Canadian Health Measures Survey:

Summary of the Biomonitoring Results and Government Actions

Introduction

The *Report on Human Biomonitoring of Environmental Chemicals in Canada* (Health Canada, 2010) provides the results of the biomonitoring component of Cycle 1 of the Canadian Health Measures Survey (CHMS), which was conducted between 2007 and 2009.

A main objective of this survey is to establish baseline levels of environmental chemicals measured in the Canadian population. The results of this survey represent the first national levels for most of the substances measured. These data will serve as a starting point for comparison with data from future surveys. This comparison will help to determine how levels may be changing over time and to assess the effectiveness of risk management actions. This information will also help with the evaluation of chemical exposure and the development of policies to protect the health of Canadians.

Chemicals Selected for Biomonitoring in the Canadian Health Measures Survey

The following chemicals were selected for biomonitoring in the CHMS based on their known or suspected health effects, the level of public concern, evidence of exposure in the Canadian population, and the need to inform government action.

Metals and Trace Elements

Metals and trace elements are naturally occurring substances that make up part of the Earth's crust. Exposure to metals and trace elements may result from both natural sources and human activities. Lead, cadmium and mercury are heavy metals of particular interest due to their potential effects on human health. Several others, such as copper, manganese, molybdenum, selenium and zinc are essential for the maintenance of good health, although exposure to high levels may adversely affect health. Other elements, such as antimony, arsenic, nickel, uranium, and vanadium, were included in the CHMS in order to establish current concentrations in the Canadian population for possible use in future scientific assessments.

Organochlorines and Polychlorinated Biphenyls (PCBs)

Organochlorine chemicals include pesticides that are no longer registered for use in Canada, and various industrial and commercial compounds, such as PCBs, that have been subject to restricted use in Canada since the 1970s. These controls were put in place because these chemicals do not break down easily and therefore can persist in the environment for many years. In addition, they tend to accumulate in the food chain, which leads to human exposure through the diet. Due to their persistence and continued use in some countries, organochlorines are widely dispersed around the world. Global efforts such as the United Nations Environment Programme (UNEP) Stockholm Convention on Persistent Organic Pollutants (POPs) have been put in place to manage these chemicals. Organochlorines and PCBs have been included in the CHMS biomonitoring component to provide national baseline data, which will be compared with future surveys to track changes in human levels in response to global actions.

Polybrominated Flame Retardants

Polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBBs) are persistent organic compounds that are produced synthetically and were used widely as fire retardants in plastics, clothing, and other consumer products. This has resulted in widespread exposure of the environment and people to these compounds. Recent studies have shown that while concentrations of PBDEs in humans are generally low, they have been increasing over the last two decades. Due to environmental concerns, manufacture and use of most PBDEs and PBBs has been phased out in recent years. Many

of the polybrominated flame retardants are now being included in various international control agreements, such as the UNEP Stockholm Convention on POPs. They have been included in the CHMS to track changes in response to both national and global control efforts.

Perfluorinated Compounds

Perfluorinated compounds, such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), have been produced for application in a variety of industrial and commercial uses since the 1950s, including fabric protectors, lubricants, wire and cable insulation, and food packaging. Perfluorohexane sulfonate (PFHxS) is a by-product resulting from the production of PFOS. Perfluorinated compounds persist in the environment and some can bioaccumulate in the food chain. They have been detected worldwide in various parts of the environment, and in humans. Due to environmental concerns, worldwide use of PFOS has decreased significantly since 2002. Canada is taking action nationally and is participating in international initiatives to reduce the global production of PFOS and to reduce PFOA emissions and product content. These substances have been measured in the CHMS to track changes in human levels in response to both national and global efforts.

Bisphenol A

Bisphenol A (BPA) is a chemical used in the production of polycarbonate plastics and epoxy resins. Polycarbonate plastic is used in the manufacture of food and beverage containers, and epoxy resins are used as a protective lining in cans. BPA is also used in products such as medical devices, sporting and safety equipment, electronics and automotive parts. The primary route of exposure to BPA for the public is through dietary intake, although some exposure can also occur from contact with outdoor and indoor air, drinking water, soil and dust, and from the use of consumer products. Levels of BPA in urine can be used as a marker of exposure. There is some concern that low-level exposure to BPA, particularly at sensitive early life stages, may affect health later in life. To date, there has been no data available to estimate Canadians' overall exposure to BPA through biomonitoring. The CHMS is the first national survey to provide population reference ranges for levels of BPA in Canadians.

Organophosphate Insecticides

Organophosphate insecticides are used in agricultural, forestry and residential settings. Health Canada began to re-evaluate organophosphate insecticides in 1999. As a result, 16 organophosphate insecticides have been or are in the process of being removed from the marketplace and the remaining 11 have had their uses restricted to reduce human and environmental exposure. After entry into the body, organophosphate pesticides rapidly break down into metabolites, which are excreted in urine. Levels of these metabolites in urine can be used as a marker of exposure to the pesticides or their breakdown products. The measurement of organophosphate metabolites was included in the CHMS in order to provide national reference ranges for their levels in Canadians.

Pyrethroid Insecticides

Pyrethrins are naturally occurring compounds found in certain chrysanthemum flowers and have been used for their insect-control properties since the late 1800s. Pyrethroids are manufactured versions of pyrethrins and are widely used in Canada to control insects in agricultural, forestry and residential settings. Pyrethroid insecticides are quickly converted to metabolites in the body and excreted in urine. Levels of these metabolites in urine can be used as a marker of exposure to the pesticides or their breakdown products. Although baseline data have been collected in other countries, they may not be applicable to Canada because of differences in use patterns. The measurement of pyrethroid metabolites was included in the CHMS in order to provide national reference ranges for their levels in Canadians.

Phenoxy Herbicide

The pesticide 2,4-dichlorophenoxyacetic acid (2,4-D) is used for the control of broadleaf weeds in residential, agricultural and forest environments. The sale and use of 2,4-D is regulated in Canada by Health Canada, which recently completed a re-evaluation of this herbicide. Health Canada has determined that 2,4-D meets strict health and safety standards, and as such is acceptable for continued use in Canada. The measurement of 2,4-D was included in the CHMS in order to provide national baseline data on general population exposures to this substance.

Chlorophenol

2,4-dichlorophenol (2,4-DCP) is part of the chlorophenol group of chemicals and is not naturally present in the environment. Sources of 2,4-DCP include the manufacture of pesticides and pharmaceuticals, chlorination of organic material in wastewaters, incineration of organochlorine-containing waste, and degradation of chlorinated compounds. The measurement of 2,4-DCP was included in the CHMS in order to provide national baseline data on general population exposures to this substance.

Cotinine

Cotinine is the primary metabolite of nicotine, a chemical commonly found in tobacco products. It is considered the best indicator of exposure to tobacco products and tobacco smoke. As a result of the adverse effects of tobacco smoke, including second-hand smoke, the Government of Canada, along with various provincial and municipal governments, has taken several steps to reduce exposure to tobacco smoke, particularly involuntary exposure. Cotinine was included in the CHMS to better quantify Canadians' exposure to tobacco.

Results

Table 1 presents summary biomonitoring results of the Canadian Health Measures Survey (Health Canada, 2010) and those reported for the United States by the Centers for Disease Control and Prevention's National Health and Nutrition Examination Survey (NHANES) (CDC, 2009; CDC, 2010). This table includes only those chemicals that were measured in both surveys and in similar biological tissues. Both the geometric mean (a type of average commonly used to report biomonitoring results) and the 95th percentile (the value below which 95% of results fall and that provides an estimation of the upper levels in the population) are shown.

A preliminary examination of these results suggests that the concentrations of the chemicals measured in Canadians are in similar ranges to those reported for the United States. However, it should be noted that a more robust analysis of these results is needed in order to take into account differences in the populations sampled, the years that the surveys were undertaken, the specific biological tissues measured (e.g., blood plasma vs. blood serum), the laboratory analytical methods used, and how results were reported (e.g., age groupings).

The presence of a chemical in a person's body does not necessarily mean that it will affect a person's health. A variety of factors, such as the chemical's toxicity and the amount to which a person is exposed, must be considered to determine health risk. For chemicals such as lead or mercury, scientific studies have provided a good understanding of the health risks associated with elevated levels in blood. However, for many chemicals, further research is needed to understand what health effects, if any, are related to different levels of these chemicals in blood or urine.

Table 1

Summary Results of Canadian and United States National Biomonitoring Surveys[1].

Chemical	Canada (CHMS)[2]						United States (NHANES)[3]					
	Matrix	Collection period	Age (yrs)	Units	Geometric Mean	95th percentile	Matrix	Collection period	Age (yrs)	Units	Geometric Mean	95th percentile
Metals and Trace Elements												
Cadmium	blood	2007–2009	6–79	µg/L	0.35	3.63	blood	2005–2006	1+	µg/L	0.310	1.53
Lead	blood	2007–2009	6–79	µg/dL	1.34	3.79	blood	2005–2006	1+	µg/dL	1.29	3.91
Mercury (total)	blood	2007–2009	6–79	µg/L	0.69	4.70	blood	2005–2006	1+	µg/L	0.863	4.64
Mercury (inorganic)	blood	2007–2009	6–79	µg/L	—	0.88	blood	2005–2006	1+	µg/L	—	0.660
Antimony	urine	2007–2009	6–79	µg/L	0.04	0.18	urine	2005–2006	6+	µg/L	0.073	0.300
Arsenic (total)	urine	2007–2009	6–79	µg/L	12.00	70.63	urine	2005–2006	6+	µg/L	9.29	66.7
Cadmium	urine	2007–2009	6–79	µg/L	0.35	1.65	urine	2005–2006	6+	µg/L	0.191	1.05
Lead	urine	2007–2009	6–79	µg/L	0.48	2.11	urine	2005–2006	6+	µg/L	0.554	2.14
Molybdenum	urine	2007–2009	6–79	µg/L	36.30	138.28	urine	2005–2006	6+	µg/L	45.0	158
Uranium	urine	2007–2009	6–79	µg/L	—	0.02	urine	2005–2006	6+	µg/L	0.006	0.030
Organochlorines[4]												
Aldrin	plasma	2007–2009	20–79	µg/L	—	<LOD	serum	2003–2004	20+	ng/g	—	<LOD
trans-Nonachlor	plasma	2007–2009	20–79	µg/L	0.04	0.14	serum	2003–2004	20+	ng/g	0.106	0.520
Oxychlordane	plasma	2007–2009	20–79	µg/L	0.03	0.09	serum	2003–2004	20+	ng/g	0.067	0.286
p,p'-DDT	plasma	2007–2009	20–79	µg/L	—	0.09	serum	2003–2004	20+	ng/g	—	0.142
p,p'-DDE	plasma	2007–2009	20–79	µg/L	0.91	6.51	serum	2003–2004	20+	ng/g	1.69	12.8
Hexachlorobenzene	plasma	2007–2009	20–79	µg/L	0.05	0.17	serum	2003–2004	20+	ng/g	0.097	0.191
beta-Hexachlorocyclohexane	plasma	2007–2009	20–79	µg/L	0.04	0.54	serum	2003–2004	20+	ng/g	0.050	0.412
gamma-Hexachlorocyclohexane	plasma	2007–2009	20–79	µg/L	—	<LOD	serum	2003–2004	20+	ng/g	—	<LOD
Mirex	plasma	2007–2009	20–79	µg/L	—	0.05	serum	2003–2004	20+	ng/g	—	0.106
Polychlorinated Biphenyls[4]												
PCB 28	plasma	2007–2009	20–79	µg/L	—	<LOD	serum	2003–2004	20+	ng/g	0.031	0.067
PCB 52	plasma	2007–2009	20–79	µg/L	—	<LOD	serum	2003–2004	20+	ng/g	0.016	0.043
PCB 66	plasma	2007–2009	20–79	µg/L	—	<LOD	serum	2003–2004	20+	ng/g	0.009	0.026
PCB 74	plasma	2007–2009	20–79	µg/L	—	0.10	serum	2003–2004	20+	ng/g	0.034	0.167
PCB 99	plasma	2007–2009	20–79	µg/L	—	0.07	serum	2003–2004	20+	ng/g	0.028	0.127
PCB 101	plasma	2007–2009	20–79	µg/L	—	<LOD	serum	2003–2004	20+	ng/g	0.010	0.034
PCB 128	plasma	2007–2009	20–79	µg/L	—	<LOD	serum	2003–2004	20+	ng/g	—	0.004
PCB 146	plasma	2007–2009	20–79	µg/L	0.01	0.06	serum	2003–2004	20+	ng/g	0.016	0.084
PCB 153	plasma	2007–2009	20–79	µg/L	0.11	0.54	serum	2003–2004	20+	ng/g	0.148	0.671
PCB 170	plasma	2007–2009	20–79	µg/L	0.03	0.14	serum	2003–2004	20+	ng/g	0.043	0.199
PCB 178	plasma	2007–2009	20–79	µg/L	—	0.03	serum	2003–2004	20+	ng/g	0.007	0.043
PCB 180	plasma	2007–2009	20–79	µg/L	0.09	0.49	serum	2003–2004	20+	ng/g	0.119	0.572
PCB 183	plasma	2007–2009	20–79	µg/L	—	0.04	serum	2003–2004	20+	ng/g	0.011	0.057
PCB 187	plasma	2007–2009	20–79	µg/L	0.02	0.13	serum	2003–2004	20+	ng/g	0.033	0.172
PCB 194	plasma	2007–2009	20–79	µg/L	0.02	0.10	serum	2003–2004	20+	ng/g	0.023	0.133
PCB 206	plasma	2007–2009	20–79	µg/L	—	0.03	serum	2003–2004	20+	ng/g	0.016	0.090

Chemical	Canada (CHMS)[2]						United States (NHANES)[3]					
	Matrix	Collection period	Age (yrs)	Units	Geometric Mean	95th percentile	Matrix	Collection period	Age (yrs)	Units	Geometric Mean	95th percentile
Polybrominated Flame Retardants[4]												
PBB 153	plasma	2007–2009	20–79	µg/kg lipid[5]	—	<LOD	serum	2003–2004	20+	µg/kg lipid	2.72	34.6
PBDE 17	plasma	2007–2009	20–79	µg/kg lipid[5]	—	<LOD	serum	2003–2004	20+	µg/kg lipid	—	<LOD
PBDE 28	plasma	2007–2009	20–79	µg/kg lipid[5]	—	<LOD	serum	2003–2004	20+	µg/kg lipid	1.17	8.20
PBDE 47	plasma	2007–2009	20–79	µg/kg lipid[5]	10.04	66.60	serum	2003–2004	20+	µg/kg lipid	19.5	163
PBDE 99	plasma	2007–2009	20–79	µg/kg lipid[5]	—	12.63	serum	2003–2004	20+	µg/kg lipid	—	41.6
PBDE 100	plasma	2007–2009	20–79	µg/kg lipid[5]	—	15.09	serum	2003–2004	20+	µg/kg lipid	3.77	36.6
PBDE 153	plasma	2007–2009	20–79	µg/kg lipid[5]	—	35.18	serum	2003–2004	20+	µg/kg lipid	5.41	73.3
Perfluorinated Compounds[4]												
PFOS	plasma	2007–2009	20–79	µg/L	8.85	27.53	serum	2005–2006	20+	µg/L	17.4	49.6
PFOA	plasma	2007–2009	20–79	µg/L	2.52	5.50	serum	2005–2006	20+	µg/L	3.97	11.6
PFHxS	plasma	2007–2009	20–79	µg/L	2.26	12.49	serum	2005–2006	20+	µg/L	1.62	7.20
Environmental Phenol												
Bisphenol A	urine	2007–2009	6–79	µg/L	1.16	7.01	urine	2005–2006	6+	µg/L	1.90	11.5
Organophosphate Insecticides (metabolites)												
DMP	urine	2007–2009	6–79	µg/L	2.96	25.00	urine	2003–2004	6–59	µg/L	—	14.8
DMTP	urine	2007–2009	6–79	µg/L	2.03	40.18	urine	2003–2004	6–59	µg/L	2.10	31.1
DMDTP	urine	2007–2009	6–79	µg/L	—	5.99	urine	2003–2004	6–59	µg/L	—	5.05
DEP	urine	2007–2009	6–79	µg/L	2.30	12.98	urine	2003–2004	6–59	µg/L	—	15.7
DETP	urine	2007–2009	6–79	µg/L	—	4.01	urine	2003–2004	6–59	µg/L	—	2.80
DEDTP	urine	2007–2009	6–79	µg/L	—	<LOD	urine	2003–2004	6–59	µg/L	—	0.320
Pyrethroid Insecticides (metabolites)												
4-F-3-PBA	urine	2007–2009	6–79	µg/L	—	0.08	urine	2001–2002	6–59	µg/L	—	<LOD
cis-DBCA	urine	2007–2009	6–79	µg/L	—	0.07	urine	2001–2002	6–59	µg/L	—	<LOD
cis-DCCA	urine	2007–2009	6–79	µg/L	0.08	0.94	urine	2001–2002	6–59	µg/L	—	0.890
trans-DCCA	urine	2007–2009	6–79	µg/L	0.20	2.53	urine	2001–2002	6–59	µg/L	—	2.54
3-PBA	urine	2007–2009	6–79	µg/L	0.25	2.96	urine	2001–2002	6–59	µg/L	0.321	3.32
Phenoxy Herbicide												
2,4-D	urine	2007–2009	6–79	µg/L	—	<LOD	urine	2001–2002	6–59	µg/L	—	1.27

[1] It should be noted that comparisons between the Canadian and U.S. results must take into account differences in the populations sampled, the years that the surveys were undertaken, the specific biological tissues measured (e.g., blood plasma vs. blood serum), the laboratory analytical methods used, and how results were reported (e.g., age groupings).

[2] Source: Health Canada, 2010

[3] Sources: CDC, 2009; CDC, 2010

[4] CHMS measured these chemicals in blood plasma, while NHANES measured them in blood serum.

[5] In the CHMS, PBDEs and PBBs were measured in plasma, while lipids were measured in serum. Refer to Health Canada, 2010 for further details.

— The geometric mean was not calculated when the proportion of results below the laboratory method's limit of detection was greater than 40%. Refer to Health Canada, 2010 for further details.

<LOD Below the limit of detection. The lowest concentration of a chemical that can be reliably measured. Refer to Health Canada, 2010; CDC, 2009; CDC, 2010 for further details.

The Government of Canada's Management of Chemicals

The Government of Canada plays a key role in protecting Canadians from exposure to harmful chemicals through legislation that governs chemical substances in food, water, drugs, pesticides and consumer products. The majority of the chemicals measured in the CHMS are currently being managed by various legislative acts. These are summarized in Table 2.

Biomonitoring data from the first and future cycles of the CHMS and from other monitoring initiatives will provide valuable information for the Government's assessment and management of environmental chemicals, with the ultimate goal of improving the health of Canadians.

References

CDC (Centers for Disease Control and Prevention). (2009). *Fourth National Report on Human Exposure to Environmental Chemicals.* Atlanta (GA). Retrieved August 4, 2010, from www.cdc.gov

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Table 2

Government of Canada's Management of Chemicals: Selected Acts Related to Human Health

Chemical	Legislation	For More Information
Metals and trace elements	*Canadian Environmental Protection Act* *Food and Drugs Act* *Hazardous Products Act* *Pest Control Products Act* *Tobacco Act*	It's Your Health – Effects of Lead on Human Health www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/lead-plomb-eng.php It's Your Health – Mercury and Human Health www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/merc-eng.php Food and Nutrition – Mercury www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/mercur/index-eng.php It's Your Health – Arsenic in Drinking Water www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/arsenic-eng.php Food and Nutrition – Arsenic www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/arsenic-eng.php
Organochlorines	*Canadian Environmental Protection Act* *Food and Drugs Act*	Persistent Organic Pollutants (POPs) Fact Sheet Series: Dichlorodiphenyltrichloroethane (DDT) www.ainc-inac.gc.ca/ai/scr/yt/pubs/2010fs/ddt-eng.asp Persistent Organic Pollutants (POPs) Fact Sheet Series: Toxaphene www.ainc-inac.gc.ca/ai/scr/yt/pubs/2010fs/txp-eng.asp Chemicals At A Glance – Lindane (gamma-hexachlorocyclohexane) www.chemicalsubstanceschimiques.gc.ca/fact-fait/lindane-eng.php
Polychlorinated biphenyls (PCBs)	*Canadian Environmental Protection Act* *Food and Drugs Act* *Hazardous Products Act*	Chemicals At A Glance – Polychlorinated Biphenyls (PCBs) www.chemicalsubstanceschimiques.gc.ca/fact-fait/pcb-bpc-eng.php Food and Nutrition – Polychlorinated Biphenyls (PCBs) www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/pcb-bpc/index-eng.php
Polybrominated flame retardants	*Canadian Environmental Protection Act* *Food and Drugs Act*	It's Your Health – PBDE Flame Retardants and Human Health www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/pbde-eng.php Food and Nutrition – Polybrominated Diphenyl Ethers (PBDEs) www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/pbde-edpb/index-eng.php
Perfluorinated compounds (PFCs)	*Canadian Environmental Protection Act* *Food and Drugs Act*	Perfluorooctane Sulfonate (PFOS) and Health www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/perflurooctane_sulfonate-eng.php Food and Nutrition – Perfluorinated Chemicals in Food www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/pcf-cpa/index-eng.php

Chemical	Legislation	For More Information
Bisphenol A (BPA)	*Canadian Environmental Protection Act* *Food and Drugs Act* *Hazardous Products Act*	Chemicals At A Glance – Bisphenol A www.chemicalsubstanceschimiques.gc.ca/fact-fait/bisphenol-a-eng.php Questions and Answers on Bisphenol A www.chemicalsubstanceschimiques.gc.ca/fact-fait/bisphenol-a_qa-qr-eng.php Food and Nutrition – Bisphenol A www.hc-sc.gc.ca/fn-an/securit/packag-emball/bpa/index-eng.php
Organophosphate insecticides	*Food and Drugs Act* *Pest Control Products Act*	Pesticides and Health www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/pesticides-eng.php Pesticides and Food www.hc-sc.gc.ca/cps-spc/pubs/pest/_fact-fiche/pesticide-food-alim/index-eng.php
Pyrethroid insecticides	*Food and Drugs Act* *Pest Control Products Act*	Pesticides and Health www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/pesticides-eng.php Homeowner Guidelines for Pesticide Use www.hc-sc.gc.ca/cps-spc/pest/part/protect-proteger/use-utiliser/_home-maison/index-eng.php
Phenoxy herbicides	*Canadian Environmental Protection Act* *Food and Drugs Act* *Pest Control Products Act*	Homeowner Guidelines for Pesticide Use www.hc-sc.gc.ca/cps-spc/pest/part/protect-proteger/use-utiliser/_home-maison/index-eng.php Questions and Answers – Final Decision on the Re-evaluation of 2,4-D www.hc-sc.gc.ca/cps-spc/pest/part/protect-proteger/use-utiliser/_24d/24d-faq-eng.php
Chlorophenol	*Canadian Environmental Protection Act* *Food and Drugs Act*	
Cotinine	*Tobacco Act*	It's Your Health – Second-hand Smoke www.hc-sc.gc.ca/hl-vs/iyh-vsv/life-vie/shs-fs-eng.php