E (<LOD–1.4)	4.1 ^E (2.5–5.6)	21 ^E (8.9–32)	28 ^E (7.2–50)
6 (2018–2019)	329	97.7 (91.6–99.4)	2.6 (2.0–3.4)	0.48 ^E (0.25–0.71)	2.8 ^E (1.6–4.0)	13 (9.3–17)	17 (11–24)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	360	100	6.0 (4.8–7.5)	1.6 ^E (0.95–2.2)	5.6 ^E (2.9–8.2)	20 ^E (12–28)	33 ^E (4.3–61)
5 (2016–2017)	358	97.3 (92.6–99.0)	3.3 (2.4–4.6)	0.72 ^E (0.41–1.0)	3.1 (2.1–4.1)	18 ^E (11–25)	23 ^E (9.3–37)
6 (2018–2019)	340	97.4 (91.3–99.3)	1.9 (1.4–2.6)	0.40 ^E (0.21–0.59)	2.1 ^E (1.3–2.9)	6.5 ^E (3.0–9.9)	13 ^E (4.1–23)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	290	100	5.2 (4.3–6.4)	1.0 ^E (0.55–1.5)	4.7 (3.7–5.8)	23 (16–30)	36 ^E (15–57)
5 (2016–2017)	352	96.2 (92.9–98.0)	2.8 (2.4–3.3)	0.65 (0.47–0.82)	2.7 (2.1–3.2)	15 ^E (7.3–23)	21 (15–27)
6 (2018–2019)	338	99.3 (95.4–99.9)	2.3 (1.8–2.9)	0.52 (0.38–0.66)	2.2 (1.8–2.7)	11 ^E (<LOD–23)	23 ^E (8.9–37)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.5, 0.2, 0.37 and 0.14 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
 b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.
 E Use data with caution.

Table 14.1.17

Monobenzyl phthalate (MBzP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2549	100	7.4 (6.4–8.5)	2.1 (1.8–2.5)	6.8 (5.6–8.0)	28 (22–34)	44 (37–51)
5 (2016–2017)	2682	96.3 (92.6–98.2)	3.7 (3.1–4.4)	0.96 (0.83–1.1)	3.4 (2.7–4.1)	16 (13–19)	25 (18–32)
6 (2018–2019)	2515	98.3 (96.9–99.1)	2.8 (2.3–3.4)	0.69 (0.47–0.91)	2.6 (2.1–3.1)	12 (9.3–15)	20 (16–24)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1277	100	6.8 (6.0–7.7)	2.1 (1.8–2.4)	5.9 (5.0–6.8)	25 (20–30)	39 (27–50)
5 (2016–2017)	1338	95.9 (89.6–98.4)	3.3 (2.6–4.1)	0.86 (0.67–1.1)	2.9 (2.2–3.6)	16 (9.9–21)	22 (16–28)
6 (2018–2019)	1249	98.5 (96.1–99.4)	2.6 (2.1–3.2)	0.56 ^E (0.28–0.83)	2.5 (1.9–3.1)	11 (9.0–14)	19 (13–24)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1272	100	8.1 (6.6–9.9)	2.2 (1.5–3.0)	7.7 (5.7–9.7)	32 (24–41)	46 (40–52)
5 (2016–2017)	1344	96.8 (94.0–98.3)	4.2 (3.6–5.0)	1.1 (0.88–1.3)	3.9 (3.1–4.8)	16 (13–19)	29 (19–39)
6 (2018–2019)	1266	98.2 (94.7–99.4)	3.1 (2.5–3.7)	0.80 (0.55–1.1)	2.7 (2.1–3.2)	13 (8.7–18)	21 (15–27)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	521	100	29 (24–35)	9.4 (8.1–11)	26 (20–32)	100 (70–130)	150 (110–200)
5 (2016–2017)	544	97.0 (90.5–99.1)	13 ^E (8.6–20)	3.2 ^E (1.9–4.5)	12 ^E (7.0–17)	60 ^E (<LOD–130)	120 ^E (<LOD–190)
6 (2018–2019)	510	99.1 (95.1–99.8)	9.6 ^E (6.2–15)	1.8 ^E (0.34–3.2)	8.6 ^E (4.1–13)	57 (39–76)	80 (57–100)
6–11 years							
1 (2007–2009)	1034	100	32 (27–39)	10 (8.5–12)	31 (25–37)	100 (86–110)	140 (110–170)
2 (2009–2011)	514	100	22 (18–26)	6.2 (4.3–8.2)	21 (17–25)	73 (58–88)	98 (78–120)
5 (2016–2017)	529	99.4 (98.4–99.8)	11 (9.7–14)	2.9 (2.0–3.8)	10 (7.4–13)	43 (32–53)	58 ^E (33–84)
6 (2018–2019)	496	99.9 (99.1–100)	7.5 (5.3–11)	2.4 (1.8–2.9)	6.5 ^E (3.4–9.7)	32 ^E (17–47)	47 ^E (27–67)
12–19 years							
1 (2007–2009)	989	100	16 (14–19)	5.6 (4.1–7.1)	15 (13–17)	49 ^E (30–69)	70 (57–83)
2 (2009–2011)	510	100	9.4 (7.7–11)	3.1 (2.4–3.9)	9.3 (7.7–11)	28 (21–36)	44 (34–54)
5 (2016–2017)	531	99.1 (98.1–99.6)	4.0 (3.0–5.4)	1.0 (0.70–1.3)	3.4 ^E (2.0–4.8)	16 (10–21)	22 ^E (8.6–35)
6 (2018–2019)	502	99.5 (98.0–99.9)	3.1 (2.4–4.0)	0.88 (0.59–1.2)	3.0 (2.2–3.8)	10 ^E (6.0–14)	18 (12–24)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	728	100	11 (8.9–13)	3.0 ^E (1.9–4.0)	10 (8.1–12)	36 (27–45)	54 (42–65)
2 (2009–2011)	357	100	6.3 (4.8–8.3)	2.0 ^E (1.1–2.9)	5.6 (4.0–7.2)	22 ^E (11–34)	36 (26–46)
5 (2016–2017)	370	93.8 (80.2–98.2)	3.4 (2.5–4.6)	0.81 ^E (<LOD–1.2)	3.3 ^E (2.0–4.5)	12 ^E (6.4–18)	21 ^E (9.6–33)
6 (2018–2019)	329	97.7 (91.6–99.4)	2.5 (1.9–3.1)	0.51 ^E (0.18–0.85)	2.5 (1.7–3.2)	12 ^E (5.6–18)	19 ^E (11–26)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	358	100	6.1 (5.1–7.2)	2.0 (1.7–2.4)	5.4 ^E (3.4–7.4)	17 (13–20)	28 ^E (16–39)
5 (2016–2017)	357	97.3 (92.6–99.0)	3.0 (2.5–3.6)	0.93 (0.80–1.1)	2.6 (1.9–3.4)	11 ^E (6.6–16)	15 ^E (9.6–21)
6 (2018–2019)	340	97.4 (91.3–99.3)	2.2 (1.7–3.0)	0.66 ^E (0.31–1.0)	2.1 (1.6–2.7)	7.4 ^E (3.9–11)	12 (7.6–16)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	289	100	6.0 (5.2–7.0)	1.9 (1.6–2.3)	5.8 (4.5–7.1)	24 (17–31)	27 ^E (9.5–44)
5 (2016–2017)	351	96.2 (92.9–98.0)	3.2 (2.6–3.9)	0.93 (0.74–1.1)	2.9 (2.4–3.5)	13 (9.0–18)	18 (16–21)
6 (2018–2019)	338	99.3 (95.4–99.9)	2.7 (2.1–3.4)	0.75 (0.63–0.88)	2.4 (1.6–3.2)	11 ^E (<LOD–19)	18 ^E (5.2–30)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.18

Mono[2-(carboxymethyl)hexyl]phthalate (MCMHP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2705	96.5 (93.9–98.0)	1.8 (1.5–2.1)	0.47 (0.34–0.61)	1.8 (1.5–2.2)	6.1 (4.4–7.7)	8.4 (6.5–10)
6 (2018–2019)	2512	94.4 (91.8–96.2)	1.6 (1.5–1.8)	0.43 (0.37–0.48)	1.8 (1.6–2.0)	5.2 (4.6–5.8)	7.3 (6.2–8.5)
Males, 3–79 years							
5 (2016–2017)	1348	97.2 (93.8–98.7)	1.8 (1.5–2.2)	0.50 ^E (0.27–0.72)	1.8 (1.5–2.2)	6.3 (4.1–8.6)	8.4 (5.8–11)
6 (2018–2019)	1247	94.3 (90.6–96.6)	1.8 (1.6–2.0)	0.51 (0.39–0.64)	2.0 (1.8–2.2)	5.6 (4.2–7.1)	8.5 (6.6–10)
Females, 3–79 years							
5 (2016–2017)	1357	95.8 (92.0–97.8)	1.7 (1.4–2.2)	0.46 ^E (0.28–0.65)	1.9 (1.5–2.3)	5.9 (4.4–7.3)	8.0 (6.2–9.8)
6 (2018–2019)	1265	94.6 (91.1–96.7)	1.5 (1.4–1.6)	0.40 (0.32–0.47)	1.6 (1.3–1.9)	4.9 (4.2–5.6)	6.6 (5.8–7.3)
3–5 years							
5 (2016–2017)	553	99.5 (97.8–99.9)	3.3 (2.5–4.4)	0.97 (0.75–1.2)	3.3 ^F (2.1–4.5)	10 (8.4–12)	14 (11–17)
6 (2018–2019)	511	99.6 (95.2–100)	2.9 (2.4–3.4)	0.99 (0.82–1.2)	2.7 (2.0–3.3)	9.6 (6.7–12)	13 (9.7–17)
6–11 years							
5 (2016–2017)	537	98.8 (96.1–99.6)	3.1 (2.7–3.6)	0.99 (0.76–1.2)	3.1 (2.5–3.7)	8.8 (6.2–11)	13 ^E (5.9–19)
6 (2018–2019)	496	97.3 (86.4–99.5)	2.6 (2.0–3.3)	0.69 ^E (0.32–1.1)	2.6 (2.0–3.3)	7.6 (6.1–9.1)	9.7 (8.2–11)
12–19 years							
5 (2016–2017)	537	97.4 (95.4–98.5)	1.9 (1.7–2.2)	0.60 (0.40–0.80)	2.2 (2.0–2.3)	5.1 (4.3–5.9)	7.3 (5.5–9.2)
6 (2018–2019)	499	95.3 (87.7–98.3)	1.8 (1.4–2.3)	0.57 ^E (0.28–0.86)	1.8 (1.3–2.3)	5.3 (3.8–6.8)	7.5 ^E (2.7–12)
20–39 years							
5 (2016–2017)	369	95.8 (88.0–98.6)	1.5 (1.1–2.0)	0.29 ^E (<LOD–0.49)	1.6 (1.1–2.1)	5.5 ^E (3.1–8.0)	8.5 ^E (4.7–12)
6 (2018–2019)	326	92.2 (87.8–95.2)	1.6 (1.4–1.9)	0.39 ^E (<LOD–0.57)	1.9 (1.5–2.3)	5.1 (3.7–6.5)	6.8 ^E (4.1–9.5)
40–59 years							
5 (2016–2017)	358	96.4 (90.4–98.7)	1.7 (1.3–2.1)	0.50 (0.33–0.66)	1.7 (1.3–2.2)	5.2 ^E (2.8–7.5)	7.4 (4.8–10)
6 (2018–2019)	342	92.3 (85.1–96.2)	1.3 (1.1–1.5)	0.36 (<LOD–0.48)	1.4 (1.0–1.8)	3.9 (3.4–4.5)	4.8 (3.9–5.7)
60–79 years							
5 (2016–2017)	351	95.8 (92.5–97.7)	1.7 (1.5–2.0)	0.56 (0.42–0.70)	1.8 (1.4–2.1)	5.1 (3.3–6.9)	7.2 (6.1–8.2)
6 (2018–2019)	338	98.2 (95.5–99.3)	1.7 (1.5–1.9)	0.48 (0.35–0.62)	1.6 (1.3–2.0)	5.3 (4.4–6.3)	7.6 (6.1–9.0)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.27 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.19

Mono[2-(carboxymethyl)hexyl] phthalate (MCMHP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2673	96.5 (93.9–98.0)	1.7 (1.5–1.9)	0.71 (0.61–0.81)	1.6 (1.4–1.8)	4.4 (3.8–5.0)	6.5 (4.8–8.2)
6 (2018–2019)	2511	94.4 (91.8–96.2)	1.8 (1.6–1.9)	0.74 (0.66–0.83)	1.7 (1.5–1.8)	4.8 (4.3–5.3)	6.4 (5.4–7.5)
Males, 3–79 years							
5 (2016–2017)	1333	97.2 (93.8–98.7)	1.5 (1.4–1.7)	0.68 (0.59–0.77)	1.4 (1.2–1.5)	3.9 (3.5–4.3)	5.9 (4.5–7.3)
6 (2018–2019)	1246	94.3 (90.6–96.6)	1.7 (1.5–1.9)	0.72 (0.61–0.84)	1.5 (1.3–1.7)	4.6 (3.4–5.7)	5.6 ^E (3.4–7.8)
Females, 3–79 years							
5 (2016–2017)	1340	95.8 (92.0–97.8)	1.9 (1.6–2.3)	0.79 (0.56–1.0)	1.8 (1.5–2.2)	4.8 (4.0–5.6)	6.6 (4.4–8.9)
6 (2018–2019)	1265	94.6 (91.1–96.7)	1.9 (1.7–2.1)	0.75 (0.65–0.86)	1.8 (1.6–2.0)	4.8 (4.2–5.5)	6.8 (5.6–8.1)
3–5 years							
5 (2016–2017)	542	99.5 (97.8–99.9)	5.8 (4.9–6.9)	2.2 ^E (1.3–3.1)	5.6 (4.4–6.9)	13 (12–15)	19 (12–25)
6 (2018–2019)	510	99.6 (95.2–100)	4.7 (3.9–5.7)	2.2 (1.6–2.9)	4.3 (3.4–5.3)	11 (7.7–15)	15 (13–18)
6–11 years							
5 (2016–2017)	529	98.8 (96.1–99.6)	3.6 (3.1–4.2)	1.5 (1.3–1.8)	3.3 (2.9–3.7)	9.4 (6.3–13)	12 ^E (7.5–17)
6 (2018–2019)	496	97.3 (86.4–99.5)	3.1 (2.7–3.6)	1.3 (0.87–1.8)	3.1 (2.5–3.8)	6.5 (4.8–8.2)	9.5 (7.8–11)
12–19 years							
5 (2016–2017)	530	97.4 (95.4–98.5)	1.5 (1.3–1.7)	0.76 (0.67–0.85)	1.4 (1.2–1.6)	2.9 (2.4–3.4)	3.6 ^E (2.0–5.1)
6 (2018–2019)	499	95.3 (87.7–98.3)	1.5 (1.3–1.7)	0.73 (0.64–0.83)	1.4 (1.1–1.7)	2.8 ^E (1.6–3.9)	4.2 ^E (2.5–5.8)
20–39 years							
5 (2016–2017)	365	95.8 (88.0–98.6)	1.4 (1.2–1.5)	0.65 (<LOD–0.74)	1.1 (0.89–1.3)	3.7 (2.7–4.6)	4.3 ^E (2.2–6.4)
6 (2018–2019)	326	92.2 (87.8–95.2)	1.5 (1.3–1.8)	0.60 ^E (<LOD–0.82)	1.3 (0.85–1.7)	4.8 (3.4–6.2)	5.6 ^E (3.5–7.7)
40–59 years							
5 (2016–2017)	357	96.4 (90.4–98.7)	1.5 (1.3–1.8)	0.59 ^E (0.30–0.88)	1.5 (1.2–1.8)	3.8 (2.9–4.7)	4.6 (3.8–5.5)
6 (2018–2019)	342	92.3 (85.1–96.2)	1.5 (1.4–1.7)	0.63 (<LOD–0.81)	1.5 (1.3–1.8)	3.4 (2.4–4.4)	4.8 (3.5–6.0)
60–79 years							
5 (2016–2017)	350	95.8 (92.5–97.7)	2.0 (1.7–2.3)	0.85 (0.75–0.95)	1.8 (1.6–2.1)	4.6 (3.4–5.8)	5.6 (3.6–7.6)
6 (2018–2019)	338	98.2 (95.5–99.3)	2.0 (1.7–2.3)	0.90 (0.73–1.1)	1.8 (1.4–2.2)	4.4 (3.3–5.5)	6.1 (4.9–7.3)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.20

Mono(2-ethylhexyl) phthalate (MEHP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2498	99.2 (98.0–99.7)	1.9 (1.7–2.1)	0.55 (0.44–0.66)	1.9 (1.6–2.1)	6.5 (5.4–7.6)	9.0 (7.8–10)
5 (2016–2017)	2691	98.5 (96.5–99.4)	1.0 (0.86–1.2)	0.26 (0.20–0.31)	0.96 (0.83–1.1)	3.9 (2.8–4.9)	5.8 ^E (3.6–8.0)
6 (2018–2019)	2471	99.3 (98.2–99.7)	0.92 (0.81–1.0)	0.22 (0.19–0.25)	0.94 (0.82–1.0)	3.5 (2.8–4.2)	5.1 (4.0–6.2)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1253	99.3 (97.5–99.8)	2.1 (1.8–2.5)	0.58 (0.39–0.76)	2.2 (1.8–2.5)	7.2 (5.2–9.2)	11 (7.6–14)
5 (2016–2017)	1342	98.4 (94.5–99.6)	1.0 (0.83–1.2)	0.27 (0.19–0.36)	0.99 (0.78–1.2)	3.8 (2.7–4.9)	5.4 (4.1–6.6)
6 (2018–2019)	1225	99.0 (96.3–99.7)	1.0 (0.90–1.2)	0.24 (0.17–0.30)	1.1 (0.92–1.2)	3.9 (3.4–4.5)	5.1 (3.6–6.6)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1245	99.1 (97.5–99.7)	1.7 (1.5–1.9)	0.55 (0.41–0.69)	1.7 (1.3–2.1)	5.3 (4.2–6.3)	7.9 (6.5–9.3)
5 (2016–2017)	1349	98.6 (96.5–99.4)	1.0 (0.80–1.3)	0.25 (0.17–0.33)	0.90 (0.74–1.1)	4.0 ^E (2.2–5.8)	7.4 ^E (4.3–11)
6 (2018–2019)	1246	99.6 (99.2–99.8)	0.82 (0.69–0.96)	0.21 (0.17–0.25)	0.81 (0.68–0.93)	3.1 (2.3–3.9)	4.8 ^E (2.8–6.7)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	512	99.9 (99.4–100)	2.7 (2.4–3.2)	0.94 (0.77–1.1)	2.7 (2.3–3.1)	7.5 (5.8–9.3)	9.6 ^E (0.44–19)
5 (2016–2017)	553	99.8 (98.6–100)	1.5 (1.3–1.8)	0.36 ^E (0.21–0.52)	1.4 (1.0–1.7)	5.8 (4.7–7.0)	8.2 (6.9–9.5)
6 (2018–2019)	504	99.9 (99.4–100)	1.5 (1.2–1.8)	0.44 (0.35–0.53)	1.4 (1.1–1.7)	5.2 (3.6–6.7)	7.8 ^E (3.9–12)
6–11 years							
1 (2007–2009)	1037	100	3.3 (2.9–3.8)	0.86 (0.70–1.0)	3.3 (2.7–3.8)	12 (10–13)	18 (14–21)
2 (2009–2011)	508	100	2.7 (2.3–3.1)	0.85 ^E (0.53–1.2)	2.5 (2.1–2.9)	8.1 ^E (5.2–11)	11 (8.3–14)
5 (2016–2017)	534	99.9 (98.8–100)	1.4 (1.2–1.6)	0.35 (0.27–0.43)	1.4 (1.1–1.7)	5.1 (3.7–6.4)	5.8 (4.8–6.8)
6 (2018–2019)	489	98.9 (95.9–99.7)	1.1 (0.94–1.4)	0.28 ^E (0.083–0.48)	1.2 (1.0–1.5)	3.4 (2.8–4.1)	4.3 (3.2–5.3)
12–19 years							
1 (2007–2009)	991	99.4 (98.6–99.7)	3.5 (2.8–4.3)	0.79 (0.58–1.0)	3.2 (2.5–3.9)	14 (9.9–19)	23 ^E (6.6–40)
2 (2009–2011)	501	99.2 (96.9–99.8)	2.4 (2.0–2.8)	0.64 (0.52–0.76)	2.4 (2.0–2.8)	6.8 (5.0–8.6)	13 ^E (7.7–18)
5 (2016–2017)	530	97.8 (93.8–99.2)	1.1 (0.96–1.2)	0.32 (0.24–0.41)	1.0 (0.89–1.2)	3.8 (3.0–4.5)	5.4 (4.6–6.2)
6 (2018–2019)	489	99.4 (97.9–99.8)	1.1 (0.88–1.3)	0.25 ^E (0.14–0.36)	1.1 (0.89–1.3)	3.9 (2.9–4.9)	5.5 (3.6–7.4)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	730	99.9 (99.3–100)	4.0 (3.5–4.5)	0.95 (0.72–1.2)	3.9 (3.2–4.6)	15 (11–19)	23 ^E (12–34)
2 (2009–2011)	349	99.5 (97.2–99.9)	1.9 (1.6–2.2)	0.44 ^E (0.19–0.70)	1.9 (1.5–2.4)	7.1 (5.3–8.8)	8.8 ^E (4.9–13)
5 (2016–2017)	371	99.6 (98.5–99.9)	1.2 (0.95–1.6)	0.28 ^E (<LOD–0.50)	1.0 (0.67–1.4)	5.0 ^E (1.3–8.7)	11 ^E (5.5–17)
6 (2018–2019)	324	99.9 (99.6–100)	1.2 (0.91–1.5)	0.28 ^E (0.17–0.40)	1.2 (0.81–1.5)	4.1 ^E (2.3–6.0)	5.8 (4.0–7.5)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	349	98.9 (96.3–99.7)	1.9 (1.5–2.2)	0.63 (0.55–0.72)	1.9 (1.4–2.3)	5.4 (3.7–7.1)	9.0 ^E (4.8–13)
5 (2016–2017)	356	96.9 (89.5–99.1)	0.87 (0.66–1.1)	0.20 (0.13–0.27)	0.90 (0.72–1.1)	2.8 ^E (1.0–4.7)	5.2 ^E (1.7–8.7)
6 (2018–2019)	335	98.8 (94.8–99.7)	0.73 (0.62–0.87)	0.20 (0.15–0.25)	0.74 (0.58–0.89)	3.0 (2.2–3.9)	4.2 (3.0–5.4)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	279	98.8 (94.7–99.7)	1.3 (1.1–1.5)	0.44 (0.29–0.59)	1.2 (0.96–1.5)	4.7 ^E (2.8–6.5)	7.1 ^E (4.2–9.9)
5 (2016–2017)	347	98.8 (97.2–99.5)	0.78 (0.71–0.86)	0.25 (0.22–0.29)	0.73 (0.61–0.85)	2.3 (1.6–3.0)	3.7 (2.8–4.6)
6 (2018–2019)	330	99.2 (97.5–99.8)	0.71 (0.62–0.82)	0.20 (0.14–0.25)	0.75 (0.55–0.95)	2.2 (1.7–2.8)	3.6 (2.8–4.4)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.3, 0.09, 0.11 and 0.077 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.
E Use data with caution.

Table 14.1.21

Mono(2-ethylhexyl) phthalate (MEHP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2489	99.2 (98.0–99.7)	1.8 (1.7–2.0)	0.64 (0.52–0.76)	1.7 (1.6–1.9)	5.5 (4.8–6.1)	8.7 (7.3–10)
5 (2016–2017)	2660	98.5 (96.5–99.4)	0.98 (0.86–1.1)	0.29 (0.24–0.34)	0.97 (0.85–1.1)	3.3 (2.6–4.1)	4.6 (3.0–6.2)
6 (2018–2019)	2470	99.3 (98.2–99.7)	0.99 (0.88–1.1)	0.31 (0.27–0.35)	0.95 (0.86–1.1)	3.4 (2.9–3.8)	4.5 (3.5–5.4)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1249	99.3 (97.5–99.8)	1.7 (1.5–2.0)	0.58 (0.45–0.70)	1.6 (1.3–1.8)	5.7 (4.7–6.7)	9.3 (6.6–12)
5 (2016–2017)	1328	98.4 (94.5–99.6)	0.87 (0.77–0.99)	0.28 (0.22–0.34)	0.83 (0.62–1.0)	2.8 (2.1–3.5)	3.9 (3.2–4.7)
6 (2018–2019)	1224	99.0 (96.3–99.7)	0.95 (0.85–1.1)	0.31 (0.26–0.36)	0.95 (0.84–1.1)	3.2 (2.5–3.9)	4.1 (3.3–5.0)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1240	99.1 (97.5–99.7)	1.9 (1.7–2.2)	0.75 (0.59–0.91)	1.8 (1.6–2.1)	5.2 (4.3–6.0)	7.9 (6.3–9.6)
5 (2016–2017)	1332	98.6 (96.5–99.4)	1.1 (0.91–1.3)	0.30 (0.21–0.39)	1.0 (0.86–1.2)	3.7 (2.6–4.8)	6.0 ^F (3.3–8.6)
6 (2018–2019)	1246	99.6 (99.2–99.8)	1.0 (0.86–1.2)	0.33 (0.24–0.41)	0.95 (0.81–1.1)	3.4 (2.6–4.1)	5.0 ^F (2.3–7.6)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	511	99.9 (99.4–100)	4.7 (4.1–5.4)	1.8 (1.4–2.2)	4.4 (3.9–4.9)	12 (7.6–16)	19 ^F (12–26)
5 (2016–2017)	542	99.8 (98.6–100)	2.7 (2.2–3.2)	1.0 (0.91–1.1)	2.5 (2.0–2.9)	8.3 (7.0–9.6)	10 ^F (6.2–14)
6 (2018–2019)	503	99.9 (99.4–100)	2.4 (2.0–2.9)	0.98 (0.72–1.2)	2.1 (1.5–2.7)	6.7 (5.4–7.9)	10 ^F (5.8–15)
6–11 years							
1 (2007–2009)	1034	100	5.1 (4.5–5.7)	1.9 (1.6–2.1)	4.8 (4.3–5.3)	16 (14–18)	22 (18–25)
2 (2009–2011)	506	100	3.1 (2.7–3.5)	1.1 (0.83–1.3)	2.8 (2.4–3.2)	8.8 (7.0–11)	11 (8.5–13)
5 (2016–2017)	526	99.9 (98.8–100)	1.6 (1.4–1.9)	0.59 (0.43–0.75)	1.4 (1.2–1.7)	4.6 (3.6–5.5)	5.7 (4.3–7.0)
6 (2018–2019)	489	98.9 (95.9–99.7)	1.4 (1.2–1.5)	0.47 (0.36–0.57)	1.4 (1.2–1.5)	3.4 (2.9–4.0)	4.3 (3.1–5.5)
12–19 years							
1 (2007–2009)	989	99.4 (98.6–99.7)	3.0 (2.3–3.8)	0.82 (0.63–1.0)	2.8 (2.3–3.2)	10 (6.6–14)	19 ^F (0.21–38)
2 (2009–2011)	499	99.2 (96.9–99.8)	1.8 (1.6–2.0)	0.64 (0.56–0.72)	1.8 (1.6–2.0)	4.8 (3.4–6.2)	6.4 ^F (3.2–9.6)
5 (2016–2017)	524	97.8 (93.8–99.2)	0.82 (0.68–1.0)	0.24 (0.20–0.29)	0.82 (0.64–1.0)	2.2 (1.5–2.9)	3.1 (2.0–4.3)
6 (2018–2019)	489	99.4 (97.9–99.8)	0.88 (0.76–1.0)	0.27 ^E (0.14–0.39)	0.88 (0.79–0.96)	2.9 (2.4–3.4)	3.7 (3.1–4.4)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	728	99.9 (99.3–100)	4.2 (3.7–4.8)	1.2 ^E (0.75–1.7)	3.7 (3.1–4.3)	14 (11–16)	21 ^E (13–30)
2 (2009–2011)	347	99.5 (97.2–99.9)	1.6 (1.3–1.9)	0.65 ^E (0.41–0.90)	1.4 (1.1–1.7)	4.8 (3.3–6.4)	6.6 ^E (3.4–9.9)
5 (2016–2017)	367	99.6 (98.5–99.9)	1.1 (0.88–1.4)	0.29 (<LOD–0.37)	0.96 (0.71–1.2)	3.6 ^E (0.55–6.6)	6.8 ^E (0.78–13)
6 (2018–2019)	324	99.9 (99.6–100)	1.1 (0.87–1.4)	0.32 (0.24–0.41)	0.97 (0.76–1.2)	3.4 ^E (1.9–4.8)	5.2 ^E (<LOD–12)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	348	98.9 (96.3–99.7)	1.8 (1.6–2.1)	0.59 ^E (0.35–0.83)	1.8 (1.5–2.1)	4.8 (4.1–5.5)	7.6 ^E (4.0–11)
5 (2016–2017)	355	96.9 (89.5–99.1)	0.79 (0.66–0.96)	0.22 ^E (0.088–0.35)	0.81 (0.55–1.1)	2.5 (1.7–3.3)	3.5 (2.5–4.4)
6 (2018–2019)	335	98.8 (94.8–99.7)	0.86 (0.74–1.0)	0.28 (0.20–0.37)	0.85 (0.67–1.0)	3.4 ^E (1.9–4.8)	4.2 (3.4–5.0)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	278	98.8 (94.7–99.7)	1.5 (1.3–1.7)	0.50 (0.33–0.68)	1.4 (1.1–1.6)	4.6 (3.3–5.8)	7.2 ^E (4.4–10)
5 (2016–2017)	346	98.8 (97.2–99.5)	0.89 (0.80–1.0)	0.30 (0.26–0.34)	0.88 (0.76–1.0)	2.6 (2.0–3.3)	4.2 (2.9–5.5)
6 (2018–2019)	330	99.2 (97.5–99.8)	0.84 (0.73–0.96)	0.29 (0.22–0.36)	0.82 (0.69–0.94)	2.5 (1.8–3.2)	3.4 (2.5–4.2)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.22

Mono(2-ethyl-5-carboxypentyl) phthalate (MECPP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2705	99.5 (97.0–99.9)	6.1 (5.2–7.3)	1.8 (1.3–2.3)	6.3 (5.1–7.4)	21 (16–26)	30 (23–36)
6 (2018–2019)	2501	99.5 (98.3–99.8)	5.2 (4.7–5.7)	1.5 (1.3–1.6)	5.3 (4.7–5.9)	16 (13–19)	22 (18–26)
Males, 3–79 years							
5 (2016–2017)	1346	99.1 (93.6–99.9)	6.0 (4.9–7.3)	1.7 ^E (1.0–2.4)	6.2 (5.1–7.3)	21 (15–27)	29 ^E (15–44)
6 (2018–2019)	1240	99.0 (96.6–99.7)	5.4 (4.7–6.3)	1.6 (1.1–2.0)	5.7 (4.9–6.5)	18 (14–21)	25 (19–31)
Females, 3–79 years							
5 (2016–2017)	1359	99.9 (99.5–100)	6.3 (5.0–8.0)	1.9 (1.3–2.5)	6.4 (4.6–8.2)	21 (16–27)	30 (23–37)
6 (2018–2019)	1261	99.9 (99.7–100)	4.9 (4.4–5.4)	1.4 (1.3–1.6)	5.0 (4.1–5.8)	14 (12–15)	20 (17–24)
3–5 years							
5 (2016–2017)	555	100	15 (12–19)	4.7 ^E (2.9–6.5)	15 (11–19)	49 (40–57)	57 (49–64)
6 (2018–2019)	509	100	12 (10–15)	4.4 (3.3–5.5)	11 (8.9–13)	38 (29–46)	51 ^E (32–70)
6–11 years							
5 (2016–2017)	535	100	13 (11–15)	4.2 (2.7–5.7)	13 (11–14)	38 (26–49)	52 ^E (29–75)
6 (2018–2019)	496	100	9.8 (8.1–12)	3.3 (2.2–4.4)	10 (8.7–11)	28 (21–34)	34 (29–39)
12–19 years							
5 (2016–2017)	536	99.9 (99.5–100)	6.9 (6.1–7.7)	2.0 (1.6–2.3)	7.8 (7.0–8.6)	19 (15–22)	23 (18–29)
6 (2018–2019)	497	98.8 (94.5–99.7)	6.3 (5.0–7.9)	2.0 ^E (1.2–2.8)	6.8 (5.3–8.3)	18 (15–22)	26 ^E (14–37)
20–39 years							
5 (2016–2017)	373	100 (99.9–100)	5.6 (4.1–7.5)	1.5 ^E (0.56–2.4)	5.3 ^E (3.1–7.5)	22 (15–29)	24 ^E (4.5–44)
6 (2018–2019)	326	100 (99.9–100)	5.1 (4.2–6.2)	1.3 ^E (0.74–1.9)	5.7 (4.0–7.5)	14 ^E (8.2–19)	21 (14–28)
40–59 years							
5 (2016–2017)	355	98.6 (89.5–99.8)	5.3 (4.1–6.8)	1.6 (1.0–2.1)	5.6 (4.4–6.8)	15 ^E (7.1–24)	24 ^E (14–35)
6 (2018–2019)	337	98.5 (93.5–99.7)	4.0 (3.5–4.4)	1.4 (1.2–1.6)	4.5 (4.2–4.8)	11 (9.1–12)	14 (11–17)
60–79 years							
5 (2016–2017)	351	99.8 (98.6–100)	5.7 (5.1–6.3)	2.1 (1.8–2.4)	5.4 (4.4–6.5)	15 (12–18)	21 (13–28)
6 (2018–2019)	336	100	4.9 (4.2–5.6)	1.7 (1.2–2.2)	5.1 (3.9–6.4)	15 (11–18)	19 (16–22)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.28 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.23

Mono(2-ethyl-5-carboxypentyl) phthalate (MECPP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2673	99.5 (97.0–99.9)	5.9 (5.2–6.7)	2.4 (2.0–2.8)	5.4 (4.5–6.3)	17 (13–21)	26 (21–31)
6 (2018–2019)	2500	99.5 (98.3–99.8)	5.6 (5.0–6.3)	2.2 (2.0–2.4)	5.1 (4.3–5.9)	14 (12–16)	23 (18–29)
Males, 3–79 years							
5 (2016–2017)	1331	99.1 (93.6–99.9)	5.2 (4.6–5.7)	2.1 (1.9–2.4)	4.6 (4.0–5.3)	14 (11–16)	22 (18–26)
6 (2018–2019)	1239	99.0 (96.6–99.7)	5.0 (4.4–5.7)	2.1 (1.8–2.4)	4.5 (3.7–5.3)	14 (12–16)	20 (15–26)
Females, 3–79 years							
5 (2016–2017)	1342	99.9 (99.5–100)	6.8 (5.7–8.3)	2.9 (2.5–3.3)	6.6 (5.3–7.9)	20 (15–26)	28 (21–35)
6 (2018–2019)	1261	99.9 (99.7–100)	6.2 (5.4–7.1)	2.4 (2.0–2.9)	5.6 (4.5–6.8)	14 (11–18)	31 ^E (17–45)
3–5 years							
5 (2016–2017)	544	100	26 (23–30)	10 (8.5–12)	25 (21–29)	61 (52–71)	76 (56–95)
6 (2018–2019)	508	100	20 (16–25)	8.7 (5.8–12)	18 (14–23)	47 (42–51)	64 ^E (34–95)
6–11 years							
5 (2016–2017)	527	100	14 (12–17)	6.2 (4.9–7.6)	14 (12–15)	34 ^E (19–49)	54 (36–72)
6 (2018–2019)	496	100	12 (11–13)	6.0 (4.7–7.3)	11 (8.3–13)	24 (22–27)	33 (25–41)
12–19 years							
5 (2016–2017)	529	99.9 (99.5–100)	5.2 (4.5–6.1)	2.1 (1.6–2.6)	5.4 (4.6–6.2)	11 (9.0–14)	15 (12–18)
6 (2018–2019)	497	98.8 (94.5–99.7)	5.1 (4.3–6.1)	2.2 (1.8–2.6)	4.9 (4.3–5.5)	14 (11–16)	16 (11–20)
20–39 years							
5 (2016–2017)	369	100 (99.9–100)	5.0 (4.2–6.0)	2.2 (1.7–2.7)	3.7 (3.1–4.3)	18 ^E (7.6–28)	25 ^E (16–35)
6 (2018–2019)	326	100 (99.9–100)	4.9 (3.9–6.0)	2.0 (1.6–2.5)	4.1 (2.9–5.2)	13 ^E (8.0–18)	21 ^E (6.9–35)
40–59 years							
5 (2016–2017)	354	98.6 (89.5–99.8)	4.8 (4.0–5.7)	2.1 (1.5–2.7)	4.8 (4.0–5.5)	10 (9.1–11)	11 (8.1–14)
6 (2018–2019)	337	98.5 (93.5–99.7)	4.7 (4.1–5.3)	2.2 (1.9–2.5)	4.5 (3.7–5.4)	9.6 (8.0–11)	13 ^E (8.3–18)
60–79 years							
5 (2016–2017)	350	99.8 (98.6–100)	6.5 (5.8–7.4)	2.7 (2.2–3.2)	6.5 (5.3–7.7)	13 (10–16)	18 (13–23)
6 (2018–2019)	336	100	5.7 (5.0–6.5)	2.4 (2.0–2.9)	5.6 (4.8–6.4)	12 (10–14)	14 ^E (8.0–20)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.24

Mono(2-ethyl-5-oxohexyl) phthalate (MEOHP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2561	100	7.4 (6.9–8.0)	2.3 (2.1–2.5)	7.4 (6.7–8.1)	23 (20–26)	34 (30–39)
5 (2016–2017)	2716	99.3 (97.1–99.8)	3.5 (3.0–4.0)	0.99 (0.83–1.2)	3.5 (2.9–4.1)	12 (9.3–14)	17 (14–21)
6 (2018–2019)	2524	99.4 (98.3–99.8)	3.1 (2.8–3.4)	0.86 (0.74–0.98)	3.1 (2.8–3.5)	9.8 (9.1–11)	13 (11–15)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1282	100	7.9 (6.8–9.1)	2.4 (2.0–2.8)	7.8 (7.0–8.7)	25 (20–31)	37 ^E (22–52)
5 (2016–2017)	1353	99.2 (93.7–99.9)	3.4 (2.8–4.1)	0.98 (0.70–1.3)	3.4 (2.8–4.1)	12 (8.5–16)	17 ^E (8.6–26)
6 (2018–2019)	1252	98.9 (96.6–99.7)	3.3 (2.9–3.7)	1.0 (0.80–1.2)	3.3 (3.0–3.7)	10 (8.7–11)	15 (12–17)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1279	100	7.0 (6.5–7.6)	2.3 (2.0–2.6)	6.7 (5.7–7.8)	22 (18–25)	29 (23–36)
5 (2016–2017)	1363	99.5 (95.1–99.9)	3.5 (2.9–4.3)	1.0 (0.86–1.1)	3.7 (2.8–4.5)	11 (8.5–14)	17 (13–22)
6 (2018–2019)	1272	99.8 (96.1–100)	2.9 (2.6–3.2)	0.79 (0.64–0.94)	2.9 (2.3–3.4)	9.7 (8.0–11)	12 (10–14)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	523	100	17 (15–19)	6.0 (4.7–7.2)	17 (15–20)	46 (35–57)	67 ^E (38–95)
5 (2016–2017)	555	100	8.5 (6.9–10)	2.6 (1.8–3.5)	8.7 (6.6–11)	27 (23–30)	34 (26–42)
6 (2018–2019)	512	100	7.4 (6.1–8.9)	2.6 (2.1–3.1)	7.3 (5.8–8.9)	22 ^E (12–31)	34 (24–44)
6–11 years							
1 (2007–2009)	1037	100	20 (18–22)	5.5 (4.7–6.4)	20 (17–22)	69 (59–78)	100 (84–120)
2 (2009–2011)	516	100	15 (13–18)	4.7 (3.4–6.1)	16 (12–20)	44 (28–60)	57 (50–65)
5 (2016–2017)	537	100	7.0 (6.0–8.2)	2.1 (1.5–2.8)	7.5 (6.2–8.8)	20 ^E (12–28)	31 ^E (19–43)
6 (2018–2019)	497	100	5.8 (4.7–7.0)	1.8 ^E (1.1–2.5)	6.1 (4.7–7.5)	16 (13–19)	19 (16–22)
12–19 years							
1 (2007–2009)	991	100	18 (15–21)	4.5 (3.6–5.5)	17 (15–20)	61 (51–72)	99 ^E (43–150)
2 (2009–2011)	512	100	10 (8.6–12)	3.2 ^E (1.7–4.7)	9.9 (8.6–11)	30 (22–38)	44 (30–59)
5 (2016–2017)	538	99.9 (99.5–100)	4.0 (3.6–4.6)	1.2 ^E (0.73–1.6)	4.5 (4.1–4.9)	11 (9.3–13)	14 (9.6–19)
6 (2018–2019)	503	99.7 (97.5–100)	3.8 (3.1–4.6)	1.2 ^E (0.65–1.8)	4.1 (3.0–5.3)	11 (8.5–13)	14 ^E (5.8–21)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	730	100	13 (11–15)	3.5 (2.6–4.4)	13 (10–15)	48 (34–62)	75 ^E (32–120)
2 (2009–2011)	359	100	6.6 (5.6–7.8)	2.4 (1.9–2.9)	6.7 (5.4–8.0)	19 (16–21)	24 ^E (14–35)
5 (2016–2017)	374	99.1 (91.7–99.9)	3.1 (2.4–4.1)	0.86 ^E (0.33–1.4)	3.0 ^E (1.9–4.2)	12 (8.2–15)	17 ^E (9.7–24)
6 (2018–2019)	331	99.8 (83.7–100)	3.2 (2.6–3.8)	0.94 (0.67–1.2)	3.4 (2.3–4.4)	9.3 (7.7–11)	11 (8.7–14)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	360	100	6.6 (5.5–7.8)	2.3 (1.7–2.8)	6.2 (5.1–7.2)	19 (15–23)	26 ^E (16–36)
5 (2016–2017)	359	98.6 (89.7–99.8)	3.0 (2.3–3.8)	0.98 (0.62–1.3)	2.9 (2.2–3.5)	8.4 ^E (3.3–13)	13 ^E (7.1–20)
6 (2018–2019)	341	98.2 (94.3–99.5)	2.3 (2.0–2.6)	0.68 (0.50–0.87)	2.7 (2.3–3.1)	6.9 (5.5–8.3)	10 (6.8–14)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	291	100	6.0 (5.1–7.0)	2.0 (1.5–2.5)	6.0 (4.7–7.4)	17 (12–22)	23 ^E (4.9–41)
5 (2016–2017)	353	100	3.2 (2.8–3.6)	0.99 (0.83–1.2)	3.2 (2.8–3.6)	8.7 (7.7–9.8)	14 ^E (7.7–19)
6 (2018–2019)	340	100	2.8 (2.4–3.3)	1.0 (0.85–1.2)	2.8 (2.0–3.7)	8.2 (6.7–9.8)	11 (9.5–12)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.2, 0.1, 0.17 and 0.17 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
 b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.
 E Use data with caution.

Table 14.1.25

Mono(2-ethyl-5-oxohexyl) phthalate (MEOHP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2551	100	7.3 (6.9–7.7)	2.8 (2.5–3.1)	6.9 (6.3–7.5)	19 (17–21)	31 (27–34)
5 (2016–2017)	2684	99.3 (97.1–99.8)	3.4 (3.0–3.7)	1.3 (1.1–1.5)	3.1 (2.7–3.6)	9.5 (8.3–11)	15 (12–19)
6 (2018–2019)	2523	99.4 (98.3–99.8)	3.3 (3.0–3.7)	1.3 (1.1–1.4)	3.0 (2.5–3.4)	9.3 (7.7–11)	14 (10–18)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1278	100	6.7 (6.0–7.4)	2.6 (2.1–3.1)	6.1 (5.3–7.0)	20 (14–26)	32 (26–37)
5 (2016–2017)	1338	99.2 (93.7–99.9)	3.0 (2.7–3.3)	1.1 (1.0–1.3)	2.5 (2.2–2.8)	8.1 (6.9–9.4)	13 (9.7–16)
6 (2018–2019)	1251	98.9 (96.6–99.7)	3.0 (2.7–3.5)	1.1 (0.98–1.3)	2.7 (2.4–2.9)	8.9 (7.2–11)	13 (8.3–17)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1273	100	8.0 (7.3–8.8)	3.2 (2.5–3.8)	7.8 (6.8–8.7)	19 (17–21)	26 (20–32)
5 (2016–2017)	1346	99.5 (95.1–99.9)	3.8 (3.3–4.5)	1.4 (1.3–1.6)	3.7 (2.9–4.5)	10 (7.0–13)	17 (12–22)
6 (2018–2019)	1272	99.8 (96.1–100)	3.6 (3.1–4.2)	1.4 (1.3–1.6)	3.3 (2.6–4.0)	10 (7.6–12)	17 ^F (10–24)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	100	30 (27–33)	13 (11–15)	28 (25–31)	71 (58–85)	90 (58–120)
5 (2016–2017)	544	100	15 (13–17)	6.2 (4.4–8.0)	14 (12–15)	35 (31–39)	43 (28–58)
6 (2018–2019)	511	100	12 (10–15)	5.7 (3.9–7.6)	10 (7.8–13)	27 (18–36)	40 (26–54)
6–11 years							
1 (2007–2009)	1034	100	30 (27–34)	12 (9.7–14)	28 (24–31)	84 (74–94)	120 (95–140)
2 (2009–2011)	514	100	17 (16–19)	7.7 (6.5–8.8)	17 (15–18)	45 (35–56)	52 (40–65)
5 (2016–2017)	529	100	8.2 (7.0–9.6)	3.4 (2.8–4.0)	8.0 (7.1–9.0)	19 (12–26)	31 (20–41)
6 (2018–2019)	497	100	6.9 (6.2–7.6)	3.1 (2.7–3.4)	6.7 (5.7–7.8)	14 (12–16)	19 (16–22)
12–19 years							
1 (2007–2009)	989	100	15 (13–18)	5.5 (4.5–6.4)	13 (11–15)	45 (31–60)	76 ^F (19–130)
2 (2009–2011)	510	100	7.8 (6.9–8.9)	3.2 (2.8–3.7)	7.6 (6.5–8.8)	17 (13–21)	25 ^E (14–35)
5 (2016–2017)	531	99.9 (99.5–100)	3.1 (2.6–3.7)	1.3 (1.1–1.5)	3.1 (2.3–3.8)	6.7 (4.9–8.4)	9.4 (7.7–11)
6 (2018–2019)	503	99.7 (97.5–100)	3.1 (2.7–3.6)	1.3 (1.1–1.6)	3.0 (2.5–3.5)	7.3 (6.3–8.3)	9.2 (6.7–12)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	728	100	14 (12–16)	5.2 (4.3–6.1)	12 (10–13)	46 (33–59)	84 (56–110)
2 (2009–2011)	357	100	5.6 (4.8–6.6)	2.2 (1.6–2.7)	4.9 (3.9–5.9)	13 ^E (7.4–19)	19 (14–25)
5 (2016–2017)	370	99.1 (91.7–99.9)	2.8 (2.4–3.3)	1.1 (0.80–1.4)	2.4 (2.1–2.6)	8.5 ^E (2.9–14)	14 ^E (6.5–22)
6 (2018–2019)	331	99.8 (83.7–100)	3.0 (2.4–3.7)	1.2 (0.86–1.5)	2.7 (2.2–3.2)	8.3 ^E (4.4–12)	15 ^E (5.3–24)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	358	100	6.6 (5.9–7.4)	2.8 (2.3–3.3)	6.6 (5.8–7.5)	14 (12–17)	21 ^E (13–29)
5 (2016–2017)	358	98.6 (89.7–99.8)	2.7 (2.4–3.2)	1.1 (0.78–1.5)	2.7 (2.4–3.0)	5.8 (4.4–7.3)	7.6 (5.0–10)
6 (2018–2019)	341	98.2 (94.3–99.5)	2.7 (2.4–3.1)	1.1 (0.78–1.4)	2.6 (2.2–3.0)	6.9 (5.2–8.7)	10 (6.9–14)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	290	100	6.9 (6.3–7.6)	3.1 (2.5–3.7)	7.0 (6.3–7.7)	14 (11–16)	18 (11–24)
5 (2016–2017)	352	100	3.6 (3.3–4.1)	1.6 (1.3–1.8)	3.6 (3.1–4.1)	7.5 (6.2–8.7)	10 (6.6–14)
6 (2018–2019)	340	100	3.3 (2.9–3.9)	1.3 (1.1–1.6)	3.3 (2.7–4.0)	6.9 (5.4–8.3)	10 (6.9–14)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.26

Mono(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2561	99.5 (97.5–99.9)	13 (12–14)	3.9 (3.4–4.4)	12 (12–13)	39 (34–44)	59 (48–70)
5 (2016–2017)	2716	99.5 (97.0–99.9)	5.2 (4.4–6.1)	1.5 (1.1–1.8)	5.3 (4.3–6.3)	17 (12–21)	26 (20–31)
6 (2018–2019)	2529	100 (99.8–100)	4.7 (4.2–5.1)	1.3 (1.1–1.4)	4.8 (4.3–5.4)	14 (13–15)	20 (17–23)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1282	99.2 (94.3–99.9)	14 (12–16)	4.2 (3.1–5.2)	13 (12–15)	43 (31–54)	69 (53–84)
5 (2016–2017)	1353	99.2 (93.7–99.9)	5.1 (4.3–6.2)	1.4 (0.91–1.8)	5.3 (4.2–6.3)	17 (12–21)	26 (20–32)
6 (2018–2019)	1254	100	5.1 (4.6–5.8)	1.4 (1.0–1.8)	5.3 (4.6–5.9)	15 (12–18)	24 (21–27)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1279	99.9 (98.6–100)	12 (11–12)	3.8 (3.2–4.4)	11 (9.4–13)	35 (31–40)	47 (39–56)
5 (2016–2017)	1363	99.9 (99.4–100)	5.2 (4.3–6.4)	1.5 (1.1–2.0)	5.5 (3.9–7.0)	17 (11–22)	24 (18–31)
6 (2018–2019)	1275	99.9 (99.7–100)	4.2 (3.8–4.7)	1.1 (0.85–1.3)	4.3 (3.5–5.0)	14 (11–16)	17 (15–19)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	523	100	26 (23–30)	8.6 (6.4–11)	25 (21–30)	69 (53–86)	99 ^F (59–140)
5 (2016–2017)	555	100	12 (9.5–14)	3.6 (2.7–4.5)	11 (8.5–14)	36 (33–39)	44 (33–55)
6 (2018–2019)	512	100	9.9 (8.2–12)	3.3 (2.8–3.8)	10 (8.4–12)	30 ^E (16–44)	47 (33–61)
6–11 years							
1 (2007–2009)	1037	100	31 (28–35)	8.8 (7.6–10)	31 (27–35)	100 (90–120)	180 (130–230)
2 (2009–2011)	516	100	24 (20–27)	7.0 (5.4–8.7)	24 (19–29)	71 (52–90)	97 (73–120)
5 (2016–2017)	537	100	9.7 (8.3–11)	3.1 ^F (1.9–4.4)	9.9 (8.2–12)	29 (19–39)	44 ^F (25–63)
6 (2018–2019)	497	100	8.0 (6.5–9.8)	2.3 ^E (0.92–3.6)	8.0 (5.7–10)	23 (19–26)	26 (18–33)
12–19 years							
1 (2007–2009)	991	100	29 (24–34)	7.5 (5.8–9.3)	29 (25–32)	99 (78–120)	160 ^F (64–260)
2 (2009–2011)	512	100	16 (14–20)	4.6 ^F (2.4–6.8)	16 (13–20)	47 (36–58)	68 (49–87)
5 (2016–2017)	538	100	5.9 (5.3–6.6)	2.1 (1.5–2.8)	6.6 (5.8–7.5)	15 (10–20)	23 (17–29)
6 (2018–2019)	504	99.8 (97.9–100)	5.4 (4.5–6.6)	1.7 ^F (0.94–2.5)	5.8 (4.5–7.2)	15 (12–19)	22 ^E (13–32)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	730	100	22 (19–26)	5.7 (4.5–6.9)	21 (16–26)	90 (67–110)	150 ^E (83–220)
2 (2009–2011)	359	98.6 (90.7–99.8)	11 (9.1–13)	3.8 (3.0–4.6)	12 (10–13)	30 (23–37)	40 ^E (20–60)
5 (2016–2017)	374	100	4.7 (3.5–6.3)	1.2 ^E (0.50–2.0)	4.8 ^E (2.6–7.0)	16 ^E (6.4–25)	25 (16–34)
6 (2018–2019)	332	100 (99.9–100)	4.9 (4.1–5.8)	1.3 (0.93–1.7)	5.3 (3.9–6.7)	14 (11–16)	19 ^E (12–26)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	360	99.8 (97.8–100)	12 (9.7–14)	4.1 ^E (2.6–5.5)	11 (8.7–13)	35 (28–41)	44 ^E (21–67)
5 (2016–2017)	359	98.6 (89.7–99.8)	4.6 (3.6–5.8)	1.5 ^E (0.91–2.1)	4.7 (3.5–5.9)	14 ^E (8.7–19)	19 (14–25)
6 (2018–2019)	342	100	3.6 (3.3–4.0)	1.0 (0.93–1.2)	4.0 (3.1–4.8)	11 (7.9–13)	15 (11–19)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	291	100	10 (8.8–12)	3.4 (2.5–4.3)	10 (7.4–13)	28 ^E (17–38)	44 ^E (23–66)
5 (2016–2017)	353	99.8 (98.6–100)	4.7 (4.2–5.4)	1.5 (1.2–1.8)	4.8 (4.0–5.5)	12 (9.7–15)	18 ^E (7.9–29)
6 (2018–2019)	342	100	4.3 (3.7–5.0)	1.5 (1.1–1.9)	4.3 (3.1–5.5)	13 (10–15)	16 ^E (8.5–23)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.4, 0.5, 0.22 and 0.22 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
 b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.
 E Use data with caution.

Table 14.1.27

Mono(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2551	99.5 (97.5–99.9)	12 (12–13)	5.0 (4.5–5.4)	12 (11–12)	32 (28–35)	51 (44–59)
5 (2016–2017)	2684	99.5 (97.0–99.9)	5.0 (4.5–5.6)	2.0 (1.7–2.4)	4.6 (4.1–5.2)	13 (11–15)	20 (16–23)
6 (2018–2019)	2528	100 (99.8–100)	5.1 (4.5–5.7)	2.0 (1.8–2.1)	4.6 (4.0–5.2)	14 (11–16)	23 (16–30)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1278	99.2 (94.3–99.9)	12 (10–13)	4.3 (3.4–5.2)	10 (9.3–11)	33 (24–43)	58 (45–72)
5 (2016–2017)	1338	99.2 (93.7–99.9)	4.4 (4.0–4.9)	1.8 (1.5–2.1)	3.9 (3.4–4.4)	12 (10–13)	19 (14–25)
6 (2018–2019)	1253	100	4.8 (4.3–5.4)	1.9 (1.7–2.0)	4.3 (3.9–4.7)	14 (11–17)	22 (15–30)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1273	99.9 (98.6–100)	13 (12–14)	5.4 (4.8–5.9)	13 (11–14)	30 (26–35)	43 (34–51)
5 (2016–2017)	1346	99.9 (99.4–100)	5.7 (4.9–6.7)	2.4 (2.0–2.7)	5.5 (4.8–6.2)	15 (10–19)	20 ^E (12–28)
6 (2018–2019)	1275	99.9 (99.7–100)	5.4 (4.7–6.2)	2.3 (1.9–2.6)	4.9 (4.1–5.7)	14 (11–18)	24 ^E (12–36)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	100	46 (41–51)	20 (17–23)	42 (37–46)	110 (89–120)	130 ^F (67–190)
5 (2016–2017)	544	100	20 (18–23)	8.5 (6.2–11)	19 (16–22)	49 (44–54)	62 (43–81)
6 (2018–2019)	511	100	16 (13–20)	7.5 (5.4–9.6)	14 (10–19)	38 ^E (24–53)	64 (44–84)
6–11 years							
1 (2007–2009)	1034	100	48 (44–53)	19 (16–22)	44 (39–48)	130 (110–150)	190 (150–240)
2 (2009–2011)	514	100	27 (24–30)	11 (9.6–13)	24 (22–27)	70 (56–83)	90 (68–110)
5 (2016–2017)	529	100	11 (9.5–13)	4.8 (3.5–6.0)	10 (8.9–12)	29 (19–40)	43 (30–56)
6 (2018–2019)	497	100	9.6 (8.6–11)	4.3 (3.8–4.7)	9.8 (8.6–11)	19 (16–22)	26 (19–34)
12–19 years							
1 (2007–2009)	989	100	25 (21–29)	9.0 (7.9–10)	22 (18–25)	76 ^E (44–110)	120 ^E (13–230)
2 (2009–2011)	510	100	12 (11–14)	5.0 (4.2–5.9)	12 (10–14)	27 (21–34)	37 ^E (15–60)
5 (2016–2017)	531	100	4.5 (3.9–5.3)	2.0 (1.6–2.4)	4.5 (3.6–5.5)	9.7 (7.2–12)	13 (8.1–17)
6 (2018–2019)	504	99.8 (97.9–100)	4.5 (4.0–5.1)	1.9 (1.6–2.2)	4.3 (3.6–5.0)	11 (8.8–13)	13 (11–16)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
20–39 years							
1 (2007–2009)	728	100	23 (21–26)	8.5 (6.7–10)	20 (18–22)	80 (53–110)	140 (93–190)
2 (2009–2011)	357	98.6 (90.7–99.8)	9.4 (7.9–11)	3.9 (2.6–5.2)	8.5 (6.2–11)	23 (18–27)	29 ^E (16–42)
5 (2016–2017)	370	100	4.3 (3.6–5.0)	1.8 (1.4–2.2)	3.9 (3.2–4.6)	12 ^E (4.1–19)	19 ^E (10–27)
6 (2018–2019)	332	100 (99.9–100)	4.6 (3.8–5.7)	1.8 (1.4–2.3)	4.1 (3.1–5.2)	12 ^E (6.6–18)	26 ^E (7.4–45)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	358	99.8 (97.8–100)	12 (11–13)	5.1 (4.3–5.9)	11 (10–13)	27 (22–33)	36 ^E (18–54)
5 (2016–2017)	358	98.6 (89.7–99.8)	4.2 (3.6–4.9)	1.8 (1.3–2.3)	4.1 (3.8–4.5)	8.8 (6.5–11)	13 (8.7–17)
6 (2018–2019)	342	100	4.3 (3.9–4.8)	1.8 (1.5–2.1)	4.1 (3.6–4.6)	10 (7.2–13)	17 ^E (8.2–25)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	290	100	12 (11–13)	5.2 (4.2–6.1)	12 (11–14)	24 (21–27)	35 (27–42)
5 (2016–2017)	352	99.8 (98.6–100)	5.4 (4.9–6.1)	2.5 (2.1–2.8)	5.3 (4.7–5.8)	11 (9.0–13)	14 ^E (8.1–20)
6 (2018–2019)	342	100	5.1 (4.4–5.8)	2.1 (1.8–2.5)	5.0 (4.2–5.7)	11 (8.3–13)	15 (13–17)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.28

Mono-carboxy-*n*-heptyl phthalate (MCHpP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2213	0.50 ^E (0.10–2.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2115	0.30 ^E (0–1.7)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1106	0.30 ^E (0–2.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1051	0.40 ^E (0.10–3.6)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1107	0.70 ^E (0.10–4.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1064	0 ^E (0–0.30)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	441	0.20 ^E (0–2.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	430	0.10 ^E (0–2.4)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
5 (2016–2017)	425	0.30 ^E (0.10–2.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	412	0.50 ^E (0.10–2.6)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
5 (2016–2017)	433	0.30 ^E (0–2.8)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	412	0.30 ^E (0.10–1.2)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
5 (2016–2017)	308	0.50 ^E (0.10–3.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	275	0.60 ^E (0–11.1)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	303	0.10 ^E (0–0.70)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	294	0	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	303	1.0 ^E (0.10–10.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	292	0.10 ^E (0–0.80)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.083 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.29

Mono-carboxy-*n*-heptyl phthalate (MCHpP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2184	0.50 ^E (0.10–2.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2115	0.30 ^E (0–1.7)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1092	0.30 ^E (0–2.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1051	0.40 ^E (0.10–3.6)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1092	0.70 ^E (0.10–4.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1064	0 ^E (0–0.30)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	433	0.20 ^E (0–2.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	430	0.10 ^E (0–2.4)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
5 (2016–2017)	417	0.30 ^E (0.10–2.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	412	0.50 ^E (0.10–2.6)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
5 (2016–2017)	426	0.30 ^E (0–2.8)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	412	0.30 ^E (0.10–1.2)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
5 (2016–2017)	304	0.50 ^E (0.10–3.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	275	0.60 ^E (0–11.1)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	302	0.10 ^E (0–0.70)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	294	0	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	302	1.0 ^E (0.10–10.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	292	0.10 ^E (0–0.80)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.30

Mono-*n*-octyl phthalate (MOP)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2558	0.90 ^E (0.30–2.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	2715	0.70 ^E (0.20–2.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2528	0.60 ^E (0.20–1.7)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1280	0.90 ^E (0.20–3.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1353	0.40 ^E (0.10–1.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1254	0.70 ^E (0.20–3.3)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1278	0.90 ^E (0.30–2.4)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1362	0.90 ^E (0.20–4.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1274	0.50 ^E (0.20–1.4)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	523	2.3 ^E (1.4–3.6)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	554	0.90 ^E (0.40–2.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	512	2.5 ^E (0.50–12.4)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
1 (2007–2009)	1037	4.6 ^E (1.8–11.3)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	516	0.10 ^E (0–0.40)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	537	1.2 ^E (0.20–6.3)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	497	0.40 ^E (0.10–2.2)	—	<LOD	<LOD	<LOD	<LOD

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	991	3.3 ^E (1.2–8.6)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	511	1.4 ^E (0.70–2.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	538	1.3 ^E (0.80–2.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	502	1.8 ^E (0.50–6.7)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
1 (2007–2009)	730	7.4 ^E (3.4–15.4)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	358	1.1 ^E (0.20–5.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	374	0.40 ^E (0–3.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	332	0.10 ^E (0–0.40)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	360	0.50 ^E (0.10–2.4)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	359	1.0 ^E (0.10–9.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	343	0	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	290	0.90 ^E (0.20–4.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	353	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	342	1.5 ^E (0.30–7.2)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.6, 0.3, 0.16 and 0.16 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.31

Mono-*n*-octyl phthalate (MOP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2548	0.90 ^E (0.30–2.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	2683	0.70 ^E (0.20–2.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2527	0.60 ^E (0.20–1.7)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1276	0.90 ^E (0.20–3.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1338	0.40 ^E (0.10–1.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1253	0.70 ^E (0.20–3.3)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1272	0.90 ^E (0.30–2.4)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1345	0.90 ^E (0.20–4.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1274	0.50 ^E (0.20–1.4)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	2.3 ^E (1.4–3.6)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	543	0.90 ^E (0.40–2.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	511	2.5 ^E (0.50–12.4)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
1 (2007–2009)	1034	4.6 ^E (1.8–11.3)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	514	0.10 ^E (0–0.40)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	529	1.2 ^E (0.20–6.3)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	497	0.40 ^E (0.10–2.2)	—	<LOD	<LOD	<LOD	<LOD

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	989	3.3 ^E (1.2–8.6)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	509	1.4 ^E (0.70–2.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	531	1.3 ^E (0.80–2.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	502	1.8 ^E (0.50–6.7)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
1 (2007–2009)	728	7.4 ^E (3.4–15.4)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	356	1.1 ^E (0.20–5.9)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	370	0.40 ^E (0–3.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	332	0.10 ^E (0–0.40)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	358	0.50 ^E (0.10–2.4)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	358	1.0 ^E (0.10–9.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	343	0	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	289	0.90 ^E (0.20–4.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	352	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	342	1.5 ^E (0.30–7.2)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.32

Mono(carboxyisooctyl) phthalate (MCiOP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2713	84.2 (79.2–88.2)	0.97 (0.85–1.1)	<LOD	0.98 (0.84–1.1)	4.2 (3.1–5.3)	7.2 (4.8–9.7)
6 (2018–2019)	2528	87.4 (83.6–90.4)	0.78 (0.69–0.88)	<LOD	0.80 (0.66–0.95)	3.6 (2.9–4.3)	7.2 (5.2–9.1)
Males, 3–79 years							
5 (2016–2017)	1350	83.2 (75.8–88.7)	0.96 (0.79–1.2)	<LOD	0.99 (0.83–1.2)	3.9 (2.8–5.1)	6.8 (5.8–7.8)
6 (2018–2019)	1255	89.5 (85.9–92.3)	0.90 (0.78–1.0)	<LOD	0.92 (0.78–1.1)	4.7 (3.3–6.2)	7.6 (5.2–10)
Females, 3–79 years							
5 (2016–2017)	1363	85.1 (80.3–88.9)	0.99 (0.86–1.2)	<LOD	0.96 (0.81–1.1)	4.6 ^E (2.9–6.4)	9.4 ^E (<LOD–19)
6 (2018–2019)	1273	85.2 (78.7–90.0)	0.68 (0.57–0.80)	<LOD	0.68 (0.54–0.83)	2.9 (2.1–3.6)	4.9 ^E (1.7–8.0)
3–5 years							
5 (2016–2017)	555	91.8 (84.4–95.9)	1.3 (1.0–1.7)	0.33 ^E (<LOD–0.48)	1.3 ^E (0.81–1.8)	5.6 ^E (2.2–8.9)	9.9 ^E (4.2–15)
6 (2018–2019)	512	94.8 (89.6–97.5)	1.1 (0.97–1.3)	0.32 ^E (0.18–0.46)	1.1 (0.98–1.2)	4.2 (3.2–5.2)	5.3 ^E (3.3–7.2)
6–11 years							
5 (2016–2017)	537	91.9 (86.3–95.3)	1.3 (1.1–1.6)	0.36 ^E (<LOD–0.51)	1.4 (1.0–1.7)	4.6 ^E (2.4–6.7)	9.3 ^E (4.3–14)
6 (2018–2019)	497	91.2 (82.3–95.8)	1.1 (0.88–1.4)	0.22 ^E (<LOD–0.38)	1.1 (0.92–1.4)	5.2 (3.7–6.7)	6.7 ^E (1.5–12)
12–19 years							
5 (2016–2017)	537	85.8 (81.2–89.5)	1.2 (0.97–1.4)	<LOD	1.2 (0.85–1.5)	5.1 (3.6–6.6)	9.9 ^E (<LOD–21)
6 (2018–2019)	502	90.7 (85.3–94.3)	0.92 (0.77–1.1)	0.14 ^E (<LOD–0.22)	1.0 (0.87–1.1)	4.7 (3.1–6.3)	7.0 (5.0–9.0)
20–39 years							
5 (2016–2017)	373	82.8 (69.7–91.0)	0.95 (0.67–1.4)	<LOD	1.0 ^E (0.55–1.5)	3.7 ^E (2.1–5.4)	7.5 ^E (<LOD–18)
6 (2018–2019)	332	84.4 (73.1–91.5)	0.77 (0.62–0.95)	<LOD	0.78 (0.53–1.0)	4.7 ^E (2.2–7.2)	7.7 ^E (<LOD–16)
40–59 years							
5 (2016–2017)	359	82.8 (76.5–87.7)	0.92 (0.77–1.1)	<LOD	0.95 (0.66–1.2)	5.3 ^E (2.9–7.6)	7.2 ^E (1.3–13)
6 (2018–2019)	343	87.9 (82.2–92.0)	0.69 (0.55–0.87)	<LOD	0.67 (0.43–0.91)	2.9 (2.4–3.5)	3.6 ^E (1.4–5.8)
60–79 years							
5 (2016–2017)	352	83.5 (75.7–89.1)	0.86 (0.72–1.0)	<LOD	0.83 (0.70–0.96)	4.1 ^E (1.8–6.3)	6.6 (5.1–8.0)
6 (2018–2019)	342	87.0 (81.5–91.0)	0.74 (0.58–0.93)	<LOD	0.72 (0.58–0.85)	3.2 (2.3–4.0)	8.4 ^E (4.3–12)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 5 and 6 are 0.30 and 0.13 $\mu\text{g/L}$, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.33

Mono(carboxyisooctyl) phthalate (MCiOP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2681	84.2 (79.2–88.2)	0.94 (0.84–1.1)	<LOD	0.82 (0.73–0.91)	3.7 (3.1–4.3)	6.4 (5.5–7.4)
6 (2018–2019)	2527	87.4 (83.6–90.4)	0.85 (0.76–0.94)	<LOD	0.81 (0.72–0.91)	3.5 (2.7–4.3)	6.3 (4.9–7.6)
Males, 3–79 years							
5 (2016–2017)	1335	83.2 (75.8–88.7)	0.82 (0.70–0.96)	<LOD	0.77 (0.63–0.91)	3.3 (2.4–4.3)	6.0 (4.7–7.4)
6 (2018–2019)	1254	89.5 (85.9–92.3)	0.84 (0.72–0.97)	<LOD	0.80 (0.62–0.99)	3.6 (2.4–4.7)	5.9 ^E (3.4–8.4)
Females, 3–79 years							
5 (2016–2017)	1346	85.1 (80.3–88.9)	1.1 (0.95–1.2)	<LOD	0.92 (0.79–1.0)	4.0 ^E (2.2–5.8)	7.3 ^E (<LOD–12)
6 (2018–2019)	1273	85.2 (78.7–90.0)	0.86 (0.73–1.0)	<LOD	0.83 (0.68–0.97)	3.5 ^E (2.2–4.8)	6.4 ^E (3.9–8.9)
3–5 years							
5 (2016–2017)	544	91.8 (84.4–95.9)	2.4 (2.0–2.8)	0.73 (<LOD–0.96)	2.2 (1.8–2.6)	8.1 ^E (4.3–12)	13 ^E (6.1–19)
6 (2018–2019)	511	94.8 (89.6–97.5)	1.8 (1.6–2.0)	0.58 ^E (0.31–0.86)	1.6 (1.3–1.9)	5.8 (4.5–7.0)	10 ^E (5.8–15)
6–11 years							
5 (2016–2017)	529	91.9 (86.3–95.3)	1.6 (1.3–1.9)	0.51 (<LOD–0.63)	1.4 (1.2–1.6)	5.1 (3.5–6.7)	7.3 ^E (3.5–11)
6 (2018–2019)	497	91.2 (82.3–95.8)	1.3 (1.1–1.5)	0.43 (<LOD–0.56)	1.3 (1.0–1.5)	5.2 ^E (3.1–7.3)	6.2 ^E (<LOD–14)
12–19 years							
5 (2016–2017)	530	85.8 (81.2–89.5)	0.90 (0.75–1.1)	<LOD	0.77 (0.66–0.89)	3.5 ^E (1.5–5.4)	8.2 ^E (<LOD–15)
6 (2018–2019)	502	90.7 (85.3–94.3)	0.76 (0.67–0.87)	0.24 (<LOD–0.30)	0.73 (0.60–0.86)	2.9 (2.0–3.8)	4.8 ^E (2.1–7.5)
20–39 years							
5 (2016–2017)	369	82.8 (69.7–91.0)	0.85 (0.68–1.1)	<LOD	0.77 (0.61–0.94)	2.6 ^E (1.5–3.7)	4.9 ^E (<LOD–11)
6 (2018–2019)	332	84.4 (73.1–91.5)	0.73 (0.61–0.87)	<LOD	0.81 (0.65–0.96)	2.8 ^E (1.2–4.4)	5.3 ^E (<LOD–11)
40–59 years							
5 (2016–2017)	358	82.8 (76.5–87.7)	0.84 (0.67–1.1)	<LOD	0.75 (0.63–0.88)	3.5 ^E (0.63–6.4)	6.5 (5.2–7.7)
6 (2018–2019)	343	87.9 (82.2–92.0)	0.82 (0.66–1.0)	<LOD	0.76 (0.51–1.0)	3.2 ^E (1.7–4.6)	6.3 ^E (3.1–9.6)
60–79 years							
5 (2016–2017)	351	83.5 (75.7–89.1)	0.98 (0.83–1.2)	<LOD	0.83 (0.70–0.95)	4.0 (2.9–5.1)	5.2 (3.4–7.0)
6 (2018–2019)	342	87.0 (81.5–91.0)	0.87 (0.70–1.1)	<LOD	0.73 (0.59–0.87)	4.0 ^E (2.5–5.6)	6.3 ^E (3.4–9.1)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.34

Monoisobutyl phthalate (MiNP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2556	0.90 ^E (0.30–3.1)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	2716	41.9 (33.2–51.1)	—	<LOD	<LOD	1.4 ^E (0.89–2.0)	3.5 ^E (1.5–5.4)
6 (2018–2019)	2503	51.3 (45.1–57.5)	—	<LOD	0.16 (<LOD–0.20)	0.99 (0.71–1.3)	2.1 ^E (0.96–3.3)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1280	1.5 ^E (0.40–6.0)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1353	44.8 (35.8–54.1)	—	<LOD	<LOD	1.1 (0.81–1.3)	2.2 ^E (1.4–3.0)
6 (2018–2019)	1237	59.3 (52.7–65.6)	—	<LOD	0.21 (0.17–0.24)	1.0 ^E (0.48–1.6)	2.2 ^E (1.0–3.4)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1276	0.40 ^E (0.10–1.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1363	38.9 (29.8–48.9)	—	<LOD	<LOD	1.8 ^E (<LOD–3.6)	4.0 ^E (1.2–6.8)
6 (2018–2019)	1266	43.4 (35.7–51.5)	—	<LOD	<LOD	0.92 ^E (0.57–1.3)	1.8 ^E (<LOD–3.5)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	522	0.40 ^E (0.10–1.2)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	555	49.1 (32.5–65.9)	—	<LOD	<LOD	1.5 (1.0–2.0)	2.4 ^E (<LOD–6.5)
6 (2018–2019)	507	69.8 (59.9–78.2)	0.27 (0.22–0.33)	<LOD	0.21 ^E (<LOD–0.29)	0.94 ^E (0.43–1.4)	1.7 ^E (1.0–2.4)
6–11 years							
1 (2007–2009)	1036	0.80 ^E (0.20–4.3)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	514	0.40 ^E (0.10–1.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	537	49.5 (38.9–60.2)	—	<LOD	<LOD	1.2 (0.75–1.6)	2.0 (1.5–2.6)
6 (2018–2019)	494	61.0 (52.2–69.3)	—	<LOD	0.26 (0.18–0.33)	0.93 (0.60–1.3)	1.6 ^E (<LOD–3.9)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	991	0.90 ^E (0.30–2.6)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	511	0.30 ^E (0.10–1.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	538	49.1 (38.1–60.2)	—	<LOD	<LOD	1.5 ^E (0.70–2.3)	3.7 ^E (<LOD–8.7)
6 (2018–2019)	497	62.1 (51.4–71.6)	—	<LOD	0.22 ^E (<LOD–0.32)	1.2 (0.90–1.5)	1.5 ^E (0.46–2.5)
20–39 years							
1 (2007–2009)	730	0.20 ^E (0–1.9)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	358	2.8 ^E (0.70–10.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	374	50.1 (33.9–66.3)	—	<LOD	<LOD	2.5 ^E (0.40–4.6)	4.9 ^E (2.1–7.7)
6 (2018–2019)	330	56.7 (44.3–68.2)	—	<LOD	0.20 (0.15–0.25)	1.2 ^E (<LOD–2.6)	4.5 ^E (<LOD–12)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	360	0.10 ^E (0–0.30)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	359	37.2 (29.2–45.9)	—	<LOD	<LOD	1.2 ^E (0.71–1.8)	2.4 ^E (<LOD–11)
6 (2018–2019)	338	47.0 (37.9–56.2)	—	<LOD	<LOD	0.72 ^E (0.28–1.2)	1.8 ^E (0.15–3.4)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	291	0.10 ^E (0–4.1)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	353	29.9 (20.8–40.9)	—	<LOD	<LOD	0.94 (0.63–1.3)	1.5 ^E (0.75–2.3)
6 (2018–2019)	337	39.1 (31.3–47.4)	—	<LOD	<LOD	0.73 ^E (0.24–1.2)	1.4 ^E (0.48–2.2)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 1, 2, 5 and 6 are 0.7, 0.4, 0.37 and 0.15 µg/L, respectively.

- a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
 b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.
 E Use data with caution.

Table 14.1.35

Monoisobutyl phthalate (MiNP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009), cycle 2 (2009–2011), cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	2546	0.90 ^E (0.30–3.1)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	2684	41.9 (33.2–51.1)	—	<LOD	<LOD	1.3 ^E (0.73–1.8)	3.3 ^E (1.4–5.1)
6 (2018–2019)	2502	51.3 (45.1–57.5)	—	<LOD	0.18 (<LOD–0.21)	0.99 (0.70–1.3)	2.4 ^E (0.80–3.9)
Males, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1276	1.5 ^E (0.40–6.0)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1338	44.8 (35.8–54.1)	—	<LOD	<LOD	1.0 (0.89–1.2)	1.8 ^E (0.67–3.0)
6 (2018–2019)	1236	59.3 (52.7–65.6)	—	<LOD	0.19 (0.17–0.22)	0.95 ^E (0.49–1.4)	1.7 ^E (<LOD–3.9)
Females, 3–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	1270	0.40 ^E (0.10–1.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	1346	38.9 (29.8–48.9)	—	<LOD	<LOD	1.7 ^E (<LOD–3.4)	4.1 ^E (0.72–7.5)
6 (2018–2019)	1266	43.4 (35.7–51.5)	—	<LOD	<LOD	1.0 (0.69–1.3)	3.0 ^E (<LOD–5.0)
3–5 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	521	0.40 ^E (0.10–1.2)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	544	49.1 (32.5–65.9)	—	<LOD	<LOD	2.4 ^E (1.1–3.8)	4.5 ^E (<LOD–9.2)
6 (2018–2019)	506	69.8 (59.9–78.2)	0.44 (0.38–0.52)	<LOD	0.38 (<LOD–0.48)	1.7 ^E (1.0–2.4)	2.9 ^E (1.7–4.2)
6–11 years							
1 (2007–2009)	1033	0.80 ^E (0.20–4.3)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	512	0.40 ^E (0.10–1.5)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	529	49.5 (38.9–60.2)	—	<LOD	<LOD	1.3 ^E (0.76–1.8)	3.1 (2.0–4.2)
6 (2018–2019)	494	61.0 (52.2–69.3)	—	<LOD	0.27 (0.21–0.34)	0.81 (0.55–1.1)	1.6 ^E (<LOD–4.8)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
12–19 years							
1 (2007–2009)	989	0.90 ^E (0.30–2.6)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	509	0.30 ^E (0.10–1.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	531	49.1 (38.1–60.2)	—	<LOD	<LOD	1.1 ^E (0.63–1.6)	2.6 ^E (<LOD–5.5)
6 (2018–2019)	497	62.1 (51.4–71.6)	—	<LOD	0.20 (<LOD–0.25)	0.94 (0.71–1.2)	1.3 ^E (0.70–1.8)
20–39 years							
1 (2007–2009)	728	0.20 ^E (0–1.9)	—	<LOD	<LOD	<LOD	<LOD
2 (2009–2011)	356	2.8 ^E (0.70–10.3)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	370	50.1 (33.9–66.3)	—	<LOD	<LOD	2.0 ^E (<LOD–4.7)	4.1 ^E (0.98–7.2)
6 (2018–2019)	330	56.7 (44.3–68.2)	—	<LOD	0.17 (0.15–0.20)	0.98 ^E (<LOD–2.1)	4.2 ^E (<LOD–9.7)
40–59 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	358	0.10 ^E (0–0.30)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	358	37.2 (29.2–45.9)	—	<LOD	<LOD	0.87 ^E (<LOD–1.5)	2.5 ^E (<LOD–6.3)
6 (2018–2019)	338	47.0 (37.9–56.2)	—	<LOD	<LOD	1.1 ^E (0.46–1.6)	3.0 ^E (0.59–5.4)
60–79 years							
1 (2007–2009) ^b	—	—	—	—	—	—	—
2 (2009–2011)	290	0.10 ^E (0–4.1)	—	<LOD	<LOD	<LOD	<LOD
5 (2016–2017)	352	29.9 (20.8–40.9)	—	<LOD	<LOD	1.1 ^E (0.61–1.5)	1.7 ^E (0.99–2.4)
6 (2018–2019)	337	39.1 (31.3–47.4)	—	<LOD	<LOD	0.80 ^E (0.42–1.2)	1.5 ^E (<LOD–3.0)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

b Data are not available, as participants under the age of six years and over 49 years were not included in cycle 1.

E Use data with caution.

Table 14.1.36

Monocarboxyisononyl phthalate (MCiNP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2551	95.9 (92.2–97.9)	0.68 (0.57–0.80)	0.16 (0.12–0.21)	0.71 (0.55–0.88)	2.5 (1.9–3.1)	4.0 (3.0–5.0)
6 (2018–2019)	2233	93.8 (90.8–95.9)	0.47 (0.41–0.53)	0.12 (0.095–0.15)	0.46 (0.41–0.51)	1.6 (1.2–2.0)	2.4 ^E (1.3–3.6)
Males, 3–79 years							
5 (2016–2017)	1272	94.9 (90.7–97.2)	0.68 (0.57–0.83)	0.17 ^E (0.081–0.25)	0.73 (0.59–0.88)	2.4 (1.8–2.9)	4.2 (3.1–5.4)
6 (2018–2019)	1103	93.0 (87.9–96.1)	0.50 (0.41–0.62)	0.13 ^E (<LOD–0.20)	0.47 (0.41–0.54)	1.7 (1.3–2.2)	2.5 ^E (<LOD–5.1)
Females, 3–79 years							
5 (2016–2017)	1279	96.9 (91.4–98.9)	0.67 (0.54–0.82)	0.16 (0.11–0.21)	0.67 (0.44–0.90)	2.5 (1.8–3.2)	3.8 (2.6–5.0)
6 (2018–2019)	1130	94.6 (91.3–96.7)	0.44 (0.38–0.50)	0.12 (0.096–0.14)	0.42 (0.36–0.48)	1.6 (1.1–2.0)	2.3 ^E (0.84–3.7)
3–5 years							
5 (2016–2017)	520	99.9 (99.5–100)	0.96 ^E (0.62–1.5)	0.27 ^E (0.16–0.38)	0.87 ^E (0.52–1.2)	3.8 ^E (1.2–6.3)	6.8 ^E (<LOD–14)
6 (2018–2019)	459	98.9 (92.2–99.9)	0.70 (0.60–0.82)	0.22 (0.18–0.26)	0.76 (0.61–0.91)	2.1 ^E (1.2–3.0)	3.3 ^E (1.8–4.7)
6–11 years							
5 (2016–2017)	517	99.5 (99.0–99.8)	1.1 (0.87–1.3)	0.33 (0.24–0.41)	1.0 (0.77–1.2)	3.3 (2.6–4.0)	4.5 ^E (2.1–6.8)
6 (2018–2019)	462	98.0 (94.4–99.3)	0.73 (0.61–0.87)	0.20 ^E (0.095–0.31)	0.76 (0.61–0.90)	2.4 (1.7–3.2)	3.1 (2.0–4.2)
12–19 years							
5 (2016–2017)	498	97.2 (93.9–98.7)	0.79 (0.68–0.92)	0.22 ^E (0.098–0.34)	0.85 (0.70–0.99)	2.3 (1.8–2.9)	3.8 (2.6–5.0)
6 (2018–2019)	435	96.4 (90.6–98.7)	0.52 (0.43–0.64)	0.15 ^E (0.085–0.21)	0.57 (0.46–0.68)	1.8 (1.3–2.4)	2.2 (1.5–2.9)
20–39 years							
5 (2016–2017)	356	94.3 (80.2–98.5)	0.58 (0.41–0.84)	0.14 ^E (<LOD–0.28)	0.56 ^E (0.28–0.83)	2.3 ^E (1.4–3.3)	3.5 ^E (2.0–5.0)
6 (2018–2019)	285	93.4 (87.4–96.6)	0.47 (0.36–0.62)	0.14 (0.096–0.18)	0.46 (0.33–0.58)	1.5 ^E (0.81–2.3)	2.2 ^E (0.18–4.3)
40–59 years							
5 (2016–2017)	325	95.0 (89.5–97.7)	0.69 (0.53–0.90)	0.15 ^E (<LOD–0.23)	0.77 (0.58–0.96)	2.8 ^E (1.8–3.8)	4.6 ^E (2.6–6.5)
6 (2018–2019)	295	93.8 (88.5–96.7)	0.42 (0.33–0.52)	0.12 ^E (<LOD–0.16)	0.37 (0.30–0.44)	1.2 ^E (0.24–2.1)	3.9 ^E (0.50–7.3)
60–79 years							
5 (2016–2017)	335	97.0 (92.1–98.9)	0.60 (0.51–0.70)	0.16 (0.12–0.19)	0.61 (0.47–0.76)	2.1 (1.7–2.6)	3.4 (2.4–4.5)
6 (2018–2019)	297	91.2 (80.2–96.3)	0.42 (0.34–0.53)	0.093 ^E (<LOD–0.16)	0.47 (0.34–0.60)	1.6 (1.3–1.9)	2.3 ^E (1.4–3.1)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 5 and 6 are 0.077 and 0.075 $\mu\text{g/L}$, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.37

Monocarboxyisononyl phthalate (MCiNP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2522	95.9 (92.2–97.9)	0.64 (0.56–0.73)	0.22 (0.18–0.26)	0.58 (0.50–0.66)	2.0 (1.6–2.3)	2.7 (2.2–3.2)
6 (2018–2019)	2233	93.8 (90.8–95.9)	0.51 (0.45–0.57)	0.16 (0.13–0.20)	0.46 (0.40–0.51)	1.7 (1.3–2.1)	2.7 (2.0–3.3)
Males, 3–79 years							
5 (2016–2017)	1257	94.9 (90.7–97.2)	0.57 (0.51–0.64)	0.20 (0.15–0.24)	0.52 (0.48–0.56)	1.9 (1.5–2.3)	2.7 (2.1–3.3)
6 (2018–2019)	1103	93.0 (87.9–96.1)	0.46 (0.37–0.58)	0.15 (<LOD–0.18)	0.43 (0.35–0.52)	1.5 (1.2–1.7)	2.3 ^E (<LOD–3.3)
Females, 3–79 years							
5 (2016–2017)	1265	96.9 (91.4–98.9)	0.71 (0.60–0.85)	0.28 (0.23–0.33)	0.64 (0.50–0.78)	2.0 (1.6–2.4)	2.7 (2.0–3.4)
6 (2018–2019)	1130	94.6 (91.3–96.7)	0.55 (0.49–0.62)	0.19 (0.14–0.24)	0.49 (0.43–0.56)	2.0 (1.5–2.5)	2.8 (2.1–3.5)
3–5 years							
5 (2016–2017)	510	99.9 (99.5–100)	1.7 (1.2–2.3)	0.63 (0.41–0.85)	1.5 (1.2–1.7)	4.9 ^E (1.1–8.7)	9.4 ^E (<LOD–17)
6 (2018–2019)	459	98.9 (92.2–99.9)	1.2 (0.98–1.4)	0.43 ^E (0.22–0.65)	1.1 (0.88–1.3)	2.7 ^E (1.1–4.3)	4.8 ^E (2.7–6.8)
6–11 years							
5 (2016–2017)	509	99.5 (99.0–99.8)	1.2 (1.0–1.5)	0.44 (0.40–0.49)	1.1 (0.90–1.2)	2.9 ^E (1.6–4.2)	6.2 ^E (1.2–11)
6 (2018–2019)	462	98.0 (94.4–99.3)	0.87 (0.75–1.0)	0.32 (0.29–0.35)	0.84 (0.66–1.0)	2.6 ^E (1.5–3.7)	3.5 (2.4–4.6)
12–19 years							
5 (2016–2017)	493	97.2 (93.9–98.7)	0.58 (0.49–0.68)	0.22 (0.17–0.27)	0.53 (0.41–0.65)	1.8 (1.4–2.2)	2.4 (1.5–3.2)
6 (2018–2019)	435	96.4 (90.6–98.7)	0.44 (0.38–0.51)	0.17 (0.14–0.20)	0.42 (0.34–0.50)	1.3 ^E (0.59–2.0)	2.1 (1.4–2.8)
20–39 years							
5 (2016–2017)	352	94.3 (80.2–98.5)	0.51 (0.42–0.62)	0.18 (<LOD–0.21)	0.47 (0.38–0.56)	1.3 ^E (0.55–2.1)	2.0 ^E (0.99–3.0)
6 (2018–2019)	285	93.4 (87.4–96.6)	0.45 (0.37–0.54)	0.16 (0.14–0.18)	0.38 (0.30–0.46)	1.7 ^E (0.82–2.5)	2.2 ^E (0.81–3.5)
40–59 years							
5 (2016–2017)	324	95.0 (89.5–97.7)	0.61 (0.51–0.74)	0.21 ^E (<LOD–0.31)	0.57 (0.44–0.70)	2.0 (1.4–2.6)	2.6 (2.0–3.2)
6 (2018–2019)	295	93.8 (88.5–96.7)	0.49 (0.39–0.63)	0.16 ^E (<LOD–0.22)	0.43 (0.34–0.52)	1.5 ^E (0.31–2.7)	2.7 ^E (<LOD–6.2)
60–79 years							
5 (2016–2017)	334	97.0 (92.1–98.9)	0.67 (0.58–0.78)	0.26 (0.23–0.30)	0.64 (0.55–0.73)	1.8 (1.4–2.2)	2.5 (1.8–3.1)
6 (2018–2019)	297	91.2 (80.2–96.3)	0.50 (0.41–0.61)	0.14 ^E (<LOD–0.20)	0.48 (0.38–0.58)	1.5 (1.1–1.9)	2.1 (1.5–2.7)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.38

Monooxisnononyl phthalate (MOiNP)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2640	90.2 (86.5–92.9)	0.67 (0.60–0.75)	<LOD ^E (<LOD–0.21)	0.63 (0.57–0.69)	3.2 (2.8–3.6)	5.4 (3.7–7.2)
6 (2018–2019)	2412	87.0 (83.9–89.6)	0.56 (0.49–0.64)	<LOD	0.53 (0.46–0.60)	2.3 (1.6–2.9)	4.0 ^E (1.6–6.4)
Males, 3–79 years							
5 (2016–2017)	1318	90.2 (84.4–93.9)	0.65 (0.54–0.78)	<LOD ^E (<LOD–0.24)	0.61 (0.52–0.70)	2.5 (1.8–3.2)	4.3 ^E (2.1–6.4)
6 (2018–2019)	1195	89.8 (85.2–93.1)	0.62 (0.51–0.74)	<LOD	0.61 (0.48–0.74)	2.5 ^E (1.5–3.5)	3.7 ^E (0.88–6.5)
Females, 3–79 years							
5 (2016–2017)	1322	90.2 (86.1–93.2)	0.69 (0.59–0.82)	<LOD ^E (<LOD–0.18)	0.66 (0.56–0.77)	3.5 (2.6–4.5)	6.1 ^E (<LOD–14)
6 (2018–2019)	1217	84.1 (78.2–88.7)	0.51 (0.43–0.60)	<LOD	0.47 (0.40–0.53)	2.2 (1.5–2.9)	5.3 ^E (1.0–9.6)
3–5 years							
5 (2016–2017)	548	97.4 (91.5–99.3)	1.1 (0.88–1.4)	0.26 ^E (<LOD–0.42)	1.1 (0.89–1.2)	4.4 (2.8–6.0)	6.7 ^E (3.4–10)
6 (2018–2019)	495	95.9 (92.8–97.7)	0.93 (0.79–1.1)	0.31 (0.23–0.40)	0.91 (0.77–1.0)	3.0 (2.0–4.0)	4.7 ^E (2.0–7.5)
6–11 years							
5 (2016–2017)	524	97.5 (94.9–98.8)	1.0 (0.87–1.3)	0.31 (0.27–0.36)	1.0 (0.80–1.3)	3.6 (2.6–4.6)	5.0 ^E (1.6–8.4)
6 (2018–2019)	478	94.1 (86.8–97.5)	0.81 (0.68–0.97)	0.23 ^E (<LOD–0.31)	0.81 (0.63–0.98)	3.0 ^E (1.8–4.1)	5.1 ^E (0.41–9.8)
12–19 years							
5 (2016–2017)	525	94.4 (90.7–96.6)	0.93 (0.79–1.1)	0.20 (<LOD–0.26)	0.90 (0.73–1.1)	3.8 ^E (2.0–5.5)	7.3 ^E (0.88–14)
6 (2018–2019)	486	90.2 (82.2–94.8)	0.68 (0.55–0.84)	0.15 ^E (<LOD–0.27)	0.69 (0.56–0.82)	2.8 (2.1–3.4)	4.4 ^E (2.6–6.1)
20–39 years							
5 (2016–2017)	358	88.4 (76.3–94.8)	0.67 (0.50–0.90)	<LOD	0.59 (0.41–0.76)	3.3 (2.2–4.3)	5.8 ^E (1.7–9.9)
6 (2018–2019)	318	88.0 (79.1–93.4)	0.60 (0.45–0.79)	<LOD	0.54 (0.36–0.72)	2.6 ^E (0.95–4.2)	6.0 ^E (<LOD–24)
40–59 years							
5 (2016–2017)	343	89.1 (75.9–95.5)	0.59 (0.46–0.75)	<LOD	0.56 (0.45–0.67)	2.9 (1.9–4.0)	5.2 ^E (<LOD–14)
6 (2018–2019)	321	84.4 (76.9–89.8)	0.47 (0.39–0.58)	<LOD	0.47 (0.37–0.58)	2.2 ^E (1.3–3.0)	3.1 ^E (1.8–4.4)
60–79 years							
5 (2016–2017)	342	88.7 (84.1–92.1)	0.55 (0.46–0.66)	<LOD	0.54 (0.40–0.68)	2.6 ^E (1.4–3.7)	3.7 ^E (2.1–5.3)
6 (2018–2019)	314	83.7 (76.1–89.3)	0.48 (0.39–0.59)	<LOD	0.44 (0.36–0.52)	1.9 ^E (0.76–3.1)	4.3 ^E (<LOD–8.9)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.15 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.39

Monooxoisononyl phthalate (MOiNP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2609	90.2 (86.5–92.9)	0.65 (0.59–0.71)	<LOD	0.55 (0.50–0.60)	2.8 (2.3–3.2)	5.2 (3.7–6.7)
6 (2018–2019)	2411	87.0 (83.9–89.6)	0.60 (0.52–0.70)	<LOD	0.51 (0.45–0.56)	2.1 ^E (1.1–3.1)	5.5 ^E (2.8–8.3)
Males, 3–79 years							
5 (2016–2017)	1304	90.2 (84.4–93.9)	0.55 (0.48–0.64)	<LOD	0.48 (0.37–0.58)	2.1 (1.7–2.5)	4.3 (2.9–5.8)
6 (2018–2019)	1194	89.8 (85.2–93.1)	0.57 (0.47–0.69)	<LOD	0.50 (0.43–0.57)	2.0 ^E (0.72–3.3)	4.1 ^E (1.4–6.9)
Females, 3–79 years							
5 (2016–2017)	1305	90.2 (86.1–93.2)	0.76 (0.68–0.85)	<LOD	0.63 (0.51–0.76)	3.4 (2.2–4.7)	5.9 ^E (<LOD–9.2)
6 (2018–2019)	1217	84.1 (78.2–88.7)	0.63 (0.54–0.75)	<LOD	0.52 (0.43–0.60)	2.4 ^E (0.66–4.2)	6.5 ^E (2.8–10)
3–5 years							
5 (2016–2017)	537	97.4 (91.5–99.3)	1.9 (1.6–2.3)	0.65 (<LOD–0.82)	1.8 (1.5–2.1)	6.2 (4.3–8.1)	10 ^E (5.2–16)
6 (2018–2019)	494	95.9 (92.8–97.7)	1.5 (1.3–1.8)	0.53 (0.38–0.68)	1.4 (1.0–1.7)	4.7 (3.5–5.9)	6.8 ^E (3.8–9.8)
6–11 years							
5 (2016–2017)	517	97.5 (94.9–98.8)	1.2 (1.0–1.5)	0.44 (0.37–0.51)	1.1 (0.92–1.2)	3.9 (2.6–5.2)	5.9 ^E (2.7–9.0)
6 (2018–2019)	478	94.1 (86.8–97.5)	0.98 (0.89–1.1)	0.36 (<LOD–0.41)	0.88 (0.80–0.95)	2.4 ^E (1.4–3.4)	5.6 ^E (0.74–10)
12–19 years							
5 (2016–2017)	518	94.4 (90.7–96.6)	0.71 (0.60–0.82)	0.24 (<LOD–0.29)	0.59 (0.50–0.68)	2.3 ^E (1.4–3.2)	5.7 ^E (1.9–9.5)
6 (2018–2019)	486	90.2 (82.2–94.8)	0.56 (0.48–0.66)	0.17 (<LOD–0.21)	0.51 (0.42–0.60)	1.8 ^E (1.0–2.7)	2.9 ^E (1.8–4.0)
20–39 years							
5 (2016–2017)	354	88.4 (76.3–94.8)	0.60 (0.51–0.71)	<LOD	0.46 (0.35–0.57)	2.8 ^E (<LOD–5.6)	5.8 ^E (3.2–8.5)
6 (2018–2019)	318	88.0 (79.1–93.4)	0.56 (0.42–0.75)	<LOD	0.45 (0.36–0.53)	1.9 ^E (<LOD–4.3)	8.2 ^E (<LOD–18)
40–59 years							
5 (2016–2017)	342	89.1 (75.9–95.5)	0.53 (0.44–0.64)	<LOD	0.50 (0.36–0.64)	2.2 ^E (1.0–3.3)	4.3 ^E (<LOD–7.6)
6 (2018–2019)	321	84.4 (76.9–89.8)	0.56 (0.44–0.71)	<LOD	0.51 (0.35–0.68)	1.8 ^E (<LOD–4.5)	5.1 ^E (2.4–7.9)
60–79 years							
5 (2016–2017)	341	88.7 (84.1–92.1)	0.62 (0.53–0.73)	<LOD	0.55 (0.43–0.67)	2.1 (1.5–2.7)	4.3 ^E (2.3–6.3)
6 (2018–2019)	314	83.7 (76.1–89.3)	0.55 (0.46–0.67)	<LOD	0.42 (0.36–0.48)	2.1 ^E (0.71–3.4)	4.4 ^E (<LOD–8.3)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.40

Monohydroxyisobutyl phthalate (MHiBP)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2659	91.5 (88.1–94.0)	0.83 (0.72–0.97)	0.11 ^E (<LOD–0.19)	0.87 (0.74–1.0)	4.5 (3.6–5.5)	7.8 ^E (4.8–11)
6 (2018–2019)	2392	87.1 (83.2–90.2)	0.65 (0.56–0.75)	<LOD	0.77 (0.68–0.85)	3.5 (2.7–4.3)	5.4 ^E (1.9–9.0)
Males, 3–79 years							
5 (2016–2017)	1317	90.9 (86.7–93.9)	0.81 (0.66–1.0)	0.077 ^E (<LOD–0.22)	0.86 (0.65–1.1)	4.2 (3.3–5.1)	6.7 ^E (4.0–9.4)
6 (2018–2019)	1179	89.8 (85.3–93.0)	0.75 (0.61–0.93)	<LOD	0.88 (0.71–1.0)	3.6 (2.6–4.6)	4.9 ^E (<LOD–10)
Females, 3–79 years							
5 (2016–2017)	1342	92.1 (87.8–94.9)	0.85 (0.71–1.0)	0.13 ^E (<LOD–0.22)	0.88 (0.68–1.1)	5.0 ^E (3.1–6.9)	8.5 ^E (<LOD–20)
6 (2018–2019)	1213	84.5 (78.6–88.9)	0.56 (0.46–0.69)	<LOD	0.64 (0.48–0.79)	3.3 (2.2–4.3)	5.7 ^E (1.2–10)
3–5 years							
5 (2016–2017)	546	98.8 (94.8–99.7)	1.6 (1.3–2.1)	0.43 ^E (0.26–0.60)	1.5 (1.1–2.0)	5.9 ^E (1.2–11)	11 ^E (1.9–19)
6 (2018–2019)	494	97.8 (95.1–99.0)	1.3 (1.1–1.5)	0.43 (0.30–0.56)	1.3 (1.1–1.4)	4.3 (3.0–5.6)	6.2 (5.0–7.5)
6–11 years							
5 (2016–2017)	533	95.3 (88.8–98.1)	1.3 (1.0–1.7)	0.36 (0.26–0.46)	1.4 (0.99–1.9)	4.8 (3.7–5.9)	7.3 ^E (1.6–13)
6 (2018–2019)	474	96.2 (92.2–98.2)	1.2 (0.98–1.4)	0.26 ^E (0.099–0.43)	1.2 (0.92–1.5)	4.0 (2.6–5.5)	7.5 ^E (<LOD–17)
12–19 years							
5 (2016–2017)	520	93.6 (88.0–96.7)	1.1 (0.91–1.3)	0.23 ^E (0.071–0.38)	1.1 (0.84–1.4)	5.8 ^E (3.4–8.2)	11 ^E (<LOD–22)
6 (2018–2019)	469	88.0 (80.7–92.8)	0.78 (0.60–1.0)	<LOD	0.98 (0.73–1.2)	3.9 (2.8–5.0)	5.5 ^E (2.1–8.9)
20–39 years							
5 (2016–2017)	367	92.7 (80.8–97.5)	0.83 ^E (0.55–1.3)	<LOD	0.80 ^E (0.49–1.1)	3.7 ^E (2.3–5.2)	6.5 ^E (0.42–13)
6 (2018–2019)	309	83.7 (75.5–89.5)	0.68 (0.50–0.92)	<LOD	0.86 (0.73–1.0)	3.5 ^E (1.7–5.3)	8.2 ^E (<LOD–40)
40–59 years							
5 (2016–2017)	347	90.5 (84.7–94.2)	0.77 (0.58–1.0)	<LOD	0.71 (0.48–0.94)	5.6 (3.8–7.4)	8.7 ^E (<LOD–24)
6 (2018–2019)	323	86.3 (76.5–92.4)	0.54 (0.38–0.75)	<LOD	0.59 ^E (0.37–0.80)	3.5 ^E (2.0–5.0)	3.7 ^E (2.1–5.4)
60–79 years							
5 (2016–2017)	346	87.7 (80.1–92.7)	0.63 (0.50–0.79)	<LOD	0.69 (0.51–0.87)	4.3 ^E (2.4–6.2)	5.7 (4.3–7.2)
6 (2018–2019)	323	87.7 (83.2–91.1)	0.55 (0.44–0.68)	<LOD	0.59 (0.46–0.72)	2.4 ^E (1.3–3.4)	6.7 ^E (0.47–13)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.065 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.41

Monohydroxyisononyl phthalate (MHiNP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2627	91.5 (88.1–94.0)	0.81 (0.73–0.90)	0.17 (<LOD–0.23)	0.74 (0.66–0.83)	4.0 (3.2–4.7)	7.4 (5.5–9.2)
6 (2018–2019)	2391	87.1 (83.2–90.2)	0.70 (0.59–0.82)	<LOD	0.73 (0.63–0.83)	3.1 ^E (1.9–4.3)	7.8 ^E (3.5–12)
Males, 3–79 years							
5 (2016–2017)	1302	90.9 (86.7–93.9)	0.70 (0.59–0.82)	0.20 ^E (<LOD–0.32)	0.65 (0.50–0.80)	3.1 (2.3–4.0)	5.7 (3.7–7.8)
6 (2018–2019)	1178	89.8 (85.3–93.0)	0.69 (0.54–0.87)	<LOD	0.74 (0.63–0.86)	3.0 ^E (1.6–4.4)	4.7 ^E (<LOD–9.4)
Females, 3–79 years							
5 (2016–2017)	1325	92.1 (87.8–94.9)	0.93 (0.82–1.1)	0.17 (<LOD–0.22)	0.86 (0.70–1.0)	4.8 (3.1–6.4)	8.1 ^E (<LOD–14)
6 (2018–2019)	1213	84.5 (78.6–88.9)	0.70 (0.59–0.84)	<LOD	0.71 (0.59–0.84)	3.5 ^E (0.97–6.1)	9.4 ^E (5.4–13)
3–5 years							
5 (2016–2017)	535	98.8 (94.8–99.7)	2.8 (2.3–3.5)	0.94 (0.70–1.2)	2.6 (2.1–3.2)	9.7 (6.2–13)	14 ^E (<LOD–31)
6 (2018–2019)	493	97.8 (95.1–99.0)	2.1 (1.8–2.5)	0.81 (0.64–0.98)	2.1 (1.6–2.6)	7.1 (5.5–8.7)	9.5 (7.4–11)
6–11 years							
5 (2016–2017)	525	95.3 (88.8–98.1)	1.6 (1.2–2.0)	0.54 (0.36–0.73)	1.4 (1.0–1.9)	5.5 (3.7–7.3)	9.4 (6.2–13)
6 (2018–2019)	474	96.2 (92.2–98.2)	1.4 (1.2–1.6)	0.52 (0.42–0.61)	1.3 (1.2–1.5)	4.0 (2.5–5.4)	7.3 ^E (<LOD–18)
12–19 years							
5 (2016–2017)	513	93.6 (88.0–96.7)	0.85 (0.70–1.0)	0.25 (0.16–0.34)	0.81 (0.73–0.90)	3.1 ^E (1.1–5.1)	7.9 ^E (<LOD–15)
6 (2018–2019)	469	88.0 (80.7–92.8)	0.65 (0.51–0.82)	<LOD	0.76 (0.58–0.94)	2.9 ^E (1.8–3.9)	4.4 (3.1–5.6)
20–39 years							
5 (2016–2017)	363	92.7 (80.8–97.5)	0.75 (0.58–0.97)	<LOD	0.70 (0.51–0.90)	3.7 ^E (1.7–5.8)	6.2 ^E (2.8–9.6)
6 (2018–2019)	309	83.7 (75.5–89.5)	0.61 (0.47–0.79)	<LOD	0.62 (0.50–0.74)	2.9 ^E (<LOD–6.2)	10 ^E (<LOD–28)
40–59 years							
5 (2016–2017)	346	90.5 (84.7–94.2)	0.70 (0.56–0.87)	<LOD	0.60 (0.42–0.79)	3.9 ^E (1.9–5.9)	7.2 ^E (<LOD–15)
6 (2018–2019)	323	86.3 (76.5–92.4)	0.64 ^E (0.44–0.93)	<LOD	0.73 (0.52–0.94)	3.1 ^E (0.80–5.5)	8.4 ^E (2.2–15)
60–79 years							
5 (2016–2017)	345	87.7 (80.1–92.7)	0.71 (0.58–0.88)	<LOD	0.71 (0.56–0.87)	3.8 ^E (2.1–5.6)	6.0 ^E (3.5–8.6)
6 (2018–2019)	323	87.7 (83.2–91.1)	0.64 (0.53–0.76)	<LOD	0.57 (0.44–0.70)	2.4 ^E (0.87–3.9)	6.3 ^E (<LOD–13)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.42

Monoisodecyl phthalate (MiDP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2710	2.4 ^E (1.1–5.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2528	3.7 (2.6–5.3)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1348	2.4 ^E (1.0–5.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1254	4.9 ^E (2.9–8.2)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1362	2.4 ^E (0.90–6.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1274	2.5 ^E (1.1–5.7)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	554	2.0 ^E (0.70–5.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	511	0.50 ^E (0–6.6)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
5 (2016–2017)	535	1.2 ^E (0.40–3.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	498	0.80 ^E (0.30–2.0)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
5 (2016–2017)	537	1.9 ^E (1.1–3.4)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	504	2.8 ^E (1.0–7.7)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
5 (2016–2017)	373	1.7 ^E (0.60–5.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	330	7.5 ^E (3.7–14.4)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	358	3.7 ^E (1.3–9.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	343	2.5 ^E (0.70–8.8)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	353	2.1 ^E (0.70–6.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	342	2.0 ^E (0.60–6.6)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.16 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.43

Monoisodecyl phthalate (MiDP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2678	2.4 ^E (1.1–5.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2527	3.7 (2.6–5.3)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1333	2.4 ^E (1.0–5.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1253	4.9 ^E (2.9–8.2)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1345	2.4 ^E (0.90–6.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1274	2.5 ^E (1.1–5.7)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	543	2.0 ^E (0.70–5.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	510	0.50 ^E (0–6.6)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
5 (2016–2017)	527	1.2 ^E (0.40–3.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	498	0.80 ^E (0.30–2.0)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
5 (2016–2017)	530	1.9 ^E (1.1–3.4)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	504	2.8 ^E (1.0–7.7)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
5 (2016–2017)	369	1.7 ^E (0.60–5.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	330	7.5 ^E (3.7–14.4)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	357	3.7 ^E (1.3–9.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	343	2.5 ^E (0.70–8.8)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	352	2.1 ^E (0.70–6.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	342	2.0 ^E (0.60–6.6)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.44

Monooxisodecyl phthalate (MOiDP)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2688	73.4 (68.6–77.6)	0.27 (0.23–0.31)	<LOD	0.24 (0.19–0.29)	1.6 (1.1–2.1)	3.4 ^E (1.4–5.4)
6 (2018–2019)	2452	75.4 (70.8–79.4)	0.33 (0.28–0.37)	<LOD	0.27 (0.22–0.32)	2.1 ^E (1.2–2.9)	5.8 ^E (1.9–9.8)
Males, 3–79 years							
5 (2016–2017)	1341	72.7 (65.5–78.8)	0.27 (0.21–0.34)	<LOD	0.26 (0.18–0.34)	1.6 ^E (0.81–2.3)	3.8 ^E (1.6–6.0)
6 (2018–2019)	1216	78.6 (73.2–83.2)	0.35 (0.29–0.43)	<LOD	0.31 (0.26–0.37)	2.0 ^E (0.56–3.5)	8.6 ^E (<LOD–21)
Females, 3–79 years							
5 (2016–2017)	1347	74.0 (67.9–79.4)	0.26 (0.21–0.34)	<LOD	0.22 (0.16–0.28)	1.7 ^E (0.97–2.3)	3.1 ^E (<LOD–6.4)
6 (2018–2019)	1236	72.0 (64.9–78.2)	0.30 (0.26–0.35)	<LOD	0.23 (0.18–0.29)	2.2 ^E (1.2–3.2)	4.9 ^E (<LOD–11)
3–5 years							
5 (2016–2017)	547	79.8 (72.0–85.8)	0.33 (0.27–0.41)	<LOD	0.31 ^E (0.17–0.45)	2.0 (1.5–2.5)	3.2 ^E (1.6–4.8)
6 (2018–2019)	498	88.0 (82.0–92.2)	0.47 ^E (0.32–0.67)	<LOD	0.41 ^E (0.22–0.60)	2.3 ^E (<LOD–9.8)	9.7 ^E (<LOD–21)
6–11 years							
5 (2016–2017)	534	85.2 (79.6–89.6)	0.38 (0.30–0.49)	<LOD	0.35 (0.25–0.45)	1.9 ^E (0.81–2.9)	4.8 ^E (2.2–7.3)
6 (2018–2019)	486	86.7 (77.7–92.4)	0.50 (0.39–0.64)	<LOD	0.44 (0.29–0.59)	4.0 ^E (2.5–5.5)	7.0 ^E (0.83–13)
12–19 years							
5 (2016–2017)	534	80.3 (73.7–85.5)	0.36 (0.27–0.49)	<LOD	0.37 (0.24–0.50)	1.9 ^E (0.47–3.4)	4.3 ^E (2.4–6.3)
6 (2018–2019)	488	86.0 (77.9–91.4)	0.42 (0.31–0.57)	<LOD	0.38 (0.26–0.51)	2.1 ^E (1.0–3.2)	4.3 ^E (<LOD–24)
20–39 years							
5 (2016–2017)	371	74.4 (63.9–82.7)	0.25 (0.19–0.34)	<LOD	0.21 ^E (0.13–0.30)	1.6 ^E (0.64–2.5)	2.0 ^E (<LOD–4.3)
6 (2018–2019)	321	82.5 (71.8–89.7)	0.50 ^E (0.34–0.74)	<LOD	0.32 (0.22–0.42)	4.8 ^E (<LOD–26)	44 ^E (<LOD–110)
40–59 years							
5 (2016–2017)	354	69.0 (59.9–76.7)	0.26 ^E (0.18–0.37)	<LOD	0.24 ^E (0.13–0.36)	1.6 ^E (0.49–2.7)	4.0 ^E (<LOD–16)
6 (2018–2019)	335	67.3 (58.5–75.1)	0.22 (0.18–0.26)	<LOD	0.19 (0.13–0.26)	1.3 ^E (0.78–1.7)	2.1 (1.4–2.8)
60–79 years							
5 (2016–2017)	348	69.9 (63.8–75.4)	0.22 (0.17–0.29)	<LOD	0.18 (0.14–0.23)	1.2 ^E (0.10–2.4)	2.5 ^E (<LOD–6.2)
6 (2018–2019)	324	66.2 (55.7–75.2)	0.23 (0.16–0.33)	<LOD	0.21 ^E (0.11–0.31)	1.3 ^E (0.48–2.2)	2.8 ^E (<LOD–10)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.097 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.45

Monooxisodecyl phthalate (MOiDP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2656	73.4 (68.6–77.6)	0.26 (0.21–0.32)	<LOD	0.21 (0.17–0.25)	1.5 (0.97–2.0)	3.0 ^E (1.0–5.0)
6 (2018–2019)	2451	75.4 (70.8–79.4)	0.35 (0.31–0.40)	<LOD	0.27 (0.23–0.30)	1.9 (1.5–2.4)	5.7 ^E (2.7–8.7)
Males, 3–79 years							
5 (2016–2017)	1326	72.7 (65.5–78.8)	0.23 (0.18–0.30)	<LOD	0.19 (0.16–0.23)	1.3 ^E (0.39–2.2)	3.4 ^E (1.1–5.8)
6 (2018–2019)	1215	78.6 (73.2–83.2)	0.33 (0.27–0.39)	<LOD	0.25 (0.22–0.29)	1.7 ^E (0.95–2.4)	5.9 ^E (<LOD–12)
Females, 3–79 years							
5 (2016–2017)	1330	74.0 (67.9–79.4)	0.29 (0.22–0.38)	<LOD	0.24 (0.19–0.29)	1.6 (1.0–2.1)	2.8 ^E (<LOD–6.0)
6 (2018–2019)	1236	72.0 (64.9–78.2)	0.39 (0.34–0.44)	<LOD	0.30 (0.24–0.37)	2.1 (1.4–2.7)	5.4 ^E (<LOD–11)
3–5 years							
5 (2016–2017)	536	79.8 (72.0–85.8)	0.57 (0.47–0.70)	<LOD	0.53 (0.43–0.64)	2.5 (1.8–3.2)	4.5 ^E (1.5–7.5)
6 (2018–2019)	497	88.0 (82.0–92.2)	0.75 ^E (0.49–1.1)	<LOD	0.69 (0.49–0.90)	3.7 ^E (<LOD–13)	15 ^E (<LOD–31)
6–11 years							
5 (2016–2017)	526	85.2 (79.6–89.6)	0.45 (0.35–0.59)	<LOD	0.38 (0.27–0.48)	2.0 ^E (0.90–3.0)	4.6 ^E (1.9–7.3)
6 (2018–2019)	486	86.7 (77.7–92.4)	0.60 (0.50–0.71)	<LOD	0.52 (0.40–0.63)	3.9 (2.6–5.3)	6.4 ^E (3.2–9.6)
12–19 years							
5 (2016–2017)	527	80.3 (73.7–85.5)	0.28 (0.21–0.38)	<LOD	0.22 ^E (0.12–0.31)	1.4 ^E (0.58–2.3)	3.0 ^E (1.0–5.0)
6 (2018–2019)	488	86.0 (77.9–91.4)	0.35 (0.26–0.47)	<LOD	0.32 (0.24–0.41)	1.3 ^E (<LOD–3.3)	4.8 ^E (<LOD–13)
20–39 years							
5 (2016–2017)	367	74.4 (63.9–82.7)	0.23 (0.17–0.31)	<LOD	0.21 (0.16–0.26)	1.3 ^E (0.70–2.0)	1.7 ^E (<LOD–3.3)
6 (2018–2019)	321	82.5 (71.8–89.7)	0.47 (0.33–0.68)	<LOD	0.31 (0.20–0.42)	2.9 ^E (<LOD–9.5)	44 ^E (<LOD–92)
40–59 years							
5 (2016–2017)	353	69.0 (59.9–76.7)	0.23 ^E (0.16–0.34)	<LOD	0.18 (0.12–0.24)	2.0 ^E (0.76–3.3)	4.3 ^E (<LOD–10)
6 (2018–2019)	335	67.3 (58.5–75.1)	0.26 (0.20–0.32)	<LOD	0.23 (0.15–0.30)	1.1 (0.80–1.5)	2.1 ^E (1.2–2.9)
60–79 years							
5 (2016–2017)	347	69.9 (63.8–75.4)	0.26 (0.20–0.33)	<LOD	0.20 (0.15–0.25)	1.5 ^E (0.68–2.2)	2.3 ^E (<LOD–6.2)
6 (2018–2019)	324	66.2 (55.7–75.2)	0.28 (0.21–0.37)	<LOD	0.22 (0.15–0.30)	1.6 ^E (<LOD–3.4)	4.7 ^E (<LOD–8.5)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.46

Monohydroxyisodecyl phthalate (MHIDP)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2700	71.4 (62.2–79.0)	0.21 (0.17–0.26)	<LOD	0.19 (0.14–0.24)	1.2 (0.88–1.6)	3.0 ^E (1.7–4.4)
6 (2018–2019)	2502	74.8 (70.9–78.3)	0.26 (0.22–0.29)	<LOD	0.23 (0.17–0.28)	1.9 ^E (0.96–2.8)	5.5 ^E (2.4–8.7)
Males, 3–79 years							
5 (2016–2017)	1347	73.3 (63.0–81.5)	0.22 (0.17–0.28)	<LOD	0.22 (0.14–0.30)	1.2 ^E (0.51–1.8)	2.6 ^E (1.3–3.8)
6 (2018–2019)	1242	79.7 (75.4–83.5)	0.29 (0.25–0.35)	<LOD	0.27 (0.23–0.31)	1.7 ^E (<LOD–3.4)	7.6 ^E (<LOD–18)
Females, 3–79 years							
5 (2016–2017)	1353	69.5 (60.0–77.5)	0.20 (0.15–0.26)	<LOD	0.18 (0.13–0.22)	1.3 (0.82–1.7)	3.7 ^E (1.5–6.0)
6 (2018–2019)	1260	69.9 (64.2–75.0)	0.22 (0.19–0.27)	<LOD	0.19 (0.14–0.23)	1.9 ^E (0.82–3.1)	4.0 ^E (0.073–7.9)
3–5 years							
5 (2016–2017)	552	79.6 (69.9–86.8)	0.28 (0.23–0.35)	<LOD	0.29 ^E (0.17–0.41)	1.9 (1.5–2.4)	2.5 (1.9–3.0)
6 (2018–2019)	504	87.4 (78.1–93.1)	0.39 ^E (0.25–0.63)	<LOD	0.36 (0.25–0.48)	1.9 ^E (<LOD–9.0)	8.2 ^E (<LOD–21)
6–11 years							
5 (2016–2017)	532	78.7 (70.3–85.2)	0.29 (0.23–0.38)	<LOD	0.31 (0.21–0.41)	1.8 ^E (1.0–2.5)	4.2 ^E (2.4–5.9)
6 (2018–2019)	494	82.4 (72.8–89.1)	0.37 (0.28–0.49)	<LOD	0.41 (0.27–0.56)	2.8 ^E (1.7–4.0)	6.2 ^E (1.8–11)
12–19 years							
5 (2016–2017)	536	76.1 (62.2–86.1)	0.27 ^E (0.18–0.39)	<LOD	0.27 (0.18–0.37)	1.6 ^E (0.50–2.7)	3.8 ^E (1.6–6.0)
6 (2018–2019)	499	80.5 (74.2–85.5)	0.32 (0.23–0.43)	<LOD	0.31 ^E (0.19–0.42)	2.1 (1.4–2.8)	3.4 ^E (<LOD–17)
20–39 years							
5 (2016–2017)	371	71.5 (60.6–80.3)	0.19 (0.13–0.28)	<LOD	0.18 ^E (0.11–0.26)	1.2 ^E (0.23–2.1)	3.2 ^E (0.57–5.8)
6 (2018–2019)	329	84.4 (75.3–90.6)	0.40 ^E (0.28–0.59)	<LOD	0.26 ^E (0.14–0.38)	4.2 ^E (<LOD–18)	35 ^E (<LOD–85)
40–59 years							
5 (2016–2017)	359	68.6 (53.0–80.8)	0.21 ^E (0.14–0.32)	<LOD	0.18 ^E (0.071–0.28)	1.3 ^E (0.41–2.2)	2.6 ^E (<LOD–12)
6 (2018–2019)	338	67.3 (59.9–74.0)	0.18 (0.15–0.21)	<LOD	0.19 (0.14–0.24)	1.2 (0.83–1.5)	1.9 ^E (0.94–2.9)
60–79 years							
5 (2016–2017)	350	69.3 (57.7–78.9)	0.18 (0.13–0.24)	<LOD	0.15 (0.11–0.19)	1.0 ^E (0.10–1.9)	1.9 ^E (<LOD–5.3)
6 (2018–2019)	338	64.7 (54.5–73.7)	0.17 ^E (0.12–0.25)	<LOD	0.15 ^E (<LOD–0.25)	1.2 ^E (0.73–1.7)	2.4 ^E (<LOD–8.8)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 5 and 6 are 0.067 and 0.065 $\mu\text{g/L}$, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.1.47

Monohydroxyisodecyl phthalate (MHIDP) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2669	71.4 (62.2–79.0)	0.20 (0.15–0.27)	<LOD	0.19 (0.15–0.23)	1.3 (0.88–1.7)	2.4 ^E (0.84–4.0)
6 (2018–2019)	2501	74.8 (70.9–78.3)	0.28 (0.25–0.31)	<LOD	0.24 (0.21–0.27)	1.7 (1.2–2.2)	5.3 ^E (2.8–7.9)
Males, 3–79 years							
5 (2016–2017)	1332	73.3 (63.0–81.5)	0.19 (0.14–0.25)	<LOD	0.19 (0.16–0.22)	1.1 ^E (0.50–1.7)	2.9 ^E (0.90–4.9)
6 (2018–2019)	1241	79.7 (75.4–83.5)	0.27 (0.23–0.33)	<LOD	0.23 (0.20–0.27)	1.4 ^E (<LOD–2.1)	5.6 ^E (<LOD–11)
Females, 3–79 years							
5 (2016–2017)	1337	69.5 (60.0–77.5)	0.22 (0.16–0.30)	<LOD	0.19 (0.14–0.24)	1.4 (0.89–1.9)	2.3 ^E (<LOD–5.1)
6 (2018–2019)	1260	69.9 (64.2–75.0)	0.28 (0.24–0.33)	<LOD	0.26 (0.18–0.33)	1.9 (1.3–2.6)	4.7 ^E (0.59–8.8)
3–5 years							
5 (2016–2017)	541	79.6 (69.9–86.8)	0.49 (0.39–0.62)	<LOD	0.48 (0.37–0.60)	2.4 (1.9–3.0)	4.0 (2.8–5.2)
6 (2018–2019)	503	87.4 (78.1–93.1)	0.64 ^E (0.39–1.0)	<LOD	0.57 ^E (0.34–0.79)	2.9 ^E (<LOD–12)	14 ^E (<LOD–32)
6–11 years							
5 (2016–2017)	525	78.7 (70.3–85.2)	0.34 (0.26–0.46)	<LOD	0.34 (0.26–0.41)	1.6 ^E (0.97–2.2)	3.8 ^E (1.3–6.4)
6 (2018–2019)	494	82.4 (72.8–89.1)	0.44 (0.36–0.54)	<LOD	0.44 (0.33–0.55)	2.6 ^E (1.6–3.6)	5.1 ^E (2.3–7.8)
12–19 years							
5 (2016–2017)	529	76.1 (62.2–86.1)	0.20 (0.14–0.29)	<LOD	0.16 ^E (0.092–0.24)	1.1 ^E (0.32–2.0)	2.3 ^E (0.91–3.6)
6 (2018–2019)	499	80.5 (74.2–85.5)	0.26 (0.20–0.35)	<LOD	0.25 (0.18–0.33)	1.0 ^E (<LOD–2.7)	3.6 ^E (<LOD–9.1)
20–39 years							
5 (2016–2017)	367	71.5 (60.6–80.3)	0.17 ^E (0.11–0.27)	<LOD	0.18 (0.12–0.23)	0.99 ^E (0.41–1.6)	1.7 ^E (0.38–3.0)
6 (2018–2019)	329	84.4 (75.3–90.6)	0.38 (0.27–0.54)	<LOD	0.27 (0.18–0.35)	2.3 ^E (<LOD–7.5)	32 ^E (<LOD–71)
40–59 years							
5 (2016–2017)	358	68.6 (53.0–80.8)	0.19 ^E (0.12–0.29)	<LOD	0.19 ^E (0.11–0.27)	1.5 ^E (0.52–2.4)	3.7 ^E (<LOD–8.0)
6 (2018–2019)	338	67.3 (59.9–74.0)	0.21 (0.17–0.26)	<LOD	0.21 (0.16–0.27)	0.95 (0.75–1.2)	2.1 ^E (0.79–3.4)
60–79 years							
5 (2016–2017)	349	69.3 (57.7–78.9)	0.20 (0.15–0.27)	<LOD	0.16 ^E (0.099–0.21)	1.1 ^E (0.69–1.6)	1.6 ^E (<LOD–5.2)
6 (2018–2019)	338	64.7 (54.5–73.7)	0.20 (0.15–0.27)	<LOD	0.16 ^E (<LOD–0.23)	1.2 ^E (<LOD–2.4)	3.8 ^E (<LOD–7.6)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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14.2 DI(ISONONYL) CYCLOHEXANE-1,2- DICARBOXYLATE (DINCH)

Di(isononyl)cyclohexane-1,2-dicarboxylate (DINCH) (CASRN 166412-78-8) is an aliphatic ester compound that is a colourless liquid at room temperature. This substance may also be referred to as diisononyl hexahydrophthalate, among other synonyms. Commercial production of DINCH uses catalytic hydrogenation of the aromatic ring of diisononyl phthalate (DINP), and results in a mixture of *cis*-isomers (~90%) and *trans*-isomers (Bhat et al., 2014; Koch et al., 2013; SCENIHR, 2016). DINCH is used as a substitute for high molecular-weight medium-chain phthalate plasticizers, such as DINP and di(2-ethylhexyl) phthalate (DEHP), primarily in polyvinyl chloride (PVC) materials for beverage and food contact applications (Bhat et al., 2014; NICNAS, 2012). DINCH is also used as a plasticizer and impact modifier in polystyrene in toys, food contact materials and medical devices (Bhat et al., 2014; Koch et al., 2013; NICNAS, 2012).

DINCH does not occur naturally and is released to the environment from anthropogenic sources. It may be released during product manufacture and from degradation of products and packaging. DINCH has very low vapour pressure (volatility) and water solubility, and is therefore expected to occur minimally in air and water (NICNAS, 2012). The general population may be exposed to DINCH dermally from contact with products such as plastic toys and car upholstery, orally from materials that contact food or beverages, orally or intravenously through medical applications, or via the inhalation or ingestion of house dust (Bhat et al., 2014; NICNAS, 2012; SCENIHR, 2016). Because the use of DINCH in products available to consumers is limited—and given that it leaches only minimally from the polymer matrix when used as a plasticizer—exposure via product use is expected to be low (NICNAS, 2012; SCENIHR, 2016). Given the very low vapour pressure of DINCH, exposure via inhalation is of minimal concern (NICNAS, 2012).

Rapid absorption of DINCH has been reported in experimental animal studies following ingestion, while no data were identified concerning dermal absorption (Bhat et al., 2014; SCENIHR, 2016). In 1

study, DINCH showed rapid but saturable absorption following oral exposure, with oral bioavailability estimated to be higher after a lower dose than a higher dose (SCENIHR, 2016). Studies of orally exposed animals indicate that DINCH is distributed throughout the body following absorption (Bhat et al., 2014; ECHA, 2016; SCENIHR, 2016). In a study of human volunteers administered DINCH orally, more than 85% of the administered dose was excreted as cyclohexane-1,2-dicarboxylic acid (CHDA) within 70 hours following hydrolysis; OH-MINCH was the main secondary metabolite, with about 14% of the administered dose (Völkel et al., 2016). In orally exposed animals, DINCH was hydrolyzed to cyclohexane-1,2-dicarboxylic mono isononyl ester (MINCH) before being further hydrolyzed to CHDA, the main urinary metabolite (Bhat et al., 2014; Koch et al., 2013). Minor urinary metabolites include the oxidized monoesters hydroxy-MINCH, oxo-MINCH and carboxy-MINCH (Bhat et al., 2014; Völkel et al., 2016). In studies with laboratory animals, unmetabolized DINCH was mainly excreted in feces within 48 hours, whereas a smaller fraction was eliminated via urinary metabolites over the same period. The total excretion of radiolabelled DINCH and its metabolites represented ~90% of the administered dose (Bhat et al., 2014).

Acute dermal and ocular exposure to DINCH was found to be non-irritating in laboratory animals, and no skin sensitization was observed. Experimental animal studies have reported that DINCH has low toxicity following acute, short-term or subchronic ingestion exposure. However, chronic ingestion of high doses of this substance was found to result in increased liver, kidney and thyroid weights (Bhat et al., 2014; SCENIHR, 2016). In a 2-generation animal study, DINCH had no adverse reproductive or developmental effects (Bhat et al., 2014). One study of laboratory animals exposed to DINCH in utero from gestational day 14 until parturition reported a long-term effect on Leydig cells of the testes, indicated by reduced circulating testosterone levels and altered testicular morphology (Capioli et al., 2017). DINCH is not considered genotoxic or carcinogenic (Bhat et al., 2014; ECHA, 2016; SCENIHR, 2016).

Six metabolites of DINCH (*trans*-cyclohexane-1,2-dicarboxylic mono isononyl ester [*trans*-MINCH]; cyclohexane-1,2-dicarboxylic mono oxoisononyl ester [oxo-MINCH]; cyclohexane-1,2-dicarboxylic mono

hydroxyisononyl ester [OH-MINCH]; *cis*-cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester [*cis*-cx-MINCH]; *trans*-cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester [*trans*-cx-MINCH]; and CHDA) were analyzed in the urine of Canadian Health Measures Survey participants aged 3–79 in cycle 5

(2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented as both µg/L and µg/g creatinine. Finding a measurable amount of these metabolites in urine can be an indicator of recent exposure to DINCH and does not necessarily mean that an adverse health effect will occur.

Table 14.2.1

trans-Cyclohexane-1,2-dicarboxylic mono isononyl ester (*trans*-MINCH)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2680	7.7 ^E (5.0–11.8)	—	<LOD	<LOD	<LOD	0.024 (<LOD–0.032)
6 (2018–2019)	2492	9.8 (7.3–13.1)	—	<LOD	<LOD	<LOD	0.031 (0.020–0.042)
Males, 3–79 years							
5 (2016–2017)	1340	8.7 ^E (5.0–14.5)	—	<LOD	<LOD	<LOD	0.025 (<LOD–0.034)
6 (2018–2019)	1237	9.5 ^E (6.2–14.3)	—	<LOD	<LOD	<LOD	0.030 ^E (<LOD–0.065)
Females, 3–79 years							
5 (2016–2017)	1340	6.8 ^E (4.5–10.2)	—	<LOD	<LOD	<LOD	0.023 (<LOD–0.030)
6 (2018–2019)	1255	10.2 ^E (6.8–15.0)	—	<LOD	<LOD	0.017 (<LOD–0.020)	0.032 ^E (0.019–0.045)
3–5 years							
5 (2016–2017)	540	32.3 (26.0–39.3)	—	<LOD	<LOD	0.045 (0.032–0.059)	0.076 ^E (0.047–0.10)
6 (2018–2019)	503	29.8 (22.0–39.0)	—	<LOD	<LOD	0.038 ^E (0.023–0.054)	0.081 ^E (0.028–0.13)
6–11 years							
5 (2016–2017)	532	19.8 (14.6–26.2)	—	<LOD	<LOD	0.029 (0.023–0.036)	0.035 ^E (0.022–0.049)
6 (2018–2019)	494	14.5 (10.0–20.6)	—	<LOD	<LOD	0.025 (<LOD–0.034)	0.037 (0.028–0.046)
12–19 years							
5 (2016–2017)	535	8.9 ^E (4.2–18.0)	—	<LOD	<LOD	<LOD	0.024 ^E (<LOD–0.034)
6 (2018–2019)	500	13.5 ^E (9.0–19.8)	—	<LOD	<LOD	0.022 (<LOD–0.029)	0.034 ^E (0.019–0.049)
20–39 years							
5 (2016–2017)	368	6.9 ^E (3.1–14.6)	—	<LOD	<LOD	<LOD	0.019 ^E (<LOD–0.030)
6 (2018–2019)	325	8.1 ^E (4.5–14.1)	—	<LOD	<LOD	<LOD	0.021 (<LOD–0.029)
40–59 years							
5 (2016–2017)	357	4.4 ^E (2.0–9.4)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	335	10.0 ^E (5.9–16.4)	—	<LOD	<LOD	<LOD	0.054 ^E (<LOD–0.13)
60–79 years							
5 (2016–2017)	348	5.3 ^E (2.1–12.8)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	335	5.7 ^E (3.6–9.0)	—	<LOD	<LOD	<LOD	0.019 ^E (<LOD–0.031)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.017 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.2

trans-Cyclohexane-1,2-dicarboxylic mono isononyl ester (*trans*-MINCH) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2650	7.7 ^E (5.0–11.8)	—	<LOD	<LOD	<LOD	0.041 (<LOD–0.048)
6 (2018–2019)	2491	9.8 (7.3–13.1)	—	<LOD	<LOD	<LOD	0.047 (0.034–0.060)
Males, 3–79 years							
5 (2016–2017)	1325	8.7 ^E (5.0–14.5)	—	<LOD	<LOD	<LOD	0.034 (<LOD–0.045)
6 (2018–2019)	1236	9.5 ^E (6.2–14.3)	—	<LOD	<LOD	<LOD	0.046 ^E (<LOD–0.072)
Females, 3–79 years							
5 (2016–2017)	1325	6.8 ^E (4.5–10.2)	—	<LOD	<LOD	<LOD	0.042 (<LOD–0.046)
6 (2018–2019)	1255	10.2 ^E (6.8–15.0)	—	<LOD	<LOD	0.036 (<LOD–0.041)	0.050 (0.038–0.061)
3–5 years							
5 (2016–2017)	530	32.3 (26.0–39.3)	—	<LOD	<LOD	0.075 (0.049–0.10)	0.13 ^E (0.058–0.21)
6 (2018–2019)	502	29.8 (22.0–39.0)	—	<LOD	<LOD	0.067 (0.043–0.091)	0.099 (0.078–0.12)
6–11 years							
5 (2016–2017)	525	19.8 (14.6–26.2)	—	<LOD	<LOD	0.034 (0.028–0.040)	0.046 ^E (0.029–0.063)
6 (2018–2019)	494	14.5 (10.0–20.6)	—	<LOD	<LOD	0.036 ^E (<LOD–0.049)	0.054 (0.041–0.067)
12–19 years							
5 (2016–2017)	528	8.9 ^E (4.2–18.0)	—	<LOD	<LOD	<LOD	0.031 (<LOD–0.042)
6 (2018–2019)	500	13.5 ^E (9.0–19.8)	—	<LOD	<LOD	0.029 ^E (<LOD–0.041)	0.047 ^E (<LOD–0.088)
20–39 years							
5 (2016–2017)	364	6.9 ^E (3.1–14.6)	—	<LOD	<LOD	<LOD	0.041 ^E (<LOD–0.057)
6 (2018–2019)	325	8.1 ^E (4.5–14.1)	—	<LOD	<LOD	<LOD	0.041 ^E (<LOD–0.056)
40–59 years							
5 (2016–2017)	356	4.4 ^E (2.0–9.4)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	335	10.0 ^E (5.9–16.4)	—	<LOD	<LOD	<LOD	0.051 ^E (<LOD–0.10)
60–79 years							
5 (2016–2017)	347	5.3 ^E (2.1–12.8)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	335	5.7 ^E (3.6–9.0)	—	<LOD	<LOD	<LOD	0.042 (<LOD–0.050)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.3

Cyclohexane-1,2-dicarboxylic mono oxoisobutyl ester (oxo-MINCH)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2655	36.8 (32.2–41.6)	—	<LOD	<LOD	0.19 (0.15–0.22)	0.35 (0.27–0.43)
6 (2018–2019)	2468	40.5 (35.6–45.7)	—	<LOD	<LOD	0.25 ^E (0.14–0.35)	0.44 ^E (0.27–0.62)
Males, 3–79 years							
5 (2016–2017)	1328	37.0 (29.5–45.1)	—	<LOD	<LOD	0.19 (0.12–0.25)	0.34 (0.22–0.46)
6 (2018–2019)	1223	41.8 (36.2–47.7)	—	<LOD	<LOD	0.30 ^E (0.15–0.44)	0.48 ^E (0.13–0.82)
Females, 3–79 years							
5 (2016–2017)	1327	36.6 (30.4–43.2)	—	<LOD	<LOD	0.19 (0.15–0.23)	0.36 (0.25–0.48)
6 (2018–2019)	1245	39.2 (32.2–46.8)	—	<LOD	<LOD	0.21 ^E (0.10–0.33)	0.42 (0.27–0.57)
3–5 years							
5 (2016–2017)	541	79.1 (71.2–85.3)	0.16 (0.13–0.20)	<LOD	0.19 (0.15–0.23)	0.81 ^E (0.47–1.2)	1.1 (0.85–1.4)
6 (2018–2019)	495	83.2 (75.4–88.8)	0.17 (0.14–0.21)	<LOD	0.20 (0.13–0.27)	0.61 (0.43–0.79)	0.92 (0.60–1.2)
6–11 years							
5 (2016–2017)	527	68.3 (62.5–73.6)	0.097 (0.085–0.11)	<LOD	0.096 (0.077–0.11)	0.49 (0.37–0.61)	0.68 (0.58–0.79)
6 (2018–2019)	489	73.2 (61.0–82.6)	0.11 (0.079–0.14)	<LOD	0.11 ^E (0.065–0.15)	0.49 (0.36–0.63)	0.55 (0.36–0.73)
12–19 years							
5 (2016–2017)	525	41.8 (36.3–47.5)	—	<LOD	<LOD	0.19 (0.14–0.25)	0.34 ^E (0.11–0.58)
6 (2018–2019)	495	58.4 (48.4–67.8)	—	<LOD	<LOD	0.41 ^E (0.25–0.57)	0.79 ^E (0.46–1.1)
20–39 years							
5 (2016–2017)	363	36.8 (29.6–44.6)	—	<LOD	<LOD	0.18 ^E (0.089–0.26)	0.28 ^E (0.17–0.38)
6 (2018–2019)	321	44.8 (31.7–58.7)	—	<LOD	<LOD	0.21 ^E (0.13–0.30)	0.31 ^E (0.18–0.44)
40–59 years							
5 (2016–2017)	353	29.4 (22.0–38.1)	—	<LOD	<LOD	0.11 ^E (<LOD–0.20)	0.32 ^E (0.064–0.57)
6 (2018–2019)	335	29.6 (21.0–40.0)	—	<LOD	<LOD	0.19 ^E (<LOD–0.52)	0.52 ^E (<LOD–1.1)
60–79 years							
5 (2016–2017)	346	27.6 (19.1–38.1)	—	<LOD	<LOD	0.11 ^E (0.069–0.15)	0.14 (0.093–0.19)
6 (2018–2019)	333	24.5 (18.2–32.1)	—	<LOD	<LOD	0.11 (0.092–0.14)	0.15 (0.12–0.18)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.047 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.4

Cyclohexane-1,2-dicarboxylic mono oxoisobutyl ester (oxo-MINCH) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2626	36.8 (32.2–41.6)	—	<LOD	<LOD	0.15 (0.14–0.17)	0.28 (0.21–0.34)
6 (2018–2019)	2467	40.5 (35.6–45.7)	—	<LOD	<LOD	0.22 ^E (0.12–0.32)	0.41 (0.27–0.55)
Males, 3–79 years							
5 (2016–2017)	1313	37.0 (29.5–45.1)	—	<LOD	<LOD	0.15 (0.12–0.18)	0.31 ^E (0.19–0.42)
6 (2018–2019)	1222	41.8 (36.2–47.7)	—	<LOD	<LOD	0.21 ^E (0.080–0.35)	0.40 ^E (<LOD–0.80)
Females, 3–79 years							
5 (2016–2017)	1313	36.6 (30.4–43.2)	—	<LOD	<LOD	0.16 (0.15–0.17)	0.25 ^E (0.14–0.36)
6 (2018–2019)	1245	39.2 (32.2–46.8)	—	<LOD	<LOD	0.23 ^E (0.13–0.32)	0.43 (0.29–0.57)
3–5 years							
5 (2016–2017)	531	79.1 (71.2–85.3)	0.28 (0.23–0.35)	<LOD	0.28 (0.21–0.35)	1.4 ^E (0.53–2.2)	1.8 ^E (0.97–2.7)
6 (2018–2019)	494	83.2 (75.4–88.8)	0.28 (0.22–0.34)	<LOD	0.29 (0.22–0.37)	1.0 (0.74–1.3)	1.2 ^E (0.31–2.1)
6–11 years							
5 (2016–2017)	520	68.3 (62.5–73.6)	0.11 (0.093–0.13)	<LOD	0.11 (0.082–0.13)	0.46 ^E (0.28–0.63)	0.69 (0.46–0.93)
6 (2018–2019)	489	73.2 (61.0–82.6)	0.13 (0.10–0.16)	<LOD	0.13 (0.085–0.17)	0.40 (0.27–0.53)	0.61 ^E (0.34–0.87)
12–19 years							
5 (2016–2017)	519	41.8 (36.3–47.5)	—	<LOD	<LOD	0.13 (0.091–0.17)	0.20 ^E (0.074–0.33)
6 (2018–2019)	495	58.4 (48.4–67.8)	—	<LOD	<LOD	0.29 (0.21–0.37)	0.41 (0.27–0.54)
20–39 years							
5 (2016–2017)	359	36.8 (29.6–44.6)	—	<LOD	<LOD	0.13 (0.092–0.16)	0.16 (0.11–0.21)
6 (2018–2019)	321	44.8 (31.7–58.7)	—	<LOD	<LOD	0.17 (0.11–0.23)	0.22 ^E (0.13–0.31)
40–59 years							
5 (2016–2017)	352	29.4 (22.0–38.1)	—	<LOD	<LOD	0.098 ^E (<LOD–0.14)	0.16 ^E (<LOD–0.31)
6 (2018–2019)	335	29.6 (21.0–40.0)	—	<LOD	<LOD	0.16 ^E (<LOD–0.37)	0.34 ^E (<LOD–1.1)
60–79 years							
5 (2016–2017)	345	27.6 (19.1–38.1)	—	<LOD	<LOD	0.10 (0.070–0.13)	0.14 ^E (0.084–0.19)
6 (2018–2019)	333	24.5 (18.2–32.1)	—	<LOD	<LOD	0.12 (0.099–0.13)	0.16 (0.10–0.21)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.5

Cyclohexane-1,2-dicarboxylic mono hydroxyisononyl ester (OH-MINCH)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2634	42.4 (36.3–48.8)	—	<LOD	<LOD	0.41 (0.31–0.51)	0.78 (0.57–0.99)
6 (2018–2019)	2365	50.9 (46.1–55.7)	0.10 (0.089–0.12)	<LOD	0.075 (<LOD–0.096)	0.61 ^E (0.36–0.86)	1.0 (0.70–1.3)
Males, 3–79 years							
5 (2016–2017)	1312	41.1 (31.8–51.1)	—	<LOD	<LOD	0.42 (0.29–0.55)	0.71 ^E (0.42–0.99)
6 (2018–2019)	1173	49.9 (45.5–54.3)	0.10 (0.088–0.12)	<LOD	<LOD	0.62 ^E (0.22–1.0)	1.1 ^E (0.36–1.8)
Females, 3–79 years							
5 (2016–2017)	1322	43.8 (37.0–50.8)	—	<LOD	<LOD	0.38 (0.26–0.50)	0.80 (0.51–1.1)
6 (2018–2019)	1192	51.9 (45.4–58.3)	0.10 (0.085–0.12)	<LOD	0.078 (<LOD–0.11)	0.58 ^E (0.31–0.84)	0.98 (0.67–1.3)
3–5 years							
5 (2016–2017)	533	80.2 (73.6–85.5)	0.30 (0.24–0.38)	<LOD	0.33 (0.22–0.44)	1.5 ^E (0.94–2.1)	2.4 ^E (1.5–3.3)
6 (2018–2019)	469	91.2 (87.0–94.2)	0.39 (0.33–0.46)	<LOD	0.43 (0.30–0.57)	1.3 (0.96–1.7)	2.0 ^E (1.0–3.0)
6–11 years							
5 (2016–2017)	519	66.6 (58.1–74.1)	0.17 (0.14–0.21)	<LOD	0.19 (0.14–0.24)	0.91 (0.73–1.1)	1.2 (0.81–1.7)
6 (2018–2019)	455	77.4 (67.7–84.8)	0.22 (0.16–0.29)	<LOD	0.24 (0.16–0.31)	1.1 (0.82–1.4)	1.4 ^E (0.80–2.0)
12–19 years							
5 (2016–2017)	517	45.3 (37.7–53.2)	—	<LOD	<LOD	0.39 (0.26–0.52)	0.88 ^E (0.27–1.5)
6 (2018–2019)	471	65.8 (57.2–73.6)	0.15 (0.12–0.18)	<LOD	0.12 (0.079–0.17)	0.84 (0.55–1.1)	1.5 (0.92–2.0)
20–39 years							
5 (2016–2017)	361	44.3 (32.0–57.3)	—	<LOD	<LOD	0.28 ^E (<LOD–0.49)	0.58 ^E (0.31–0.85)
6 (2018–2019)	310	53.7 (39.9–66.9)	—	<LOD	0.085 ^E (<LOD–0.12)	0.50 ^E (0.22–0.78)	0.94 ^E (0.53–1.4)
40–59 years							
5 (2016–2017)	355	34.9 (25.7–45.3)	—	<LOD	<LOD	0.26 ^E (<LOD–0.50)	0.71 ^E (<LOD–1.4)
6 (2018–2019)	332	42.7 (32.1–54.0)	—	<LOD	<LOD	0.45 ^E (<LOD–1.1)	1.1 ^E (<LOD–2.2)
60–79 years							
5 (2016–2017)	349	35.7 (26.5–46.0)	—	<LOD	<LOD	0.24 ^E (0.091–0.38)	0.38 ^E (0.18–0.58)
6 (2018–2019)	328	38.2 (30.6–46.4)	—	<LOD	<LOD	0.31 ^E (0.18–0.44)	0.49 (0.34–0.64)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LODs for cycles 5 and 6 are 0.078 and 0.071 µg/L, respectively.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.6

Cyclohexane-1,2-dicarboxylic mono hydroxyisononyl ester (OH-MINCH) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2605	42.4 (36.3–48.8)	—	<LOD	<LOD	0.35 (0.27–0.43)	0.59 (0.46–0.71)
6 (2018–2019)	2364	50.9 (46.1–55.7)	0.11 (0.097–0.13)	<LOD	0.099 (<LOD–0.11)	0.50 ^E (0.28–0.73)	0.99 (0.66–1.3)
Males, 3–79 years							
5 (2016–2017)	1297	41.1 (31.8–51.1)	—	<LOD	<LOD	0.32 (0.22–0.42)	0.65 (0.46–0.85)
6 (2018–2019)	1172	49.9 (45.5–54.3)	0.095 (0.082–0.11)	<LOD	<LOD	0.49 ^E (0.22–0.76)	0.98 ^E (0.088–1.9)
Females, 3–79 years							
5 (2016–2017)	1308	43.8 (37.0–50.8)	—	<LOD	<LOD	0.36 (0.27–0.44)	0.54 ^E (0.33–0.75)
6 (2018–2019)	1192	51.9 (45.4–58.3)	0.13 (0.11–0.16)	<LOD	0.11 (<LOD–0.13)	0.55 ^E (0.29–0.81)	0.99 (0.65–1.3)
3–5 years							
5 (2016–2017)	523	80.2 (73.6–85.5)	0.53 (0.43–0.66)	<LOD	0.58 (0.40–0.75)	2.8 ^E (1.2–4.4)	3.4 (2.4–4.5)
6 (2018–2019)	468	91.2 (87.0–94.2)	0.64 (0.53–0.77)	<LOD	0.69 (0.52–0.87)	2.0 (1.5–2.5)	2.8 ^E (1.4–4.2)
6–11 years							
5 (2016–2017)	512	66.6 (58.1–74.1)	0.20 (0.16–0.26)	<LOD	0.21 (0.16–0.27)	0.86 ^E (0.48–1.2)	1.7 ^E (0.73–2.7)
6 (2018–2019)	455	77.4 (67.7–84.8)	0.27 (0.21–0.35)	<LOD	0.27 ^E (0.17–0.37)	0.87 (0.56–1.2)	1.6 ^E (0.85–2.4)
12–19 years							
5 (2016–2017)	511	45.3 (37.7–53.2)	—	<LOD	<LOD	0.23 ^E (0.12–0.33)	0.54 ^E (0.23–0.85)
6 (2018–2019)	471	65.8 (57.2–73.6)	0.12 (0.10–0.15)	<LOD	0.10 (0.088–0.12)	0.58 ^E (0.35–0.81)	1.0 (0.73–1.3)
20–39 years							
5 (2016–2017)	357	44.3 (32.0–57.3)	—	<LOD	<LOD	0.24 ^E (<LOD–0.37)	0.42 ^E (0.24–0.60)
6 (2018–2019)	310	53.7 (39.9–66.9)	—	<LOD	0.099 ^E (<LOD–0.14)	0.32 ^E (0.19–0.44)	0.92 ^E (<LOD–1.8)
40–59 years							
5 (2016–2017)	354	34.9 (25.7–45.3)	—	<LOD	<LOD	0.20 ^E (<LOD–0.31)	0.37 ^E (<LOD–0.85)
6 (2018–2019)	332	42.7 (32.1–54.0)	—	<LOD	<LOD	0.32 ^E (<LOD–0.83)	0.75 ^E (<LOD–2.1)
60–79 years							
5 (2016–2017)	348	35.7 (26.5–46.0)	—	<LOD	<LOD	0.24 (0.18–0.30)	0.29 (0.21–0.36)
6 (2018–2019)	328	38.2 (30.6–46.4)	—	<LOD	<LOD	0.29 ^E (0.16–0.41)	0.40 (0.32–0.48)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.7

cis-Cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (*cis*-cx-MINCH)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2681	25.7 (21.7–30.1)	—	<LOD	<LOD	0.12 (0.099–0.14)	0.24 (0.18–0.31)
6 (2018–2019)	2488	31.0 (27.7–34.5)	—	<LOD	<LOD	0.15 (0.095–0.20)	0.30 ^E (0.16–0.43)
Males, 3–79 years							
5 (2016–2017)	1335	25.3 (19.3–32.5)	—	<LOD	<LOD	0.12 (0.084–0.15)	0.24 ^E (0.15–0.33)
6 (2018–2019)	1235	31.2 (27.0–35.8)	—	<LOD	<LOD	0.15 ^E (0.076–0.22)	0.29 ^E (<LOD–0.54)
Females, 3–79 years							
5 (2016–2017)	1346	26.0 (20.9–31.8)	—	<LOD	<LOD	0.12 (0.091–0.15)	0.25 ^E (0.15–0.34)
6 (2018–2019)	1253	30.8 (25.1–37.3)	—	<LOD	<LOD	0.15 ^E (0.085–0.21)	0.30 ^E (0.16–0.43)
3–5 years							
5 (2016–2017)	545	74.8 (66.9–81.3)	0.12 (0.10–0.15)	<LOD	0.11 (0.074–0.15)	0.54 (0.39–0.68)	0.94 ^E (0.51–1.4)
6 (2018–2019)	502	69.5 (61.3–76.6)	0.11 (0.091–0.12)	<LOD	0.11 (0.086–0.13)	0.41 ^E (0.25–0.56)	0.55 ^E (0.34–0.77)
6–11 years							
5 (2016–2017)	530	53.8 (48.3–59.2)	—	<LOD	0.066 (<LOD–0.080)	0.28 (0.22–0.34)	0.49 ^E (0.30–0.68)
6 (2018–2019)	491	56.4 (46.3–66.1)	—	<LOD	0.077 (<LOD–0.10)	0.27 ^E (0.13–0.42)	0.47 ^E (0.28–0.66)
12–19 years							
5 (2016–2017)	534	29.4 (23.2–36.5)	—	<LOD	<LOD	0.14 (0.095–0.18)	0.20 ^E (<LOD–0.42)
6 (2018–2019)	497	43.6 (35.0–52.6)	—	<LOD	<LOD	0.25 ^E (0.14–0.35)	0.33 ^E (0.20–0.47)
20–39 years							
5 (2016–2017)	368	27.1 (20.2–35.4)	—	<LOD	<LOD	0.11 (0.077–0.14)	0.14 (0.099–0.18)
6 (2018–2019)	327	35.4 (28.4–43.1)	—	<LOD	<LOD	0.12 (0.090–0.15)	0.20 ^E (0.11–0.28)
40–59 years							
5 (2016–2017)	356	17.0 ^E (11.5–24.4)	—	<LOD	<LOD	0.099 ^E (<LOD–0.17)	0.27 ^E (0.11–0.43)
6 (2018–2019)	337	23.1 ^E (15.2–33.3)	—	<LOD	<LOD	0.11 ^E (<LOD–0.41)	0.36 ^E (0.087–0.64)
60–79 years							
5 (2016–2017)	348	17.2 ^E (10.0–27.9)	—	<LOD	<LOD	0.082 ^E (<LOD–0.12)	0.11 (0.075–0.15)
6 (2018–2019)	334	16.0 (11.1–22.4)	—	<LOD	<LOD	0.098 ^E (<LOD–0.15)	0.15 ^E (0.097–0.21)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.059 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.8

cis-Cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (*cis*-cx-MINCH) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2652	25.7 (21.7–30.1)	—	<LOD	<LOD	0.13 (0.11–0.14)	0.21 (0.17–0.25)
6 (2018–2019)	2487	31.0 (27.7–34.5)	—	<LOD	<LOD	0.18 (0.14–0.22)	0.28 (0.20–0.36)
Males, 3–79 years							
5 (2016–2017)	1321	25.3 (19.3–32.5)	—	<LOD	<LOD	0.12 (0.091–0.14)	0.20 (0.14–0.27)
6 (2018–2019)	1234	31.2 (27.0–35.8)	—	<LOD	<LOD	0.18 (0.12–0.25)	0.24 ^E (<LOD–0.45)
Females, 3–79 years							
5 (2016–2017)	1331	26.0 (20.9–31.8)	—	<LOD	<LOD	0.13 (0.12–0.15)	0.22 (0.15–0.29)
6 (2018–2019)	1253	30.8 (25.1–37.3)	—	<LOD	<LOD	0.18 (0.12–0.24)	0.30 (0.23–0.36)
3–5 years							
5 (2016–2017)	536	74.8 (66.9–81.3)	0.22 (0.18–0.25)	<LOD	0.19 (0.15–0.24)	0.84 ^E (0.33–1.3)	1.3 ^E (0.36–2.3)
6 (2018–2019)	501	69.5 (61.3–76.6)	0.17 (0.14–0.21)	<LOD	0.17 (0.12–0.21)	0.57 (0.43–0.71)	0.94 (0.71–1.2)
6–11 years							
5 (2016–2017)	523	53.8 (48.3–59.2)	—	<LOD	0.080 (<LOD–0.092)	0.28 (0.20–0.36)	0.43 (0.31–0.55)
6 (2018–2019)	491	56.4 (46.3–66.1)	—	<LOD	0.088 (<LOD–0.10)	0.28 (0.20–0.37)	0.36 ^E (0.22–0.50)
12–19 years							
5 (2016–2017)	527	29.4 (23.2–36.5)	—	<LOD	<LOD	0.11 (0.073–0.14)	0.16 ^E (<LOD–0.31)
6 (2018–2019)	497	43.6 (35.0–52.6)	—	<LOD	<LOD	0.18 ^E (0.077–0.28)	0.28 ^E (0.16–0.40)
20–39 years							
5 (2016–2017)	364	27.1 (20.2–35.4)	—	<LOD	<LOD	0.094 (0.064–0.13)	0.14 (0.099–0.18)
6 (2018–2019)	327	35.4 (28.4–43.1)	—	<LOD	<LOD	0.13 (0.098–0.17)	0.20 (0.14–0.26)
40–59 years							
5 (2016–2017)	355	17.0 ^E (11.5–24.4)	—	<LOD	<LOD	0.11 (<LOD–0.13)	0.14 ^E (<LOD–0.27)
6 (2018–2019)	337	23.1 ^E (15.2–33.3)	—	<LOD	<LOD	0.17 ^E (<LOD–0.32)	0.30 ^E (<LOD–0.60)
60–79 years							
5 (2016–2017)	347	17.2 ^E (10.0–27.9)	—	<LOD	<LOD	0.11 (<LOD–0.13)	0.14 (0.12–0.17)
6 (2018–2019)	334	16.0 (11.1–22.4)	—	<LOD	<LOD	0.12 (<LOD–0.14)	0.16 ^E (0.097–0.22)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.9

trans-Cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (*trans*-cx-MINCH)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2700	2.6 (1.9–3.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2507	4.2 ^E (2.4–7.1)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1345	2.2 ^E (1.4–3.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1246	3.9 ^E (1.7–8.6)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1355	3.0 ^E (1.9–4.8)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1261	4.5 ^E (2.2–8.9)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	549	20.1 (14.1–27.7)	—	<LOD	<LOD	0.56 ^E (<LOD–0.80)	0.79 (0.58–1.0)
6 (2018–2019)	509	14.0 ^E (9.5–20.1)	—	<LOD	<LOD	0.48 (0.33–0.63)	0.67 (0.46–0.88)
6–11 years							
5 (2016–2017)	535	6.3 ^E (3.9–9.9)	—	<LOD	<LOD	<LOD	0.37 ^E (<LOD–0.53)
6 (2018–2019)	495	8.0 ^E (4.5–13.7)	—	<LOD	<LOD	<LOD	0.43 ^E (<LOD–0.59)
12–19 years							
5 (2016–2017)	537	4.1 ^E (1.6–10.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	502	5.6 ^E (3.7–8.3)	—	<LOD	<LOD	<LOD	0.36 ^E (<LOD–0.52)
20–39 years							
5 (2016–2017)	372	1.7 ^E (0.70–4.3)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	328	1.1 ^E (0.40–3.1)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	357	2.0 ^E (0.60–6.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	338	6.5 ^E (2.3–17.3)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	350	0.20 ^E (0.10–0.50)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	335	2.0 ^E (0.90–4.4)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.33 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.10

trans-Cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (*trans*-cx-MINCH) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2670	2.6 (1.9–3.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2506	4.2 ^E (2.4–7.1)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1330	2.2 ^E (1.4–3.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1245	3.9 ^E (1.7–8.6)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1340	3.0 ^E (1.9–4.8)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1261	4.5 ^E (2.2–8.9)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	539	20.1 (14.1–27.7)	—	<LOD	<LOD	0.92 (<LOD–1.1)	1.3 ^F (0.53–2.1)
6 (2018–2019)	508	14.0 ^E (9.5–20.1)	—	<LOD	<LOD	0.86 (0.74–0.97)	1.1 ^F (0.66–1.5)
6–11 years							
5 (2016–2017)	528	6.3 ^E (3.9–9.9)	—	<LOD	<LOD	<LOD	0.65 (<LOD–0.81)
6 (2018–2019)	495	8.0 ^E (4.5–13.7)	—	<LOD	<LOD	<LOD	0.86 ^E (<LOD–1.2)
12–19 years							
5 (2016–2017)	530	4.1 ^E (1.6–10.2)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	502	5.6 ^E (3.7–8.3)	—	<LOD	<LOD	<LOD	0.73 ^E (<LOD–1.5)
20–39 years							
5 (2016–2017)	368	1.7 ^E (0.70–4.3)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	328	1.1 ^E (0.40–3.1)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	356	2.0 ^E (0.60–6.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	338	6.5 ^E (2.3–17.3)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	349	0.20 ^F (0.10–0.50)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	335	2.0 ^F (0.90–4.4)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.11

Cyclohexane-1,2-dicarboxylic acid (CHDA)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2553	24.6 (21.0–28.7)	—	<LOD	<LOD	0.64 (0.51–0.76)	1.3 ^E (0.79–1.8)
6 (2018–2019)	2357	23.9 (18.3–30.6)	—	<LOD	<LOD	0.83 (0.53–1.1)	1.5 ^E (0.76–2.3)
Males, 3–79 years							
5 (2016–2017)	1288	23.4 (18.4–29.3)	—	<LOD	<LOD	0.61 (0.49–0.73)	1.1 ^E (0.53–1.7)
6 (2018–2019)	1176	20.6 (15.4–27.0)	—	<LOD	<LOD	0.70 ^E (<LOD–1.1)	1.4 ^E (0.41–2.5)
Females, 3–79 years							
5 (2016–2017)	1265	25.8 (21.8–30.2)	—	<LOD	<LOD	0.80 ^E (0.49–1.1)	1.4 ^E (0.53–2.2)
6 (2018–2019)	1181	27.2 (20.3–35.6)	—	<LOD	<LOD	0.87 (0.58–1.2)	1.5 ^E (0.86–2.2)
3–5 years							
5 (2016–2017)	485	68.4 (58.3–77.1)	0.66 (0.50–0.86)	<LOD	0.69 (0.48–0.89)	3.3 ^E (1.6–5.0)	5.0 (3.4–6.7)
6 (2018–2019)	419	78.2 (66.7–86.5)	0.74 (0.60–0.91)	<LOD	0.80 (0.62–0.98)	2.6 (2.1–3.1)	3.4 ^E (1.8–5.0)
6–11 years							
5 (2016–2017)	505	54.7 (46.4–62.8)	—	<LOD	<LOD	1.6 (1.2–2.0)	2.4 (1.7–3.0)
6 (2018–2019)	466	55.4 (42.7–67.5)	—	<LOD	0.46 ^E (<LOD–0.64)	1.5 (1.0–2.0)	2.6 ^E (1.5–3.6)
12–19 years							
5 (2016–2017)	511	30.4 (22.3–40.0)	—	<LOD	<LOD	0.83 (0.59–1.1)	1.4 ^E (0.38–2.3)
6 (2018–2019)	478	30.4 (23.5–38.3)	—	<LOD	<LOD	0.95 ^E (0.60–1.3)	1.6 ^E (0.60–2.6)
20–39 years							
5 (2016–2017)	363	22.4 (16.9–29.0)	—	<LOD	<LOD	0.47 (0.30–0.64)	0.62 (0.41–0.84)
6 (2018–2019)	326	20.7 ^E (14.0–29.5)	—	<LOD	<LOD	0.62 (0.44–0.79)	0.87 ^E (0.50–1.2)
40–59 years							
5 (2016–2017)	347	18.9 ^E (12.4–27.7)	—	<LOD	<LOD	0.56 ^E (<LOD–0.93)	1.8 ^E (0.40–3.2)
6 (2018–2019)	333	16.9 ^E (8.7–30.2)	—	<LOD	<LOD	0.58 ^E (<LOD–1.7)	1.6 ^E (0.49–2.7)
60–79 years							
5 (2016–2017)	342	16.9 ^E (10.9–25.3)	—	<LOD	<LOD	0.43 ^E (<LOD–0.61)	0.61 (0.46–0.76)
6 (2018–2019)	335	17.0 ^E (11.5–26.7)	—	<LOD	<LOD	0.57 ^E (0.31–0.83)	0.75 ^E (0.36–1.1)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.30 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.2.12

Cyclohexane-1,2-dicarboxylic acid (CHDA) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations (µg/g creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2526	24.6 (21.0–28.7)	—	<LOD	<LOD	0.77 (0.71–0.83)	1.2 (0.98–1.5)
6 (2018–2019)	2356	23.9 (18.3–30.6)	—	<LOD	<LOD	1.0 (0.77–1.2)	1.5 (0.95–2.0)
Males, 3–79 years							
5 (2016–2017)	1273	23.4 (18.4–29.3)	—	<LOD	<LOD	0.63 (0.46–0.80)	1.2 (0.90–1.5)
6 (2018–2019)	1175	20.6 (15.4–27.0)	—	<LOD	<LOD	0.85 ^E (<LOD–1.2)	1.3 ^E (<LOD–2.3)
Females, 3–79 years							
5 (2016–2017)	1253	25.8 (21.8–30.2)	—	<LOD	<LOD	0.82 (0.67–0.98)	1.3 (0.87–1.6)
6 (2018–2019)	1181	27.2 (20.3–35.6)	—	<LOD	<LOD	1.1 (0.83–1.3)	1.7 (1.2–2.2)
3–5 years							
5 (2016–2017)	477	68.4 (58.3–77.1)	1.1 (0.87–1.5)	<LOD	1.1 (0.70–1.5)	5.0 ^E (2.8–7.2)	7.1 (5.8–8.5)
6 (2018–2019)	418	78.2 (66.7–86.5)	1.2 (0.98–1.5)	<LOD	1.3 (0.86–1.8)	3.4 (2.7–4.0)	6.0 (4.2–7.8)
6–11 years							
5 (2016–2017)	499	54.7 (46.4–62.8)	—	<LOD	<LOD	1.7 (1.1–2.3)	2.2 ^E (0.33–4.2)
6 (2018–2019)	466	55.4 (42.7–67.5)	—	<LOD	0.50 (<LOD–0.65)	1.6 (1.1–2.0)	3.3 ^E (1.9–4.6)
12–19 years							
5 (2016–2017)	504	30.4 (22.3–40.0)	—	<LOD	<LOD	0.62 (0.47–0.77)	0.80 ^E (0.39–1.2)
6 (2018–2019)	478	30.4 (23.5–38.3)	—	<LOD	<LOD	1.1 ^E (0.63–1.6)	1.6 (1.1–2.1)
20–39 years							
5 (2016–2017)	359	22.4 (16.9–29.0)	—	<LOD	<LOD	0.48 ^E (0.16–0.81)	0.80 (0.63–0.97)
6 (2018–2019)	326	20.7 ^E (14.0–29.5)	—	<LOD	<LOD	0.73 ^E (0.33–1.1)	1.1 (0.75–1.5)
40–59 years							
5 (2016–2017)	346	18.9 ^E (12.4–27.7)	—	<LOD	<LOD	0.59 ^E (<LOD–0.82)	0.97 ^E (0.58–1.4)
6 (2018–2019)	333	16.9 ^E (8.7–30.2)	—	<LOD	<LOD	0.78 ^E (<LOD–1.3)	1.3 ^E (<LOD–2.4)
60–79 years							
5 (2016–2017)	341	16.9 ^E (10.9–25.3)	—	<LOD	<LOD	0.59 (<LOD–0.70)	0.77 (0.67–0.87)
6 (2018–2019)	335	17.0 ^E (11.5–26.7)	—	<LOD	<LOD	0.78 (0.58–0.99)	1.1 ^E (0.66–1.5)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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14.3 2,2,4-TRIMETHYL-1,3-PENTANEDIOL DIISOBUTYRATE (TXIB)

2,2,4-Trimethyl-1,3-pentanediol diisobutyrate (TXIB) (CASRN 6846-50-0) is an ester compound with the appearance of a clear liquid at room temperature. This substance may also be referred to as propanoic acid, 2-methyl-, 2,2-dimethyl-1-(1-methylethyl)-1,3-propanediyl ester, among other synonyms. It is produced commercially, and is commonly synthesized by the esterification of isobutyraldehyde with 2,2,4-trimethyl-1,3-pentanediol (Törmäkangas and Koskinen, 2001). TXIB is a secondary plasticizer, used in combination with other plasticizers, and is used in products like weather stripping, furniture, wallpaper, vinyl flooring, sporting goods, traffic cones, vinyl gloves, inks, water-based paints and toys (CIR, 2017).

TXIB does not occur naturally and is released to the environment from anthropogenic sources. TXIB has moderate volatility and water solubility; therefore, it can be expected to occur in air and water, although it will likely volatilize from water surfaces (CIR, 2017). Given that TXIB can leach out of the polymer matrix when used as a plasticizer, the general population may be exposed to it dermally from the use of products available to consumers such as cosmetics. Exposure may also occur through the inhalation of indoor air or dust. Research suggests that oral exposure may occur as a result of migration from baby bottles (Onghena et al., 2016; Simoneau et al., 2012).

The toxicokinetics and health effects of TXIB are not well studied in humans. Experimental animal studies have reported a high level of absorption of TXIB following ingestion; however, no dermal absorption data were identified (CIR, 2017). Animal studies indicate that TXIB is not significantly distributed throughout the body following absorption. In animals exposed by ingestion, TXIB was found to undergo metabolic hydrolysis to the monoisobutyrate of 2,2,4-trimethyl-1,3-pentanediol (TMPD) (CIR, 2017). Total excretion of TXIB following metabolism represented 95% to 99% of the administered dose. It is mainly excreted in urine within 72 hours; a smaller fraction is eliminated in feces over approximately 1 week (CIR, 2017). Animal studies report that TXIB is predominantly excreted as the O-glucuronide of TMPD in urine, and to a much lesser extent as 2,2,4-trimethyl-3-hydroxyvaleric acid

(HTMV) and its glucuronides, 2-methylmalonic acid, and unchanged TXIB (CIR, 2017). In feces, TXIB is excreted unchanged and as the metabolite TMPD and its monoester (CIR, 2017; ECHA, 2021).

Experimental animal studies have reported that TXIB has low toxicity following acute ingestion exposure (producing moderate weakness and some vasodilation), while subchronic oral exposure has been associated with increased liver and kidney weights (CIR, 2017; OECD, 1995). Histopathological investigation of subchronically exposed animals revealed necrosis of the proximal tubules, dilatation of distal tubules and fibrosis in the kidneys, and centrilobular swelling of hepatocytes in the liver (CIR, 2017; OECD, 1995). TXIB has been associated with reproductive toxicity in animal studies on the basis of a reduction in the number of implantation sites in females (ECHA, 2001). TXIB has not been found to be genotoxic in bacterial assays or in mammalian cells, while no carcinogenicity or chronic studies have been identified (OECD, 1995).

A Chemicals Management Plan screening-level risk assessment is currently underway to determine whether TXIB presents or may present a risk to the environment or human health as per the criteria set out in section 64 of the *Canadian Environmental Protection Act, 1999* (Canada, 1999; ECCC, 2019). TXIB is found in cosmetic products notified under the Cosmetic Regulations of the *Food and Drugs Act* (Canada, 1985).

Two metabolites of TXIB (TMPD and HTMV) were analyzed in the urine of Canadian Health Measures Survey participants aged 3–79 in cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented as both $\mu\text{g/L}$ and $\mu\text{g/g}$ creatinine. Finding a measurable amount of these metabolites in urine can be an indicator of recent exposure to TXIB and does not necessarily mean that an adverse health effect will occur.

Table 14.3.1

2,2,4-Trimethyl-1,3-pentanediol (TMPD)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2589	98.5 (96.7–99.3)	17 (15–19)	4.4 (4.0–4.8)	16 (14–18)	69 (48–89)	150 ^E (84–220)
6 (2018–2019)	2492	96.8 (93.6–98.4)	13 (10–16)	3.1 (2.0–4.2)	12 (8.8–16)	50 (38–62)	76 (49–100)
Males, 3–79 years							
5 (2016–2017)	1295	98.0 (94.4–99.3)	18 (15–22)	4.4 (3.8–5.0)	17 (14–20)	78 ^E (47–110)	200 ^E (44–360)
6 (2018–2019)	1236	96.2 (91.6–98.4)	14 (11–18)	3.1 ^E (<LOD–4.7)	14 (8.8–19)	55 (41–68)	90 ^E (54–130)
Females, 3–79 years							
5 (2016–2017)	1294	99.0 (97.9–99.5)	15 (14–17)	4.4 (3.5–5.2)	15 (12–17)	57 (40–75)	100 ^E (32–170)
6 (2018–2019)	1256	97.4 (94.3–98.8)	12 (9.0–15)	3.0 ^E (1.9–4.2)	11 (8.6–13)	46 (31–61)	57 ^E (34–80)
3–5 years							
5 (2016–2017)	514	100	25 ^E (17–36)	7.3 (5.4–9.2)	22 ^E (12–32)	87 (59–120)	140 (100–180)
6 (2018–2019)	507	99.8 (99.3–100)	20 (17–25)	6.3 (4.6–8.0)	21 (14–27)	58 (41–75)	77 ^E (41–110)
6–11 years							
5 (2016–2017)	518	99.6 (98.8–99.8)	23 (19–29)	6.4 (5.0–7.8)	23 (17–28)	74 (57–91)	140 ^E (5.2–270)
6 (2018–2019)	491	99.7 (98.8–99.9)	20 (16–24)	6.2 (5.1–7.3)	18 (12–23)	66 (51–80)	76 ^E (23–130)
12–19 years							
5 (2016–2017)	513	99.9 (99.4–100)	21 (18–25)	6.8 (4.9–8.8)	18 (14–22)	91 ^E (54–130)	130 ^E (78–180)
6 (2018–2019)	492	99.3 (98.3–99.8)	17 (12–23)	4.6 ^E (2.4–6.9)	15 ^E (7.8–23)	53 ^E (16–90)	99 ^E (48–150)
20–39 years							
5 (2016–2017)	365	99.0 (94.2–99.8)	18 (14–23)	4.3 ^E (1.8–6.8)	17 (13–20)	80 ^E (13–150)	210 ^E (16–400)
6 (2018–2019)	330	97.3 (92.1–99.1)	15 (12–19)	3.3 ^E (<LOD–5.4)	15 (9.9–21)	54 (43–65)	85 ^E (53–120)
40–59 years							
5 (2016–2017)	345	97.1 (88.0–99.3)	15 (11–19)	4.4 (3.2–5.6)	14 (10–18)	54 ^E (34–75)	110 ^E (8.2–210)
6 (2018–2019)	336	98.1 (94.3–99.4)	10 (7.4–14)	2.6 ^E (<LOD–3.8)	10 ^E (6.1–14)	33 (22–45)	45 (29–61)
60–79 years							
5 (2016–2017)	334	98.6 (94.1–99.7)	14 (11–18)	3.7 (2.8–4.6)	14 (11–16)	52 ^E (27–78)	100 ^E (<LOD–200)
6 (2018–2019)	336	91.9 (78.1–97.3)	10 ^E (6.8–15)	2.0 ^E (<LOD–4.6)	10 (7.2–13)	47 ^E (23–71)	86 ^E (14–160)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 1.7 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.3.2

2,2,4-Trimethyl-1,3-pentanediol (TMPD) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2562	98.5 (96.7–99.3)	17 (15–19)	5.0 (4.1–6.0)	15 (12–17)	62 (49–75)	92 (65–120)
6 (2018–2019)	2491	96.8 (93.6–98.4)	14 (11–17)	4.6 (3.4–5.8)	13 (10–16)	39 (32–46)	59 (39–80)
Males, 3–79 years							
5 (2016–2017)	1281	98.0 (94.4–99.3)	16 (14–19)	5.0 (3.8–6.2)	13 (10–16)	66 (42–90)	130 ^E (32–230)
6 (2018–2019)	1235	96.2 (91.6–98.4)	13 (11–16)	4.3 ^E (<LOD–6.1)	12 (9.5–15)	39 (27–51)	69 ^E (43–95)
Females, 3–79 years							
5 (2016–2017)	1281	99.0 (97.9–99.5)	17 (15–20)	5.1 (3.9–6.2)	16 (13–18)	58 (45–71)	86 (69–100)
6 (2018–2019)	1256	97.4 (94.3–98.8)	15 (12–19)	4.7 (3.5–5.8)	14 (11–18)	39 (32–46)	53 (36–71)
3–5 years							
5 (2016–2017)	506	100	42 (32–55)	14 (10–18)	37 ^E (23–52)	140 ^E (81–190)	240 ^E (150–330)
6 (2018–2019)	506	99.8 (99.3–100)	33 (27–42)	12 ^E (6.1–17)	31 (24–39)	87 (68–110)	130 ^E (58–200)
6–11 years							
5 (2016–2017)	512	99.6 (98.8–99.8)	28 (23–33)	9.4 (8.0–11)	26 (21–31)	74 (56–92)	130 ^E (15–240)
6 (2018–2019)	491	99.7 (98.8–99.9)	24 (19–30)	9.1 (7.7–10)	23 (18–29)	60 (44–75)	99 ^E (62–140)
12–19 years							
5 (2016–2017)	506	99.9 (99.4–100)	16 (13–20)	5.4 (3.9–6.8)	14 (11–18)	53 (40–66)	77 (50–100)
6 (2018–2019)	492	99.3 (98.3–99.8)	14 (10–19)	4.3 ^E (2.1–6.5)	13 (10–17)	40 ^E (24–56)	54 ^E (11–97)
20–39 years							
5 (2016–2017)	361	99.0 (94.2–99.8)	17 (14–20)	5.3 (4.1–6.6)	14 (11–17)	54 ^E (28–81)	100 ^E (<LOD–250)
6 (2018–2019)	330	97.3 (92.1–99.1)	14 (12–17)	4.8 (<LOD–6.2)	14 (10–17)	37 (31–43)	48 ^E (27–70)
40–59 years							
5 (2016–2017)	344	97.1 (88.0–99.3)	14 (12–16)	4.4 (2.9–6.0)	12 (10–14)	51 (35–67)	73 (51–96)
6 (2018–2019)	336	98.1 (94.3–99.4)	12 (9.5–15)	4.4 ^E (<LOD–6.3)	12 (7.5–16)	30 (20–41)	39 (26–51)
60–79 years							
5 (2016–2017)	333	98.6 (94.1–99.7)	17 (13–20)	4.2 (3.1–5.2)	15 (12–18)	59 ^E (29–88)	92 ^E (<LOD–180)
6 (2018–2019)	336	91.9 (78.1–97.3)	12 (8.9–16)	3.3 ^E (<LOD–4.8)	11 (7.5–14)	41 ^E (26–57)	70 ^E (<LOD–140)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.3.3

2,2,4-Trimethyl-3-hydroxy valeric acid (HTMV)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2587	96.7 (94.2–98.2)	3.3 (2.8–3.8)	0.80 (0.62–0.98)	3.2 (2.9–3.6)	13 (8.8–17)	28 (18–38)
6 (2018–2019)	2485	94.9 (91.7–96.9)	2.5 (2.0–3.1)	0.62 (0.48–0.76)	2.3 (1.5–3.1)	9.3 (8.0–11)	15 (10–19)
Males, 3–79 years							
5 (2016–2017)	1297	95.7 (91.8–97.8)	3.3 (2.6–4.2)	0.74 (0.48–1.0)	3.1 (2.3–4.0)	17 ^E (9.1–25)	32 ^E (11–52)
6 (2018–2019)	1236	94.5 (89.1–97.3)	2.8 (2.2–3.4)	0.68 (0.50–0.86)	2.7 (1.7–3.6)	9.8 (7.8–12)	16 ^E (10–23)
Females, 3–79 years							
5 (2016–2017)	1290	97.7 (95.4–98.8)	3.2 (2.9–3.6)	0.93 (0.75–1.1)	3.3 (3.0–3.7)	11 (8.9–14)	22 ^E (9.6–35)
6 (2018–2019)	1249	95.3 (90.3–97.8)	2.2 (1.7–2.8)	0.57 (<LOD–0.74)	2.1 (1.5–2.6)	9.1 (7.3–11)	12 (7.5–16)
3–5 years							
5 (2016–2017)	529	99.9 (99.1–100)	5.4 (3.8–7.7)	1.6 (1.1–2.0)	4.8 (3.1–6.4)	23 (15–32)	30 (21–40)
6 (2018–2019)	502	99.9 (99.2–100)	4.9 (4.0–5.8)	1.2 (0.94–1.5)	4.8 (3.0–6.5)	15 (11–18)	20 (17–23)
6–11 years							
5 (2016–2017)	518	99.4 (98.2–99.8)	5.0 (4.0–6.4)	1.5 (1.0–2.0)	4.6 (3.0–6.2)	17 (14–20)	30 ^E (<LOD–59)
6 (2018–2019)	492	99.8 (99.0–99.9)	4.1 (3.3–5.1)	1.2 (0.87–1.6)	4.3 (3.2–5.4)	13 (9.2–18)	19 (14–24)
12–19 years							
5 (2016–2017)	509	99.4 (97.8–99.8)	4.2 (3.6–4.9)	1.1 (0.97–1.3)	4.1 (3.3–5.0)	16 ^E (5.0–27)	27 ^E (11–43)
6 (2018–2019)	493	98.9 (97.5–99.5)	3.2 (2.4–4.3)	0.89 (0.64–1.2)	3.1 (2.0–4.1)	9.6 ^E (4.0–15)	15 ^E (6.3–25)
20–39 years							
5 (2016–2017)	356	97.3 (90.3–99.3)	3.5 (2.6–4.6)	0.81 ^E (<LOD–1.2)	3.3 (2.3–4.3)	16 ^E (2.4–31)	31 ^E (3.7–59)
6 (2018–2019)	329	94.3 (86.7–97.7)	2.7 (2.1–3.5)	0.62 (0.46–0.79)	2.8 ^E (1.5–4.1)	9.5 (7.4–11)	15 ^E (8.2–22)
40–59 years							
5 (2016–2017)	341	95.3 (87.2–98.4)	2.8 (2.2–3.6)	0.64 ^E (<LOD–1.0)	2.7 (2.2–3.3)	11 ^E (5.9–16)	20 ^E (7.7–32)
6 (2018–2019)	336	96.3 (92.2–98.3)	2.0 (1.5–2.7)	0.63 (0.46–0.80)	1.7 ^E (1.0–2.4)	7.7 (6.5–9.0)	9.3 (6.5–12)
60–79 years							
5 (2016–2017)	334	95.1 (89.5–97.8)	2.7 (2.2–3.3)	0.64 (0.50–0.78)	2.6 (2.1–3.2)	11 (6.9–14)	16 ^E (<LOD–42)
6 (2018–2019)	333	89.7 (80.8–94.8)	1.9 (1.3–2.7)	<LOD	1.9 ^E (1.1–2.6)	8.4 ^E (4.7–12)	15 ^E (5.1–26)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.42 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.3.4

2,2,4-Trimethyl-3-hydroxy valeric acid (HTMV) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2563	96.7 (94.2–98.2)	3.3 (2.8–3.8)	0.98 (0.81–1.2)	2.9 (2.3–3.5)	11 (8.5–14)	19 (15–23)
6 (2018–2019)	2484	94.9 (91.7–96.9)	2.7 (2.2–3.2)	0.87 (0.66–1.1)	2.6 (2.0–3.2)	7.9 (6.5–9.3)	13 (8.5–17)
Males, 3–79 years							
5 (2016–2017)	1284	95.7 (91.8–97.8)	3.0 (2.4–3.6)	0.86 (0.56–1.2)	2.4 (1.7–3.1)	11 (8.9–14)	22 ^E (14–31)
6 (2018–2019)	1235	94.5 (89.1–97.3)	2.6 (2.2–3.1)	0.83 (0.63–1.0)	2.4 (1.9–3.0)	7.9 (6.6–9.3)	14 (9.2–18)
Females, 3–79 years							
5 (2016–2017)	1279	97.7 (95.4–98.8)	3.6 (3.2–4.1)	1.2 (0.96–1.4)	3.4 (3.0–3.7)	11 ^E (5.1–17)	19 (15–22)
6 (2018–2019)	1249	95.3 (90.3–97.8)	2.8 (2.3–3.5)	0.97 (<LOD–1.3)	2.8 (2.1–3.5)	7.6 (5.8–9.4)	12 ^E (7.4–17)
3–5 years							
5 (2016–2017)	520	99.9 (99.1–100)	9.4 (7.4–12)	3.0 (2.0–4.0)	8.3 (5.4–11)	31 ^E (19–44)	43 ^E (25–62)
6 (2018–2019)	501	99.9 (99.2–100)	7.9 (6.4–9.7)	3.1 (2.3–4.0)	7.9 (6.7–9.1)	21 (15–28)	35 ^E (18–52)
6–11 years							
5 (2016–2017)	512	99.4 (98.2–99.8)	5.9 (4.7–7.3)	2.0 (1.5–2.4)	5.7 (4.3–7.0)	17 (13–22)	29 ^E (<LOD–49)
6 (2018–2019)	492	99.8 (99.0–99.9)	5.0 (3.9–6.3)	1.6 ^E (0.84–2.4)	4.6 (3.6–5.6)	14 (9.2–18)	19 (14–24)
12–19 years							
5 (2016–2017)	505	99.4 (97.8–99.8)	3.2 (2.6–4.0)	1.1 (0.73–1.4)	2.9 (2.1–3.7)	9.7 (7.7–12)	14 ^E (4.0–23)
6 (2018–2019)	493	98.9 (97.5–99.5)	2.7 (2.0–3.5)	0.99 (0.74–1.2)	2.4 (1.7–3.1)	7.1 (4.8–9.4)	9.1 ^E (4.6–14)
20–39 years							
5 (2016–2017)	353	97.3 (90.3–99.3)	3.2 (2.7–3.9)	1.2 (<LOD–1.4)	2.7 (1.9–3.5)	11 (7.1–15)	18 ^E (4.1–32)
6 (2018–2019)	329	94.3 (86.7–97.7)	2.6 (2.2–3.1)	0.86 ^E (0.47–1.3)	2.6 (2.0–3.1)	6.2 (4.3–8.0)	8.8 (5.8–12)
40–59 years							
5 (2016–2017)	340	95.3 (87.2–98.4)	2.6 (2.2–3.2)	0.84 (<LOD–1.0)	2.2 (1.6–2.9)	8.4 ^E (4.9–12)	14 ^E (6.5–22)
6 (2018–2019)	336	96.3 (92.2–98.3)	2.4 (2.0–2.9)	0.93 (0.70–1.2)	2.3 (1.7–2.9)	5.6 (4.4–6.7)	8.7 (5.8–12)
60–79 years							
5 (2016–2017)	333	95.1 (89.5–97.8)	3.2 (2.7–3.7)	0.79 ^E (0.46–1.1)	3.1 (2.5–3.8)	12 ^E (7.1–18)	21 (<LOD–28)
6 (2018–2019)	333	89.7 (80.8–94.8)	2.3 (1.8–3.0)	<LOD	2.2 (1.5–2.9)	7.7 ^E (4.0–11)	14 ^E (6.5–21)

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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14.4 TRI-(2-ETHYLHEXYL) TRIMELLITATE (TEHT)

Tri-(2-ethylhexyl) trimellitate (TEHT) (CASRN 3319-31-1) is an ester compound with the appearance of a yellow oily liquid at room temperature. This substance may also be referred to as trioctyl trimellitate (TOTM) or triethylhexyl trimellitate, among other synonyms. It is most commonly manufactured through the esterification of trimellitic anhydride with 2-ethylhexyl alcohol (CIR, 2015). TEHT is primarily used as a plasticizer in floor coverings, building and construction materials, plastic and rubber materials, medical devices, and in cosmetics as an emollient and skin-conditioning agent. It may also be used as a fuel additive, in adhesives and sealants used in the transportation sector, and as a lubricant and lubricant additive (CIR, 2015; ECCC and HC, 2019).

TEHT does not occur naturally and is released to the environment from anthropogenic sources (ECCC and HC, 2019). TEHT has very low vapour pressure (volatility) and water solubility; therefore, it is expected to occur minimally in air and water (ECCC and HC, 2019). The general population may be exposed to TEHT dermally from the use of products available to consumers, including cosmetics, and through the ingestion of dust (CIR, 2015; ECCC and HC, 2019). Since only low levels leach out of the polymer matrix when TEHT is used as a plasticizer, exposure via the use of consumer products is expected to be low (SCENIHR, 2016). The mouthing of plastic toys is not expected to result in exposure to TEHT (ECCC and HC, 2019). Given the very low volatility of TEHT, exposure via inhalation is of minimal concern (ECCC and HC, 2019).

The toxicokinetics and health effects of TEHT have not been well studied in humans. Experimental animal studies have shown that the absorption of TEHT following dermal exposure is low (<1%) (CPSC, 2018). TEHT was mainly distributed to the liver, lungs and spleen in animals following an intravenous dose (OECD, 2002). In animals exposed through ingestion

TEHT was found to undergo hydrolysis; elimination of TEHT metabolites was biphasic, with half-lives of 3.1 and 42 hours in urine, and 4.3 and 31 hours in expired CO₂ (CIR, 2015). TEHT was mainly excreted in feces (75%), with 16% excreted in urine as hydrolysis products of TEHT and approximately 2% excreted as expired CO₂. The hydrolysis products in feces were mono-(2-ethylhexyl) trimellitate, di-(2-ethylhexyl) trimellitate and unidentified polar metabolites; in urine, the metabolites were mono-(2-ethylhexyl) trimellitate, 2-ethylhexanol, 2-ethylhexanoic acid and 2-heptanone (CIR, 2015).

Experimental animal studies have reported that TEHT has low toxicity following acute ingestion exposure; chronic ingestion was found to result in enlarged liver and spleen (CIR, 2015; OECD, 2002). Animals acutely exposed to high concentrations of TEHT via inhalation showed lung irritation, but no other signs of toxicity (CIR, 2015; OECD, 2002). TEHT is associated with male reproductive toxicity in laboratory animals, based on dose-related reduction in testes weight and decreased numbers of spermatocytes and spermatids (CPSC, 2018; ECCC and HC, 2019; OECD, 2002). TEHT is not considered genotoxic, and is not expected to be carcinogenic (ECCC and HC, 2019).

The Government of Canada has conducted a science-based screening assessment under the Chemicals Management Plan to determine whether TEHT presents or may present a risk to the environment or human health as per the criteria set out in section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Canada, 1999; ECCC and HC, 2019). The assessment concluded that TEHT does not meet any of the criteria for being considered toxic under CEPA 1999. TEHT is found in cosmetic products notified under the Cosmetic Regulations of the *Food and Drugs Act* (Canada, 1985).

Three metabolites of TEHT—1-mono(2-ethylhexyl) trimellitate (1-MEHTM), 2-mono(2-ethylhexyl) trimellitate (2-MEHTM), and 4-mono(2-ethylhexyl) trimellitate (4-MEHTM)—were analyzed in the urine of Canadian Health Measures Survey participants aged 3–79 in cycle 5 (2016–2017) and cycle 6 (2018–2019). Data from these cycles are presented as both µg/L and µg/g creatinine. Finding a measurable amount of these metabolites in urine can be an indicator of recent exposure to TEHT and does not necessarily mean that an adverse health effect will occur.

Table 14.4.1

1-Mono(2-ethylhexyl) trimellitate (1-MEHTM)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2701	0 ^E (0–0.10)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2507	0.10 ^E (0–0.30)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1347	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1246	0.10 ^E (0–0.30)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1354	0 ^E (0–0.10)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1261	0.10 ^E (0–0.40)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	551	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	510	0.10 ^E (0–0.60)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
5 (2016–2017)	535	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	494	0.70 ^E (0.10–2.9)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
5 (2016–2017)	537	0.20 ^E (0–0.80)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	502	0.20 ^E (0–0.90)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
5 (2016–2017)	371	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	328	0	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	357	0 ^E (0–0.10)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	338	0	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	350	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	335	0.10 ^E (0–0.90)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.22 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.2

1-Mono(2-ethylhexyl) trimellitate (1-MEHTM) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2671	0 ^E (0–0.10)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2506	0.10 ^E (0–0.30)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1332	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1245	0.10 ^E (0–0.30)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1339	0 ^E (0–0.10)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1261	0.10 ^E (0–0.40)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	541	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	509	0.10 ^E (0–0.60)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
5 (2016–2017)	528	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	494	0.70 ^E (0.10–2.9)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
5 (2016–2017)	530	0.20 ^E (0–0.80)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	502	0.20 ^E (0–0.90)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
5 (2016–2017)	367	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	328	0	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	356	0 ^E (0–0.10)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	338	0	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	349	0	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	335	0.10 ^E (0–0.90)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.3

2-Mono(2-ethylhexyl) trimellitate (2-MEHTM)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/L}$) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2637	7.1 ^E (4.6–11.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2462	5.5 ^E (3.2–9.2)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1314	6.3 ^E (3.6–10.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1222	6.4 ^E (4.2–9.7)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1323	7.9 ^E (4.7–12.9)	—	<LOD	<LOD	<LOD	0.25 ^E (<LOD–0.42)
6 (2018–2019)	1240	4.6 ^E (1.7–11.5)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	538	3.9 ^E (2.0–7.3)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	506	1.5 ^E (0.60–3.9)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
5 (2016–2017)	525	6.0 ^E (3.0–11.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	487	5.7 ^E (2.1–14.4)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
5 (2016–2017)	526	5.2 ^E (2.9–9.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	498	1.1 ^E (0.30–3.6)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
5 (2016–2017)	364	5.6 ^E (1.9–15.2)	—	<LOD	<LOD	<LOD	0.21 (<LOD–0.28)
6 (2018–2019)	318	4.4 ^E (1.5–12.6)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	347	8.0 ^E (3.5–17.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	331	6.9 ^E (4.1–11.5)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	337	9.9 ^E (5.3–17.9)	—	<LOD	<LOD	<LOD	0.53 ^E (0.31–0.75)
6 (2018–2019)	322	7.7 ^E (3.5–16.3)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.16 $\mu\text{g/L}$.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.4

2-Mono(2-ethylhexyl) trimellitate (2-MEHTM) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2607	7.1 ^E (4.6–11.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2461	5.5 ^E (3.2–9.2)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1299	6.3 ^E (3.6–10.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1221	6.4 ^E (4.2–9.7)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1308	7.9 ^E (4.7–12.9)	—	<LOD	<LOD	<LOD	0.46 (<LOD–0.61)
6 (2018–2019)	1240	4.6 ^E (1.7–11.5)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	528	3.9 ^E (2.0–7.3)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	505	1.5 ^E (0.60–3.9)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
5 (2016–2017)	518	6.0 ^E (3.0–11.5)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	487	5.7 ^E (2.1–14.4)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
5 (2016–2017)	519	5.2 ^E (2.9–9.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	498	1.1 ^E (0.30–3.6)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
5 (2016–2017)	360	5.6 ^E (1.9–15.2)	—	<LOD	<LOD	<LOD	0.39 (<LOD–0.48)
6 (2018–2019)	318	4.4 ^E (1.5–12.6)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	346	8.0 ^E (3.5–17.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	331	6.9 ^E (4.1–11.5)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	336	9.9 ^E (5.3–17.9)	—	<LOD	<LOD	<LOD	0.49 (0.34–0.64)
6 (2018–2019)	322	7.7 ^E (3.5–16.3)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.5

4-Mono(2-ethylhexyl) trimellitate (4-MEHTM)—Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2309	2.0 ^E (1.0–4.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2296	1.1 ^E (0.50–2.4)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1144	2.2 ^E (0.80–6.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1129	0.90 ^E (0.20–4.1)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1165	1.9 ^E (0.80–4.4)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1167	1.3 ^E (0.50–3.3)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	475	1.0 ^E (0.30–3.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	469	0.60 ^E (0.10–3.2)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
5 (2016–2017)	417	0.30 ^E (0–2.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	450	1.1 ^E (0.40–2.8)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
5 (2016–2017)	450	0.50 ^E (0.10–1.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	448	2.5 ^E (0.80–7.8)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
5 (2016–2017)	337	2.3 ^E (0.60–8.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	304	0.90 ^E (0.10–8.1)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	308	1.0 ^E (0.30–2.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	309	0.30 ^E (0–2.6)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	322	4.2 ^E (1.3–12.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	316	2.1 ^E (0.80–5.2)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

Note: The LOD for cycles 5 and 6 is 0.098 µg/L.

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

Table 14.4.6

4-Mono(2-ethylhexyl) trimellitate (4-MEHTM) (creatinine adjusted)—Geometric means and selected percentiles of urine concentrations ($\mu\text{g/g}$ creatinine) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017) and cycle 6 (2018–2019)

Cycle	n	Detection Frequency (95% CI)	GM ^a (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years							
5 (2016–2017)	2279	2.0 ^E (1.0–4.1)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	2295	1.1 ^E (0.50–2.4)	—	<LOD	<LOD	<LOD	<LOD
Males, 3–79 years							
5 (2016–2017)	1129	2.2 ^E (0.80–6.0)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1128	0.90 ^E (0.20–4.1)	—	<LOD	<LOD	<LOD	<LOD
Females, 3–79 years							
5 (2016–2017)	1150	1.9 ^E (0.80–4.4)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	1167	1.3 ^E (0.50–3.3)	—	<LOD	<LOD	<LOD	<LOD
3–5 years							
5 (2016–2017)	465	1.0 ^E (0.30–3.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	468	0.60 ^E (0.10–3.2)	—	<LOD	<LOD	<LOD	<LOD
6–11 years							
5 (2016–2017)	410	0.30 ^E (0–2.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	450	1.1 ^E (0.40–2.8)	—	<LOD	<LOD	<LOD	<LOD
12–19 years							
5 (2016–2017)	443	0.50 ^E (0.10–1.6)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	448	2.5 ^E (0.80–7.8)	—	<LOD	<LOD	<LOD	<LOD
20–39 years							
5 (2016–2017)	333	2.3 ^E (0.60–8.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	304	0.90 ^E (0.10–8.1)	—	<LOD	<LOD	<LOD	<LOD
40–59 years							
5 (2016–2017)	307	1.0 ^E (0.30–2.7)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	309	0.30 ^E (0–2.6)	—	<LOD	<LOD	<LOD	<LOD
60–79 years							
5 (2016–2017)	321	4.2 ^E (1.3–12.9)	—	<LOD	<LOD	<LOD	<LOD
6 (2018–2019)	316	2.1 ^E (0.80–5.2)	—	<LOD	<LOD	<LOD	<LOD

CI: confidence interval; GM: geometric mean; LOD: limit of detection

a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.

E Use data with caution.

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APPENDIX

A

LIMITS OF DETECTION

Laboratory analyses of environmental chemicals and creatinine were performed at analytical laboratories within Health Canada, l'Institut national de santé publique du Québec and the ALS Laboratory Group. Laboratories developed standardized operating procedures for the analytical methods used to measure environmental chemicals or their metabolites in biological samples. The limit of detection (LOD) is defined as the lowest concentration of the analyte whose analytical response is measured to be greater than the noise level with 99% confidence and evaluated using U.S. Environmental Protection Agency methodology (EPA, 2015).

Table A-1
Limits of detection

Chemical	Cycle 1 (2007–2009)	Cycle 2 (2009–2011)	Cycle 3 (2012–2013)	Cycle 4 (2014–2015)	Cycle 5 (2016–2017)	Cycle 6 (2018–2019)
Metals and trace elements in blood						
Lead	0.02 µg/dL	0.1 µg/dL	0.16 µg/dL	0.16 µg/dL	0.17 µg/dL	0.17 µg/dL
Cadmium	0.04 µg/L	0.04 µg/L	0.080 µg/L	0.080 µg/L	0.097 µg/L	0.097 µg/L
Chromium (VI) ^a	—	—	—	—	0.12 µg/L	0.12 µg/L
Selenium	8 µg/L	20 µg/L	—	—	32 µg/L	32 µg/L
Mercury						
Mercury (total)	0.1 µg/L	0.1 µg/L	0.42 µg/L	0.42 µg/L	0.20 µg/L	0.20 µg/L
Methylmercury	—	—	0.19 µg/L	0.19 µg/L	0.19 µg/L	0.19 µg/L
Mercury (inorganic)	0.4 µg/L	—	—	—	0.22 µg/L	0.22 µg/L
Metals and trace elements in urine						
Boron	—	—	—	—	160 µg/L	160 µg/L
Cadmium	0.09 µg/L	0.07 µg/L	—	—	0.066 µg/L	0.047 µg/L
Arsenic (speciated)						
Arsenate	—	0.8 µg As/L	0.75 µg As/L	0.75 µg As/L	0.14 µg As/L	0.14 µg As/L
Arsenite	—	0.8 µg As/L	0.75 µg As/L	0.75 µg As/L	0.25 µg As/L	0.25 µg As/L
Arsenocholine and arsenobetaine	—	0.8 µg As/L	0.75 µg As/L	0.75 µg As/L	0.10 µg As/L	0.10 µg As/L
Dimethylarsinic acid (DMA)	—	0.8 µg As/L	0.75 µg As/L	0.75 µg As/L	0.14 µg As/L	0.14 µg As/L
Monomethylarsonic acid (MMA)	—	0.8 µg As/L	0.75 µg As/L	0.75 µg As/L	0.13 µg As/L	0.13 µg As/L

Chemical	Cycle 1 (2007–2009)	Cycle 2 (2009–2011)	Cycle 3 (2012–2013)	Cycle 4 (2014–2015)	Cycle 5 (2016–2017)	Cycle 6 (2018–2019)
Self-care and consumer product chemicals						
Bisphenol A (BPA)	0.2 µg/L	0.2 µg/L	0.23 µg/L	0.23 µg/L	0.32 µg/L	0.31 µg/L
Parabens						
Methyl paraben	—	—	1.3 µg/L	1.3 µg/L	1.3 µg/L	1.3 µg/L
Ethyl paraben	—	—	0.90 µg/L	0.90 µg/L	0.90 µg/L	0.90 µg/L
Propyl paraben	—	—	0.30 µg/L	0.30 µg/L	0.30 µg/L	0.30 µg/L
Butyl paraben	—	—	0.30 µg/L	0.30 µg/L	0.30 µg/L	0.30 µg/L
Nicotine in urine						
Cotinine	1 µg/L	1 µg/L	1.1 µg/L	1.1 µg/L	1.1 µg/L	1.1 µg/L
Nicotine in serum						
Cotinine (non-smokers)	—	—	—	—	—	0.0050 µg/L
Cotinine (smokers)	—	—	—	—	—	0.10 µg/L
Acrylamide						
Acrylamide haemoglobin adduct	—	—	11 pmol/g Hb	11 pmol/g Hb	11 pmol/g Hb	11 pmol/g Hb
Glycidamide haemoglobin adduct	—	—	23 pmol/g Hb	23 pmol/g Hb	23 pmol/g Hb	23 pmol/g Hb
Per- and polyfluoroalkyl substances						
Perfluorobutanoic acid (PFBA)	—	0.5 µg/L	—	—	0.075 µg/L	0.075 µg/L
Perfluorobutane sulfonate (PFBS)	—	0.4 µg/L	—	—	0.066 µg/L	0.066 µg/L
Perfluorohexanoic acid (PFHxA)	—	0.1 µg/L	—	—	0.084 µg/L	0.084 µg/L
Perfluorohexane sulfonate (PFHxS)	0.3 µg/L	0.2 µg/L	—	—	0.063 µg/L	0.063 µg/L
Perfluorooctanoic acid (PFOA)	0.3 µg/L	0.1 µg/L	—	—	0.066 µg/L	0.066 µg/L
Perfluorooctane sulfonate (PFOS)	0.3 µg/L	0.3 µg/L	—	—	0.43 µg/L	0.43 µg/L
Perfluorononanoic acid (PFNA)	—	0.2 µg/L	—	—	0.13 µg/L	0.13 µg/L
Perfluorodecanoic acid (PFDA)	—	0.1 µg/L	—	—	0.092 µg/L	0.092 µg/L
Perfluoroundecanoic acid (PFUnDA)	—	0.09 µg/L	—	—	0.12 µg/L	0.12 µg/L
Pesticides						
Ethylene thiourea (ETU)	—	—	—	—	0.033 µg/L	0.033 µg/L
Organophosphate pesticides						
Dimethylphosphate (DMP)	1 µg/L ^b	1 µg/L	—	—	0.58 µg/L	0.58 µg/L
Dimethylthiophosphate (DMTP)	0.6 µg/L	0.6 µg/L	—	—	0.44 µg/L	0.44 µg/L
Dimethyldithiophosphate (DMDTP)	0.3 µg/L ^b	0.3 µg/L	—	—	0.093 µg/L	0.093 µg/L
Diethylphosphate (DEP)	1 µg/L ^b	1 µg/L	—	—	0.29 µg/L	0.29 µg/L
Diethylthiophosphate (DETP)	0.6 µg/L ^b	0.3 µg/L	—	—	0.13 µg/L	0.13 µg/L
Diethyldithiophosphate (DEDTP)	0.3 µg/L ^b	0.3 µg/L	—	—	0.067 µg/L	0.067 µg/L
ortho-Phenylphenol (OPP)						
OPP-glucuronide	—	—	—	—	0.15 µg/L	0.15 µg/L
OPP-sulfate	—	—	—	—	0.092 µg/L	0.092 µg/L

Chemical	Cycle 1 (2007–2009)	Cycle 2 (2009–2011)	Cycle 3 (2012–2013)	Cycle 4 (2014–2015)	Cycle 5 (2016–2017)	Cycle 6 (2018–2019)
Pyrethroids						
3-Phenoxybenzoic acid (3-PBA)	0.01 µg/L	0.01 µg/L	—	—	0.012 µg/L	0.012 µg/L
4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA)	0.008 µg/L	0.008 µg/L	—	—	0.0060 µg/L	0.0060 µg/L
<i>cis</i> -3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (<i>cis</i> -DBCA)	0.006 µg/L	0.006 µg/L	—	—	0.0059 µg/L	0.0059 µg/L
<i>cis</i> -3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (<i>cis</i> -DCCA)	0.007 µg/L	0.007 µg/L	—	—	0.0045 µg/L	0.0042 µg/L
<i>trans</i> -3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (<i>trans</i> -DCCA)	0.01 µg/L	0.01 µg/L	—	—	0.0094 µg/L	0.0094 µg/L
Plasticizers						
Monomethyl phthalate (MMP)	5 µg/L	5 µg/L	—	—	0.21 µg/L	0.21 µg/L
Monoethyl phthalate (MEP)	0.5 µg/L	0.3 µg/L	—	—	0.98 µg/L	0.76 µg/L
Mono(3-carboxypropyl) phthalate (MCP)	0.2 µg/L	0.06 µg/L	—	—	0.14 µg/L	0.14 µg/L
Mono- <i>n</i> -butyl phthalate (MnBP)	0.2 µg/L	0.2 µg/L	—	—	0.60 µg/L	0.60 µg/L
Monoisobutyl phthalate (MIBP)	—	0.1 µg/L	—	—	0.57 µg/L	0.57 µg/L
Mono-3-hydroxy- <i>n</i> -butyl phthalate (3OH-MBP)	—	—	—	—	0.079 µg/L	0.068 µg/L
Monocyclohexyl phthalate (MCHP)	0.2 µg/L	0.09 µg/L	—	—	0.25 µg/L	0.25 µg/L
Monobenzyl phthalate (MBzP)	0.2 µg/L	0.05 µg/L	—	—	0.37 µg/L	0.14 µg/L
Mono[2-(carboxymethyl)hexyl] phthalate (MCMHP)	—	—	—	—	0.27 µg/L	0.27 µg/L
Mono(2-ethylhexyl) phthalate (MEHP)	0.2 µg/L	0.08 µg/L	—	—	0.11 µg/L	0.077 µg/L
Mono(2-ethyl-5-carboxypentyl) phthalate (MECPP)	—	—	—	—	0.28 µg/L	0.28 µg/L
Mono(2-ethyl-5-oxohexyl) phthalate (MEOHP)	0.2 µg/L	0.1 µg/L	—	—	0.17 µg/L	0.17 µg/L
Mono(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP)	0.4 µg/L	0.4 µg/L	—	—	0.22 µg/L	0.22 µg/L
Mono-carboxy- <i>n</i> -heptyl phthalate (MCHpP)	—	—	—	—	0.083 µg/L	0.083 µg/L
Mono- <i>n</i> -octyl phthalate (MOP)	0.7 µg/L	0.3 µg/L	—	—	0.16 µg/L	0.16 µg/L
Mono(carboxyisooctyl) phthalate (MCiOP)	—	—	—	—	0.30 µg/L	0.13 µg/L
Monoisononyl phthalate (MiNP)	0.4 µg/L	0.3 µg/L	—	—	0.37 µg/L	0.15 µg/L
Monocarboxyisononyl phthalate (MCiNP)	—	—	—	—	0.077 µg/L	0.075 µg/L
Monooxoisononyl phthalate (MOiNP)	—	—	—	—	0.15 µg/L	0.15 µg/L
Monohydroxyisononyl phthalate (MHiNP)	—	—	—	—	0.065 µg/L	0.065 µg/L
Monoisodecyl phthalate (MiDP)	—	—	—	—	0.16 µg/L	0.16 µg/L
Monooxoisodecyl phthalate (MOiDP)	—	—	—	—	0.097 µg/L	0.097 µg/L
Monohydroxyisodecyl phthalate (MHiDP)	—	—	—	—	0.067 µg/L	0.065 µg/L

Chemical	Cycle 1 (2007–2009)	Cycle 2 (2009–2011)	Cycle 3 (2012–2013)	Cycle 4 (2014–2015)	Cycle 5 (2016–2017)	Cycle 6 (2018–2019)
Di(isononyl)cyclohexane-1,2-dicarboxylate (DINCH)						
<i>trans</i> -Cyclohexane-1,2-dicarboxylic mono isononyl ester (<i>trans</i> -MINCH)	—	—	—	—	0.017 µg/L	0.017 µg/L
Cyclohexane-1,2-dicarboxylic mono oxoisonyl ester (oxo-MINCH)	—	—	—	—	0.047 µg/L	0.047 µg/L
Cyclohexane-1,2-dicarboxylic mono hydroxyisononyl ester (OH-MINCH)	—	—	—	—	0.078 µg/L	0.071 µg/L
<i>cis</i> -Cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (<i>cis</i> -cx-MINCH)	—	—	—	—	0.059 µg/L	0.059 µg/L
<i>trans</i> -Cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (<i>trans</i> -cx-MINCH)	—	—	—	—	0.33 µg/L	0.33 µg/L
Cyclohexane-1,2-dicarboxylic acid (CHDA)	—	—	—	—	0.30 µg/L	0.30 µg/L
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate (TXIB)						
2,2,4-Trimethyl-1,3-pentanediol (TMPD)	—	—	—	—	1.7 µg/L	1.7 µg/L
2,2,4-Trimethyl-3-hydroxy valeric acid (HTMV)	—	—	—	—	0.42 µg/L	0.42 µg/L
Tri-(2-ethylhexyl) trimellitate (TEHT)						
1-Mono(2-ethylhexyl)trimellitate (1-MEHTM)	—	—	—	—	0.22 µg/L	0.22 µg/L
2-Mono(2-ethylhexyl)trimellitate (2-MEHTM)	—	—	—	—	0.16 µg/L	0.16 µg/L
4-Mono(2-ethylhexyl)trimellitate (4-MEHTM)	—	—	—	—	0.098 µg/L	0.098 µg/L
Adjustment factor						
Creatinine	3 mg/dL	4 mg/dL	5.0 mg/dL	5.0 mg/dL	5.0 mg/dL	2.6 mg/dL

a Chromium (VI) was measured indirectly as total chromium in red blood cells.

b The LOD has been corrected from previous reports.

REFERENCES

EPA (U.S. Environmental Protection Agency) (2015). Definition and procedure for the determination of the method detection limit—Revision 1.11, Federal Regulation 40 CFR 136 Appendix B. U.S. Environmental Protection Agency, Washington, DC.

APPENDIX

B

CONVERSION FACTORS

Units of measurement are important. Results are reported here using standard units; however, units can be converted using the conversion factors presented below for comparison of data with other data sets.

■ **Table B-1**

Definition of units

Unit	Abbreviation	Value
litre	L	—
decilitre	dL	10 ⁻¹ L
millilitre	mL	10 ⁻³ L
microlitre	µL	10 ⁻⁶ L
gram	g	—
milligram	mg	10 ⁻³ g
microgram	µg	10 ⁻⁶ g
nanogram	ng	10 ⁻⁹ g
picogram	pg	10 ⁻¹² g

For concentrations of environmental chemicals in blood and urine, data can be converted from µg/L to µmol/L using the molecular weight (MW) of the chemical and the formula:

$Y \text{ } \mu\text{mol/L} = X \text{ } \mu\text{g/L} \times \text{conversion factor (CF)}$, where the CF is equivalent to $1/\text{MW}$.

Table B-2

Conversion factors for concentrations of environmental chemicals in blood and urine

Chemical	MW (g/mol)	CF ($\mu\text{g/L} \rightarrow \mu\text{mol/L}$)
Metals and trace elements		
Lead	207.20	0.04826 ^a
Boron	10.81	0.09251
Cadmium	112.41	0.00890
Chromium (VI)	52.00	0.01923
Selenium	78.97	0.01266
Arsenic (speciated)		
Arsenate	—	0.01335 ^b
Arsenite	—	0.01335 ^b
Arsenocholine and arsenobetaine	—	0.01335 ^b
Dimethylarsinic acid (DMA)	—	0.01335 ^b
Monomethylarsonic acid (MMA)	—	0.01335 ^b
Mercury		
Mercury (total)	200.59	0.00499
Methylmercury	215.63	0.00464
Mercury (inorganic)	200.59	0.00499
Self-care and consumer product chemicals		
Bisphenol A (BPA)	228.29	0.00438
Parabens		
Methyl paraben	152.15	0.00657
Ethyl paraben	166.18	0.00602
Propyl paraben	180.20	0.00555
Butyl paraben	194.23	0.00515
Nicotine		
Cotinine	176.22	0.00567
Acrylamide		
Acrylamide haemoglobin adduct	—	— ^c
Glycidamide haemoglobin adduct	—	— ^c
Per- and polyfluoroalkyl substances		
Perfluorobutanoic acid (PFBA)	214.04	0.00467
Perfluorobutane sulfonate (PFBS)	300.10	0.00333
Perfluorohexanoic acid (PFHxA)	314.05	0.00318
Perfluorohexane sulfonate (PFHxS)	400.11	0.00250
Perfluorooctanoic acid (PFOA)	414.07	0.00242
Perfluorooctane sulfonate (PFOS)	500.13	0.00200
Perfluorononanoic acid (PFNA)	464.08	0.00215
Perfluorodecanoic acid (PFDA)	514.08	0.00195
Perfluoroundecanoic acid (PFUnDA)	564.09	0.00177

Chemical	MW (g/mol)	CF (µg/L → µmol/L)
Pesticides		
Ethylene thiourea (ETU)	102.16	0.00979
Organophosphate pesticides		
Dimethylphosphate (DMP)	126.05	0.00793
Dimethylthiophosphate (DMTP)	141.10	0.00709
Dimethyldithiophosphate (DMDTP)	158.17	0.00632
Diethylphosphate (DEP)	154.10	0.00649
Diethylthiophosphate (DETP)	170.16	0.00588
Diethyldithiophosphate (DEDTP)	186.22	0.00537
ortho-Phenylphenol (OPP)		
OPP-glucuronide	346.34	0.00289
OPP-sulfate	249.27	0.00401
Pyrethroids		
3-Phenoxybenzoic acid (3-PBA)	214.22	0.00467
4-Fluoro-3-phenoxybenzoic acid (4-F-3-PBA)	232.21	0.00431
<i>cis</i> -3-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane carboxylic acid (<i>cis</i> -DBCA)	297.97	0.00336
<i>cis</i> -3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (<i>cis</i> -DCCA)	209.07	0.00478
<i>trans</i> -3-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid (<i>trans</i> -DCCA)	209.07	0.00478
Plasticizers		
Monomethyl phthalate (MMP)	180.16	0.00555
Monoethyl phthalate (MEP)	194.18	0.00515
Mono(3-carboxypropyl) phthalate (MCP)	252.22	0.00396
Mono- <i>n</i> -butyl phthalate (MnBP)	222.24	0.00450
Monoisobutyl phthalate (MiBP)	222.24	0.00450
Mono-3-hydroxy- <i>n</i> -butyl phthalate (3OH-MBP)	238.24	0.00420
Monocyclohexyl phthalate (MCHP)	248.27	0.00403
Monobenzyl phthalate (MBzP)	256.25	0.00390
Mono[2-(carboxymethyl)hexyl] phthalate (MCMHP)	308.33	0.00324
Mono(2-ethylhexyl) phthalate (MEHP)	278.34	0.00359
Mono(2-ethyl-5-carboxypentyl) phthalate (MECPP)	308.33	0.00324
Mono(2-ethyl-5-oxohexyl) phthalate (MEOHP)	292.33	0.00342
Mono(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP)	294.34	0.00340
Mono-carboxy- <i>n</i> -heptyl phthalate (MCHpP)	308.13	0.00325
Mono- <i>n</i> -octyl phthalate (MOP)	278.34	0.00359
Mono(carboxyisooctyl) phthalate (MCiOP)	322.35	0.00310
Monoisononyl phthalate (MiNP)	292.37	0.00342
Monocarboxyisononyl phthalate (MCiNP)	336.38	0.00297
Monooxoisononyl phthalate (MOiNP)	306.35	0.00326
Monohydroxyisononyl phthalate (MHiNP)	308.37	0.00324
Monoisodecyl phthalate (MiDP)	306.18	0.00327
Monooxoisodecyl phthalate (MOiDP)	320.38	0.00312
Monohydroxyisodecyl phthalate (MHiDP)	322.40	0.00310

Chemical	MW (g/mol)	CF ($\mu\text{g/L} \rightarrow \mu\text{mol/L}$)
Di(isononyl)cyclohexane-1,2-dicarboxylate (DINCH)		
<i>trans</i> -Cyclohexane-1,2-dicarboxylic mono isononyl ester (<i>trans</i> -MINCH)	298.42	0.00335
Cyclohexane-1,2-dicarboxylic mono oxoisonyl ester (oxo-MINCH)	312.40	0.00320
Cyclohexane-1,2-dicarboxylic mono hydroxyisononyl ester (OH-MINCH)	314.42	0.00318
<i>cis</i> -Cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (<i>cis</i> -cx-MINCH)	326.40	0.00306
<i>trans</i> -Cyclohexane-1,2-dicarboxylic mono carboxyisononyl ester (<i>trans</i> -cx-MINCH)	326.40	0.00306
Cyclohexane-1,2-dicarboxylic acid (CHDA)	172.18	0.00581
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate (TXIB)		
2,2,4-Trimethyl-1,3-pentanediol (TMPD)	146.23	0.00684
2,2,4-Trimethyl-3-hydroxy valeric acid (HTMV)	160.21	0.00624
Tri-(2-ethylhexyl) trimellitate (TEHT)		
1-Mono(2-ethylhexyl)trimellitate (1-MEHTM)	322.36	0.00310
2-Mono(2-ethylhexyl)trimellitate (2-MEHTM)	322.36	0.00310
4-Mono(2-ethylhexyl)trimellitate (4-MEHTM)	322.36	0.00310
Adjustment factor		
Creatinine	113.12	88.4 ^d

a For converting lead concentration from $\mu\text{g/dL}$ to $\mu\text{mol/L}$.

b For converting arsenic species concentration from $\mu\text{g As/L}$ to $\mu\text{mol As/L}$.

c Not applicable.

d For converting creatinine concentration from mg/dL to $\mu\text{mol/L}$.

APPENDIX

C

CREATININE

Table C-1

Creatinine—Geometric means and selected percentiles of urine concentrations (mg/dL) for the Canadian population aged 6–79 by age group, Canadian Health Measures Survey cycle 1 (2007–2009)

Cycle	n	GM (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 6–79 years						
1 (2007–2009)	5515	83 (78–89)	27 (23–30)	93 (86–99)	210 (200–220)	250 (240–260)
Males, 6–79 years						
1 (2007–2009)	2663	100 (97–110)	36 (28–43)	110 (100–110)	230 (220–240)	270 (250–280)
Females, 6–79 years						
1 (2007–2009)	2852	68 (62–74)	22 (18–25)	75 (66–84)	180 (160–190)	210 (200–230)
6–11 years						
1 (2007–2009)	1042	66 (60–72)	24 (18–29)	74 (67–81)	140 (130–150)	170 (160–180)
12–19 years						
1 (2007–2009)	992	120 (110–130)	39 (30–47)	130 (120–140)	250 (230–280)	300 (260–330)
20–39 years						
1 (2007–2009)	1172	90 (81–100)	29 (22–36)	99 (91–110)	230 (210–240)	280 (250–300)
40–59 years						
1 (2007–2009)	1221	78 (73–84)	24 (19–28)	86 (76–96)	210 (190–230)	240 (230–250)
60–79 years						
1 (2007–2009)	1088	72 (68–75)	26 (22–31)	81 (77–85)	150 (140–160)	190 (170–220)

CI: confidence interval; GM: geometric mean

Note: The limit of detection for cycle 1 is 3 mg/dL.

Table C-2

Creatinine—Geometric means and selected percentiles of urine concentrations (mg/dL) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 2 (2009–2011)

Cycle	n	GM (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years						
2 (2009–2011)	6299	100 (100–110)	35 (33–38)	110 (110–120)	240 (230–260)	280 (270–300)
Males, 3–79 years						
2 (2009–2011)	3031	120 (120–130)	47 (42–53)	130 (120–150)	260 (240–280)	310 (280–340)
Females, 3–79 years						
2 (2009–2011)	3268	89 (85–94)	30 (27–32)	100 (96–100)	200 (180–230)	250 (240–270)
3–5 years						
2 (2009–2011)	572	59 (55–63)	26 (24–29)	61 (55–67)	110 (110–120)	140 (110–160)
6–11 years						
2 (2009–2011)	1059	88 (83–94)	37 (33–42)	98 (94–100)	170 (160–170)	190 (170–210)
12–19 years						
2 (2009–2011)	1042	130 (120–150)	52 (36–68)	150 (140–160)	270 (260–280)	300 (270–340)
20–39 years						
2 (2009–2011)	1322	120 (110–130)	37 (25–48)	140 (130–160)	260 (250–280)	330 (270–380)
40–59 years						
2 (2009–2011)	1223	100 (96–110)	33 (27–40)	110 (100–120)	240 (220–260)	280 (260–310)
60–79 years						
2 (2009–2011)	1081	85 (80–89)	32 (26–37)	96 (90–100)	180 (170–200)	230 (210–260)

CI: confidence interval; GM: geometric mean

Note: The limit of detection for cycle 2 is 4 mg/dL.

Table C-3

Creatinine—Geometric means and selected percentiles of urine concentrations (mg/dL) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 3 (2012–2013)

Cycle	n	GM (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years						
3 (2012–2013)	5704	97 (93–100)	33 (29–37)	100 (100–110)	240 (220–250)	280 (250–300)
Males, 3–79 years						
3 (2012–2013)	2847	110 (110–120)	40 (35–46)	120 (110–130)	260 (230–280)	300 (260–340)
Females, 3–79 years						
3 (2012–2013)	2857	83 (76–90)	26 (21–30)	93 (81–110)	210 (190–240)	250 (220–270)
3–5 years						
3 (2012–2013)	521	51 (45–58)	19 (14–24)	58 (51–65)	110 (99–110)	120 (110–120)
6–11 years						
3 (2012–2013)	1013	84 (77–92)	35 (28–42)	93 (82–100)	160 (150–180)	200 (170–230)
12–19 years						
3 (2012–2013)	998	130 (120–150)	52 (37–66)	150 (140–160)	280 (260–300)	320 (290–360)
20–39 years						
3 (2012–2013)	1048	110 (98–120)	36 (26–45)	110 (97–130)	270 (220–320)	330 (290–380)
40–59 years						
3 (2012–2013)	1080	95 (86–110)	34 (24–44)	110 (98–110)	220 (200–250)	250 (230–280)
60–79 years						
3 (2012–2013)	1044	84 (76–91)	26 (19–32)	96 (89–100)	190 (170–210)	230 (210–240)

CI: confidence interval; GM: geometric mean

Note: The limit of detection for cycle 3 is 5.0 mg/dL.

Table C-4

Creatinine—Geometric means and selected percentiles of urine concentrations (mg/dL) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 4 (2014–2015)

Cycle	n	GM (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years						
4 (2014–2015)	5603	110 (110–120)	40 (35–46)	110 (110–120)	250 (240–260)	290 (270–310)
Males, 3–79 years						
4 (2014–2015)	2815	130 (120–140)	50 (40–60)	140 (120–150)	270 (250–290)	320 (310–330)
Females, 3–79 years						
4 (2014–2015)	2788	98 (94–100)	35 (30–39)	100 (98–100)	230 (210–240)	260 (250–270)
3–5 years						
4 (2014–2015)	513	58 (51–65)	22 (15–29)	66 (58–73)	110 (99–120)	130 (120–150)
6–11 years						
4 (2014–2015)	1008	90 (84–98)	35 (24–45)	99 (94–100)	170 (150–190)	210 (170–250)
12–19 years						
4 (2014–2015)	991	140 (130–150)	54 (46–61)	150 (140–170)	280 (270–300)	350 (320–370)
20–39 years						
4 (2014–2015)	1059	130 (120–140)	41 (36–47)	140 (130–160)	290 (260–320)	350 (320–390)
40–59 years						
4 (2014–2015)	1037	110 (100–120)	41 (29–54)	110 (110–120)	240 (220–260)	270 (260–280)
60–79 years						
4 (2014–2015)	995	100 (97–110)	37 (32–42)	100 (100–110)	200 (180–220)	240 (210–270)

CI: confidence interval; GM: geometric mean

Note: The limit of detection for cycle 4 is 5.0 mg/dL.

Table C-5

Creatinine—Geometric means and selected percentiles of urine concentrations (mg/dL) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 5 (2016–2017)

Cycle	n	GM (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years						
5 (2016–2017)	5618	98 (92–100)	32 (29–36)	100 (97–110)	230 (220–240)	260 (240–280)
Males, 3–79 years						
5 (2016–2017)	2803	110 (110–120)	43 (35–50)	120 (110–130)	240 (230–250)	280 (250–320)
Females, 3–79 years						
5 (2016–2017)	2815	84 (79–90)	28 (24–32)	92 (84–99)	210 (190–230)	240 (230–260)
3–5 years						
5 (2016–2017)	546	59 (52–66)	26 (22–30)	68 (60–76)	110 (98–120)	130 (110–140)
6–11 years						
5 (2016–2017)	1006	86 (81–92)	37 (32–43)	92 (85–99)	160 (150–170)	190 (160–220)
12–19 years						
5 (2016–2017)	1005	140 (120–150)	58 (47–69)	150 (130–170)	290 (250–320)	340 (300–380)
20–39 years						
5 (2016–2017)	1057	110 (93–120)	33 (22–44)	120 (100–140)	250 (230–270)	290 (250–330)
40–59 years						
5 (2016–2017)	1007	94 (85–100)	29 (20–37)	98 (90–110)	230 (210–250)	250 (230–270)
60–79 years						
5 (2016–2017)	997	88 (83–93)	32 (27–36)	97 (93–100)	190 (180–210)	220 (210–240)

CI: confidence interval; GM: geometric mean

Note: The limit of detection for cycle 5 is 5.0 mg/dL.

Table C-6

Creatinine—Geometric means and selected percentiles of urine concentrations (mg/dL) for the Canadian population aged 3–79 by age group, Canadian Health Measures Survey cycle 6 (2018–2019)

Cycle	n	GM (95% CI)	10 th (95% CI)	50 th (95% CI)	90 th (95% CI)	95 th (95% CI)
Total, 3–79 years						
6 (2018–2019)	5645	91 (85–96)	28 (25–31)	100 (94–110)	220 (200–240)	260 (250–270)
Males, 3–79 years						
6 (2018–2019)	2836	110 (100–120)	41 (34–47)	110 (100–120)	250 (230–270)	280 (260–300)
Females, 3–79 years						
6 (2018–2019)	2809	75 (69–81)	23 (20–26)	84 (75–93)	180 (170–200)	240 (210–270)
3–5 years						
6 (2018–2019)	523	59 (55–63)	26 (18–34)	70 (65–75)	110 (99–110)	110 (110–120)
6–11 years						
6 (2018–2019)	986	79 (71–88)	29 (20–39)	93 (82–100)	150 (140–160)	170 (150–190)
12–19 years						
6 (2018–2019)	977	130 (110–140)	43 (32–55)	150 (140–160)	270 (250–290)	320 (280–350)
20–39 years						
6 (2018–2019)	1068	95 (82–110)	26 (18–34)	100 (91–120)	250 (230–260)	280 (250–310)
40–59 years						
6 (2018–2019)	1097	87 (78–96)	27 (20–34)	99 (90–110)	210 (170–240)	260 (230–300)
60–79 years						
6 (2018–2019)	994	87 (79–97)	35 (29–40)	96 (85–110)	180 (160–200)	230 (200–270)

CI: confidence interval; GM: geometric mean

Note: The limit of detection for cycle 6 is 2.6 mg/dL.