Canadian Health Measures Survey

Recent Results of the Biomonitoring Component & Future Directions

Occupational and Environmental Health Seminar Series

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Canada

Biomonitoring

What is Biomonitoring?

Biomonitoring is the measurement of a chemical, the products it makes after it has broken down, or the products that might result from interactions in the body.

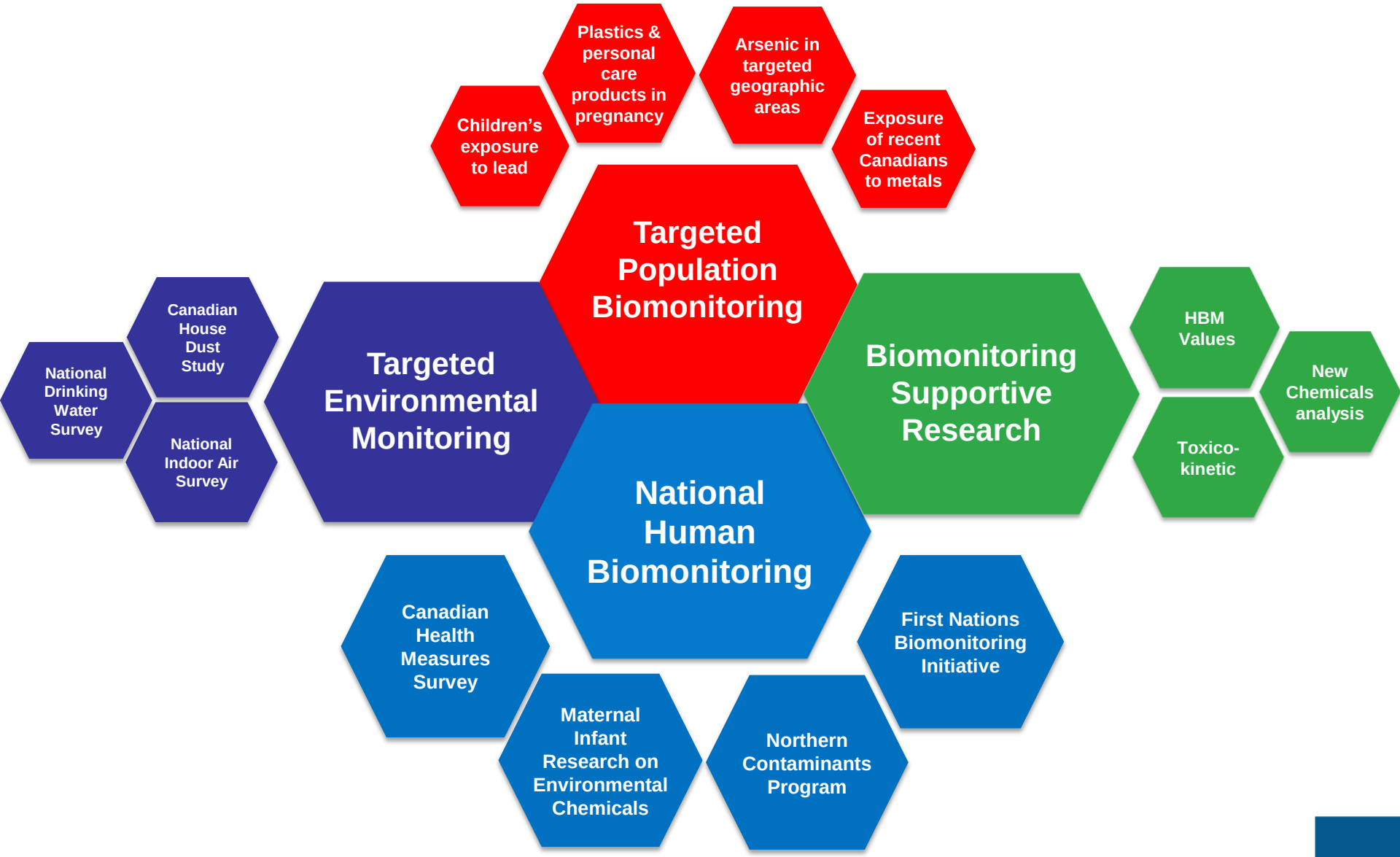
Uses of Biomonitoring Data

- Establish baseline levels of chemicals in the Canadian population.
- Assess exposure and risks.
- Identify exposed populations.
- Identify priority chemicals for which further action may be taken.
- Assess the effectiveness of risk management actions to reduce exposure and associated health risks.
- Support future research on potential links between exposure to certain chemicals and specific health effects.
- Contribute to international monitoring programs.

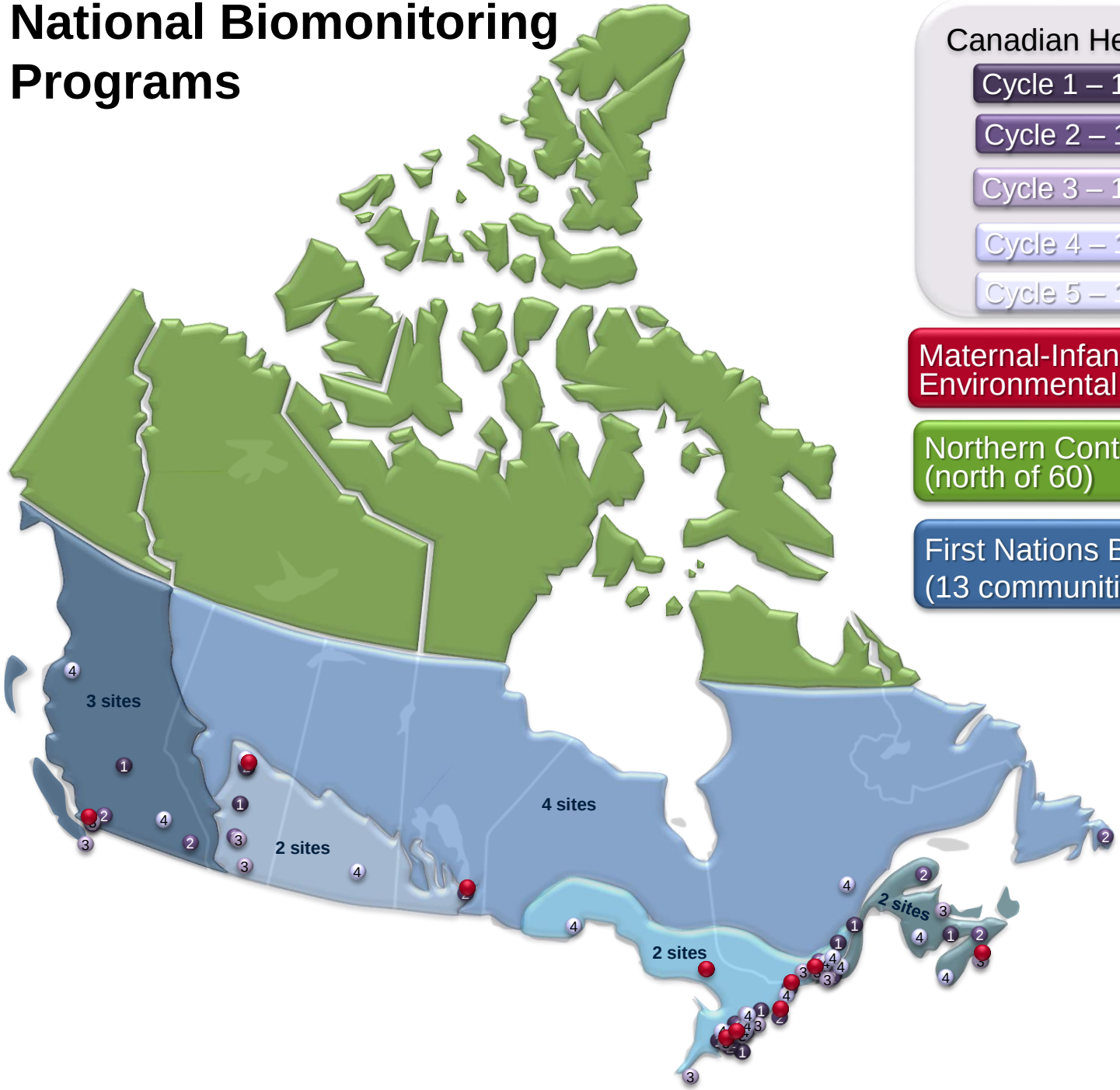
Chemicals Management Plan

In 2006, the Government of Canada launched the Chemicals Management Plan (CMP) to advance and improve the management of chemical substances and safeguard the health of Canadians

Health-Related Monitoring: Chemicals Management Plan



National Biomonitoring Programs



Canadian Health Measures Survey

- Cycle 1 – 15 sites (2007-2009)
- Cycle 2 – 18 sites (2009-2011)
- Cycle 3 – 16 sites (2012-2013)
- Cycle 4 – 16 sites (2014-2015)
- Cycle 5 – 16 sites (2016-2017)

Maternal-Infant Research on Environmental Chemicals (10 sites)

Northern Contaminants Program (north of 60)

First Nations Biomonitoring Initiative (13 communities from 5 eco-zones)

Canadian Health Measures Survey

CHMS – Overall Objectives

- **Explore** emerging public health issues and new measurement technologies
- **Establish** national baseline data on major health concerns
- **Determine** relationships among risk factors, protection practices and health status
- **Assess** the validity of self- and proxy-reported information
- **Assemble** a nationally representative sample for storage in a biobank

CHMS - Background

- Nationally-representative survey on the general health and lifestyles of Canadians to provide information on chronic and infectious disease, physical fitness, nutrition, and other factors that influence health – includes a biomonitoring component
    - Cross-sectional survey carried out in 2 year cycles
    - Age groups: 3-5, 6-11, 12-19, 20-39, 40-59, 60-79 years
    - Nationally representative of 96% of the Canadian population
    - 5,700 respondents per cycle
- Direct physical measurements
- Informed consent process
- Partnership with Statistics Canada, Health Canada, and the Public Health Agency of Canada

Direct physical measures

- Health information collected through self-report surveys or administrative records may be incomplete or inaccurate
  - Many variables cannot be assessed in the absence of direct physical measurements
  - Directly measured variables can be reported on continuous scales
  - Directly measures variables are more robust and objective
- Important health issues (metabolic syndrome, environmental chemicals, physical inactivity) cannot be monitored without direct measures

CHMS: One project, four components

- Household component – about 1¼ hours
- Mobile Examination Centre (MEC) component – about 2 ¼ to 3 hours
- Laboratory component – several external reference labs, one lab in the MEC
- Biobank component – storage for future health research of whole blood, plasma, serum, urine and DNA

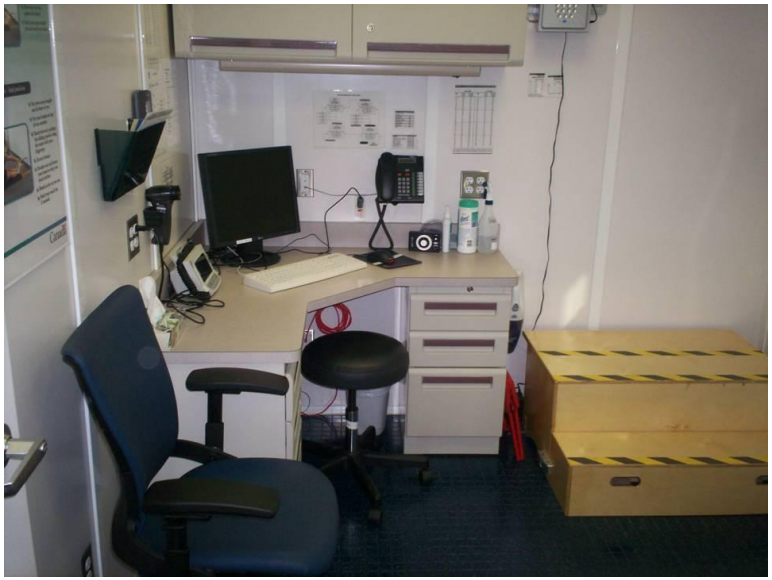
Benefits to respondents

- At end of the clinic visit, respondents receive the results of their physical tests
- Lab test results are sent to respondents about 6 to 7 months after the clinic visit (with prior consent)
- Early reporting protocols are in place for lab results beyond threshold values
- Respondents receive $100 to cover expenses for their participation (e.g., childcare, gas, transportation, parking fees)

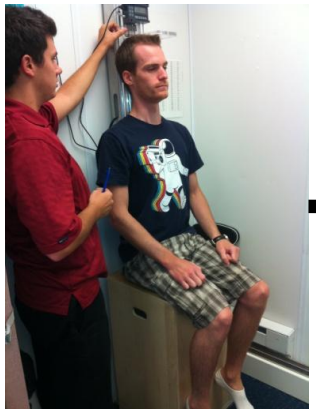
Haines, D.A. et al. (2011) *J Epidemiol Community Health*

Mobile Examination Centre (MEC)

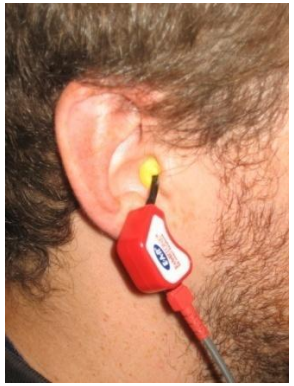
MEC (cont'd)



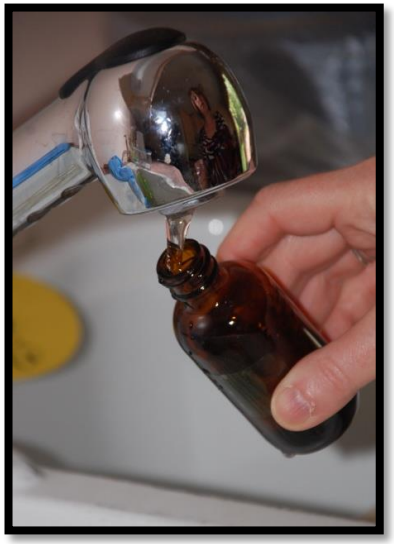
MEC experience








Measures taken at home



Questionnaire content

The questionnaire content should be considered with physical measures data, and covers the following topics:

- Health status
- Nutrition and food
- Medication use
- Health behaviours
- Environmental factors
- Socio-economic information

Physical measures (Cycles 3 & 4)

Anthropometry

- Standing height, sitting height, weight
- Waist and hip circumference

Cardiorespiratory fitness

- Resting blood pressure and heart rate
- Spirometry
- Fractional exhaled nitric oxide (FENO)

Muscular strength

- Hand grip strength

Hearing assessment

Skin pigmentation

Physical activity

- Accelerometer

Indoor air sampler

Tap water samples (taken from randomly selected households)

Blood Tests (Cycles 3 & 4)

General: Complete blood count (CBC), blood chemistry panel

Allergies

Cardiovascular health:

C-reactive protein (high sensitivity), HDL, LDL, total cholesterol and triglycerides and fatty acids

Diabetes: Fasting, non-fasting and random glucose, fasting insulin and $HbA1_c$

Environmental exposure: Metals (cadmium, lead and mercury [total and methyl]), acrylamide and volatile organic compounds (VOCs)

Infectious diseases: Hepatitis B and C

Nutritional status: Ferritin, red blood cell folate, vitamin B12, vitamin C and vitamin D

Reproductive hormones

Thyroid status

Urine Tests (Cycles 3 & 4)

- **Environmental exposure:** Metals (speciated arsenic, fluoride, inorganic mercury), benzene metabolites, bisphenol A, organophosphate insecticides, polyaromatic hydrocarbons (PAHs), parabens, cotinine, and triclosan
- **Kidney function:** Creatinine and microalbumin
- **Nutritional status:** Iodine

CHMS: Biomonitoring Component

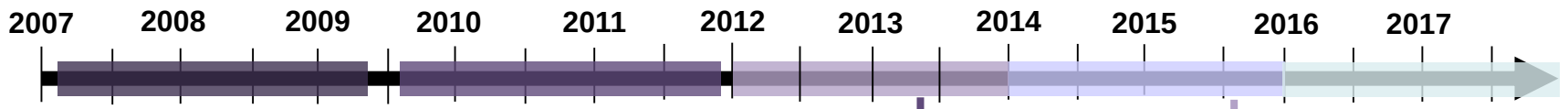
CHMS Biomonitoring Component – Objectives

- Establish national data for a range of environmental chemicals in Canadians

- Provide baseline data for tracking trends over time and to allow for comparisons with sub-populations in Canada and with other countries

- Provide data to explore relationships between environmental chemicals and other measures (e.g. blood pressure, nutrition)

CHMS Biomonitoring Milestones



Cycle 1
Mar 2007 – Feb 2009
15 sites
6-79 years (n = 5,600)
92 chemicals

Cycle 1 biomonitoring report (August 2010)

Cycle 2
Aug 2009 – Nov 2011
18 sites
3-79 years (n = 6,400)
91 chemicals

Cycle 2 biomonitoring report (April 2013)

Cycle 3
Jan 2012 – Dec 2013
16 sites
3-79 years (n = 5,700)
104 chemicals

Cycle 3 biomonitoring report (July 2015)

Cycle 4
Jan 2014 – Dec 2015
16 sites
3-79 years (n = 5,700)
same chemicals as Cycle 3

Cycle 5
Jan 2016 – Dec 2017
16 sites
3-79 years (n = 5,700)
~115 chemicals

Selection of CHMS Biomonitoring Chemicals

Based on

- Health Canada program priorities
- Expert workshop (2003) and national stakeholder consultations (2008 & 2015)

Criteria

- Public health considerations (known or suspected health risk or effects, need for public health action, public concern)
- Regulatory needs (risk assessment and management)
- Evidence of population exposures or sources of exposure
- Feasibility of field collection of biospecimens / respondent burden
- Availability and efficiency of laboratory analytical methods
- Consistency with other surveys
- International commitments (e.g., Stockholm Convention on POPs)
- Cost

CHMS Biomonitoring Chemicals

CYCLE 1	CYCLE 2	CYCLES 3 & 4
		Parabens
		VOCs
		Acrylamide
		Dioxins/Furans
	Benzene Metabolites	
	PAHs	
Flame Retardants		Flame Retardants
PCBs		PCBs
Organochlorines & POPs		Organochlorines & POPs
Chlorophenols		
Phthalates		
Perfluoroalkyl Substances		
Smoking Status		
Pesticides		
Environmental Phenols		
Metals & Trace Elements		

CHMS Environmental Monitoring

CYCLE 2

CYCLE 3

CYCLE 4

Indoor Air Analysis:

- Trihalomethanes
- Benzene, Toluene, Ethylbenzene, Xylenes
- Siloxanes
- Other Volatile Organic Compounds

Tap Water Analysis:

- Trihalomethanes
- Benzene, Toluene, Ethylbenzene, Xylene
- Fluoride

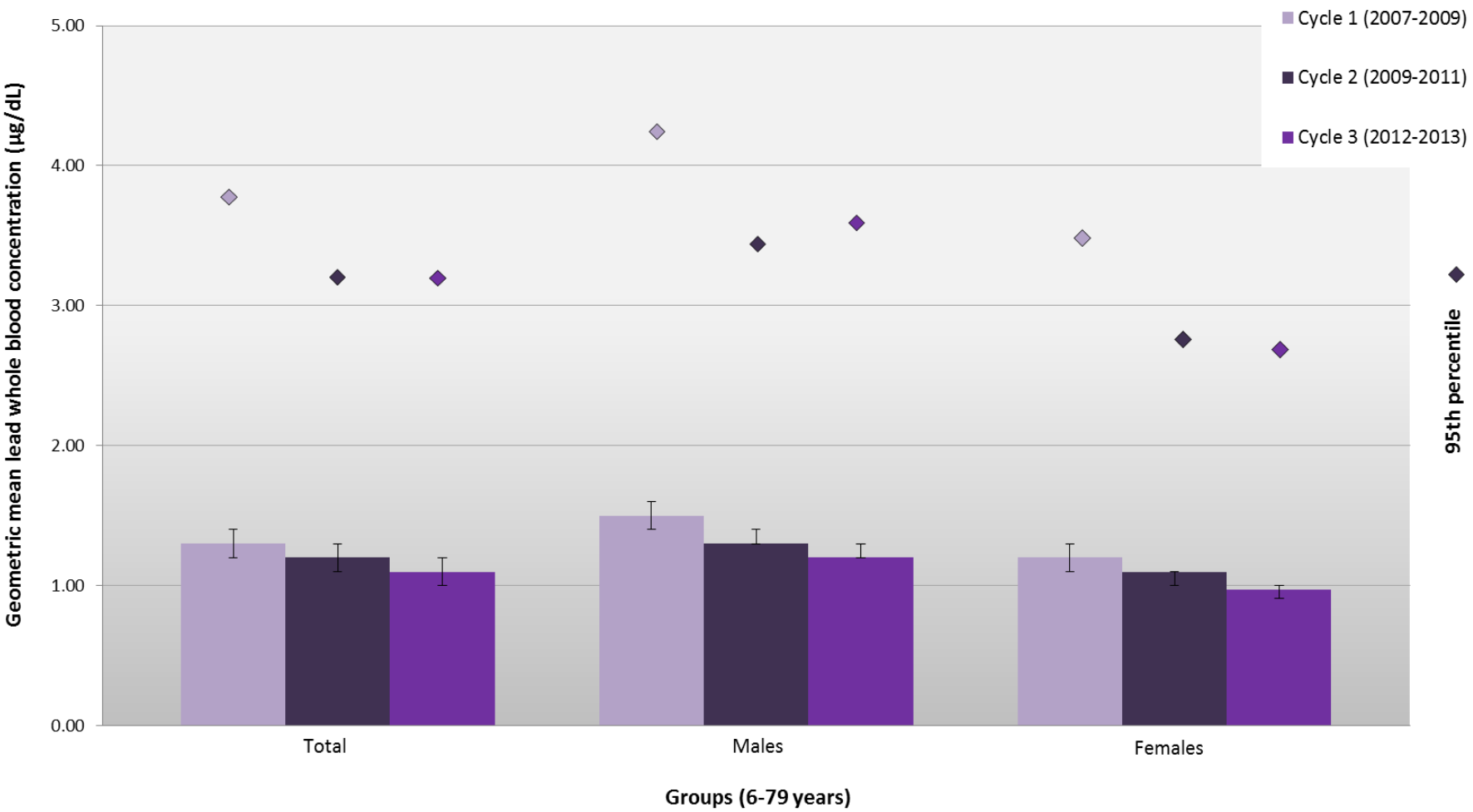
CHMS Cycle 3 Biomonitoring Component: Results

Cycle 3 Results - Highlights

- Overall, Canadian levels are within similar ranges as those previously reported in Canada (2007-2009 and 2009-2011) and internationally

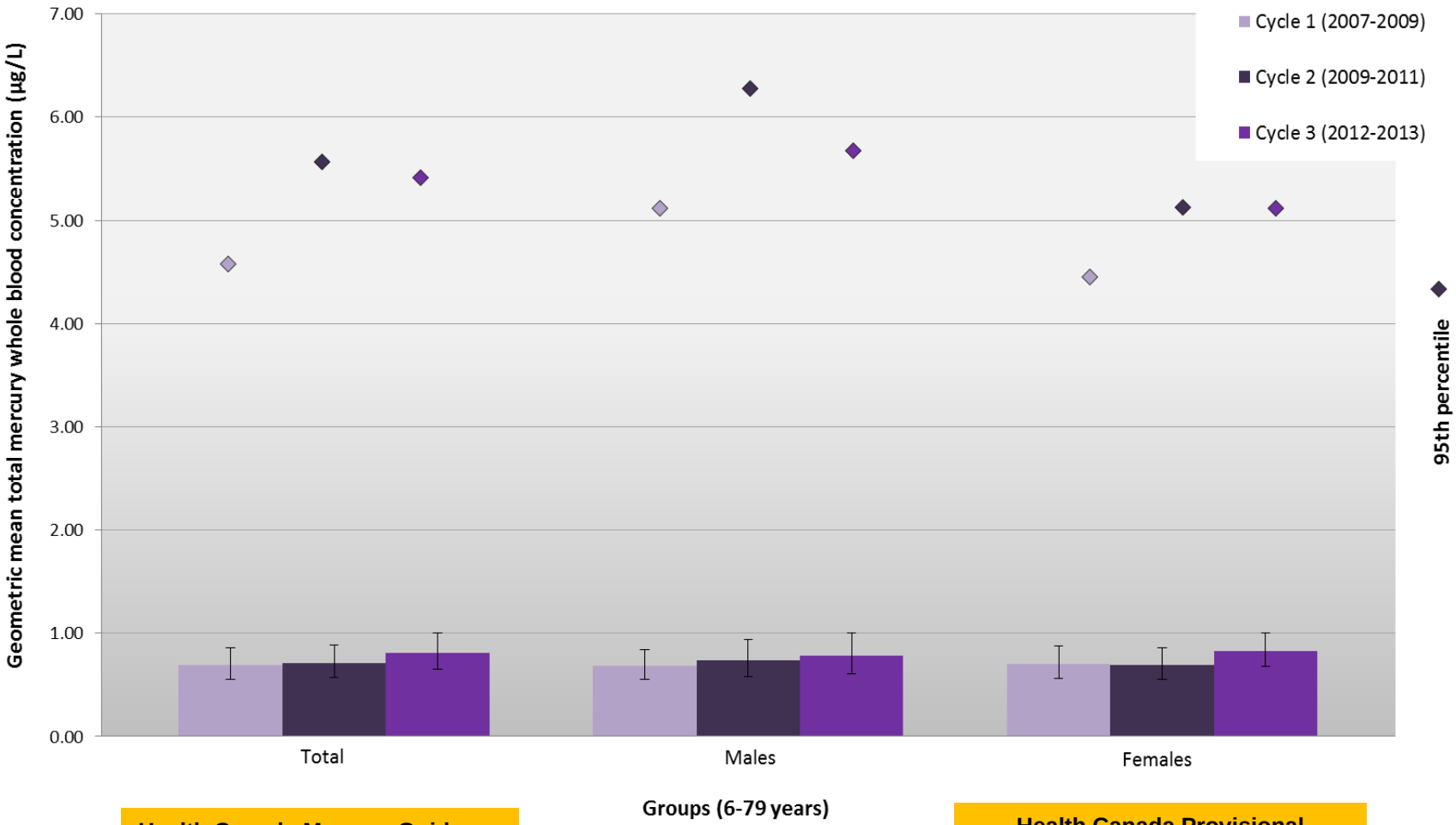
- For population comparisons, further analysis needs to take into account:
    - differences in the populations sampled
    - years that the surveys were undertaken
    - the specific biological tissues measured (e.g. plasma vs. serum)
    - the laboratory analytical methods used
    - how results were reported (e.g. age groupings)

Lead in Blood - Cycles 1-3



Health Canada Blood Lead Guidance Value – 10 µg/dL

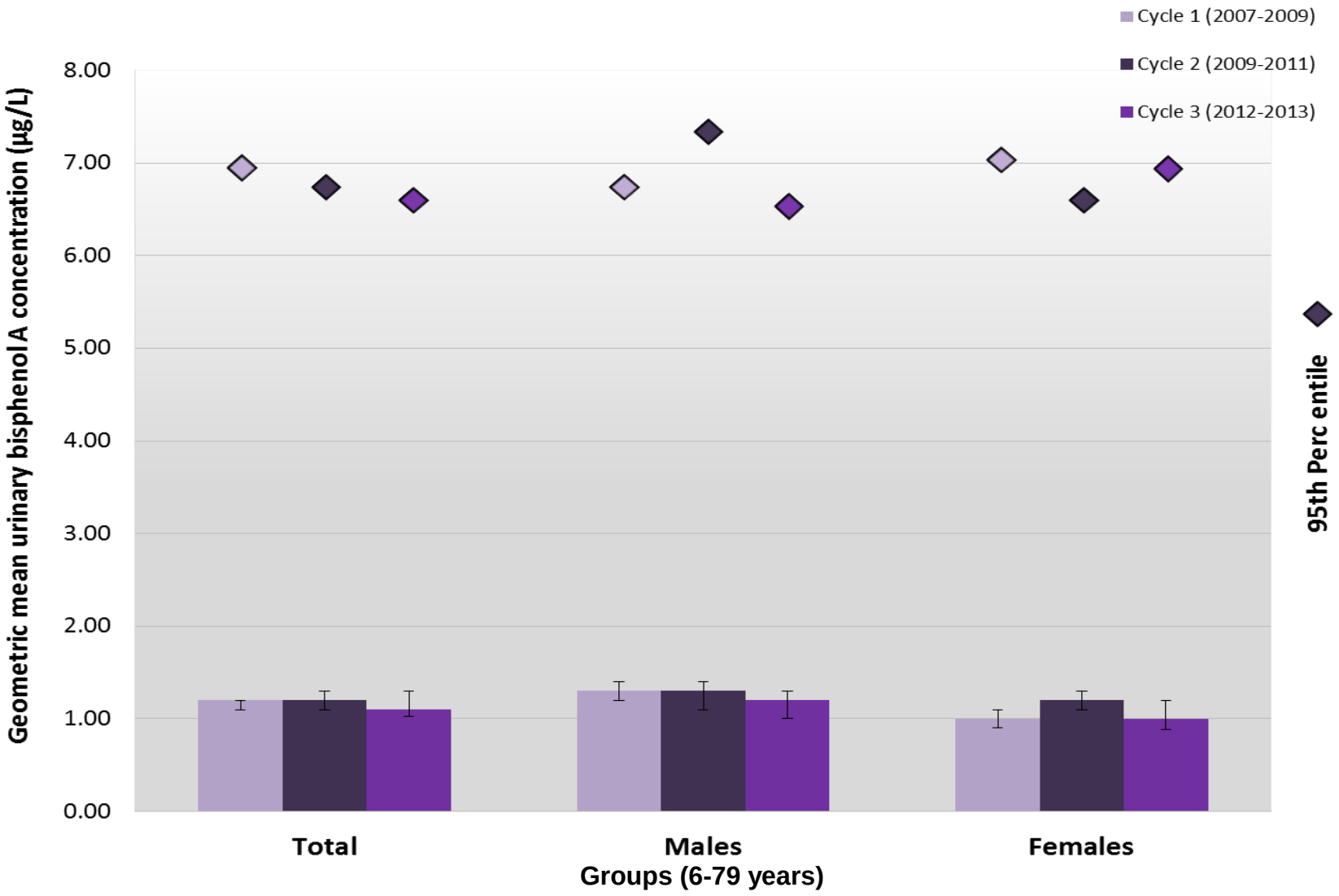
Mercury in Blood - Cycles 1-3



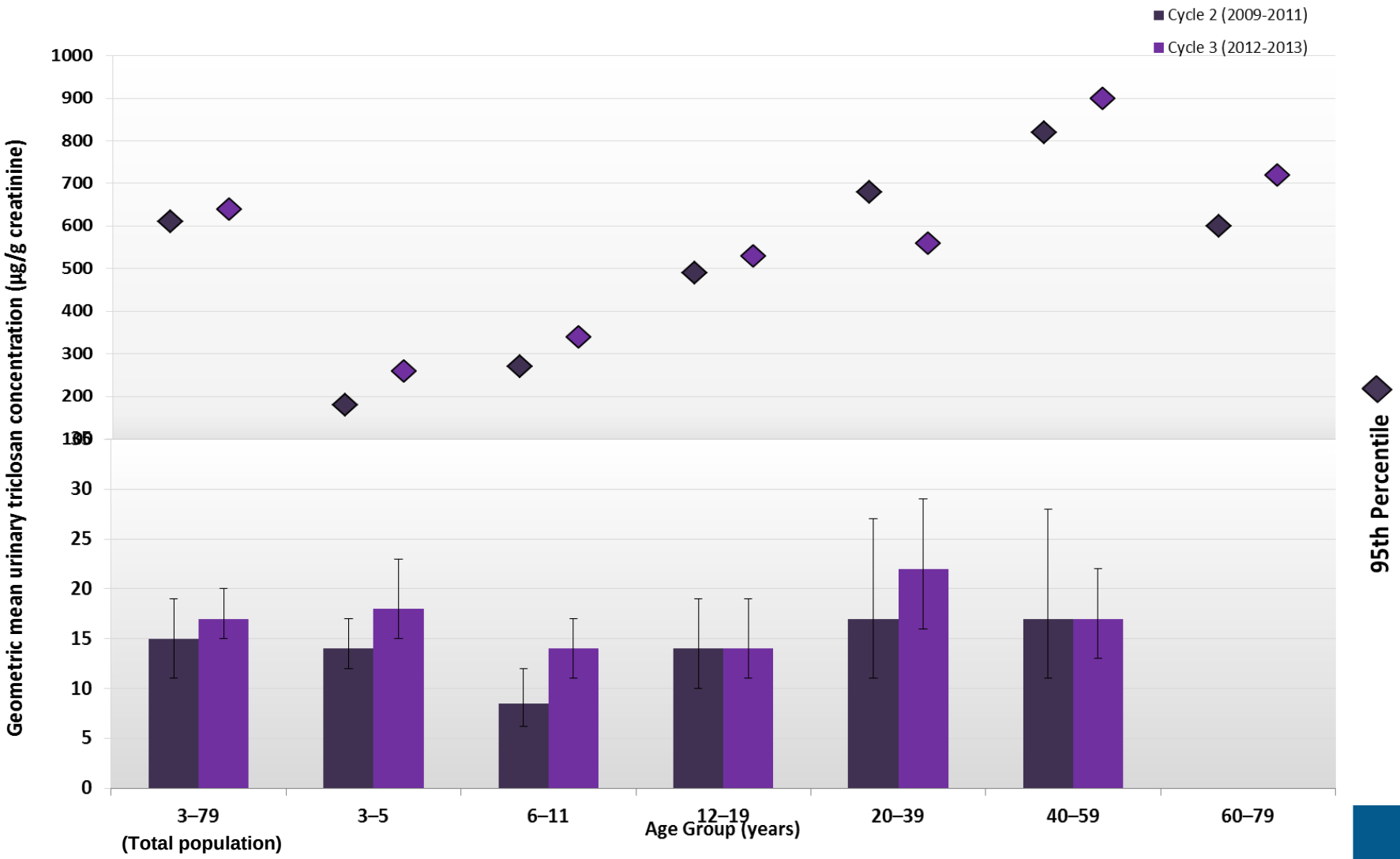
Health Canada Mercury Guidance Value (Adult Males, Women >50 years) – 20 µg/L

Health Canada Provisional Mercury Guidance Value (Pregnant Women, Women of Child-Bearing Age, Children) – 8 µg/L

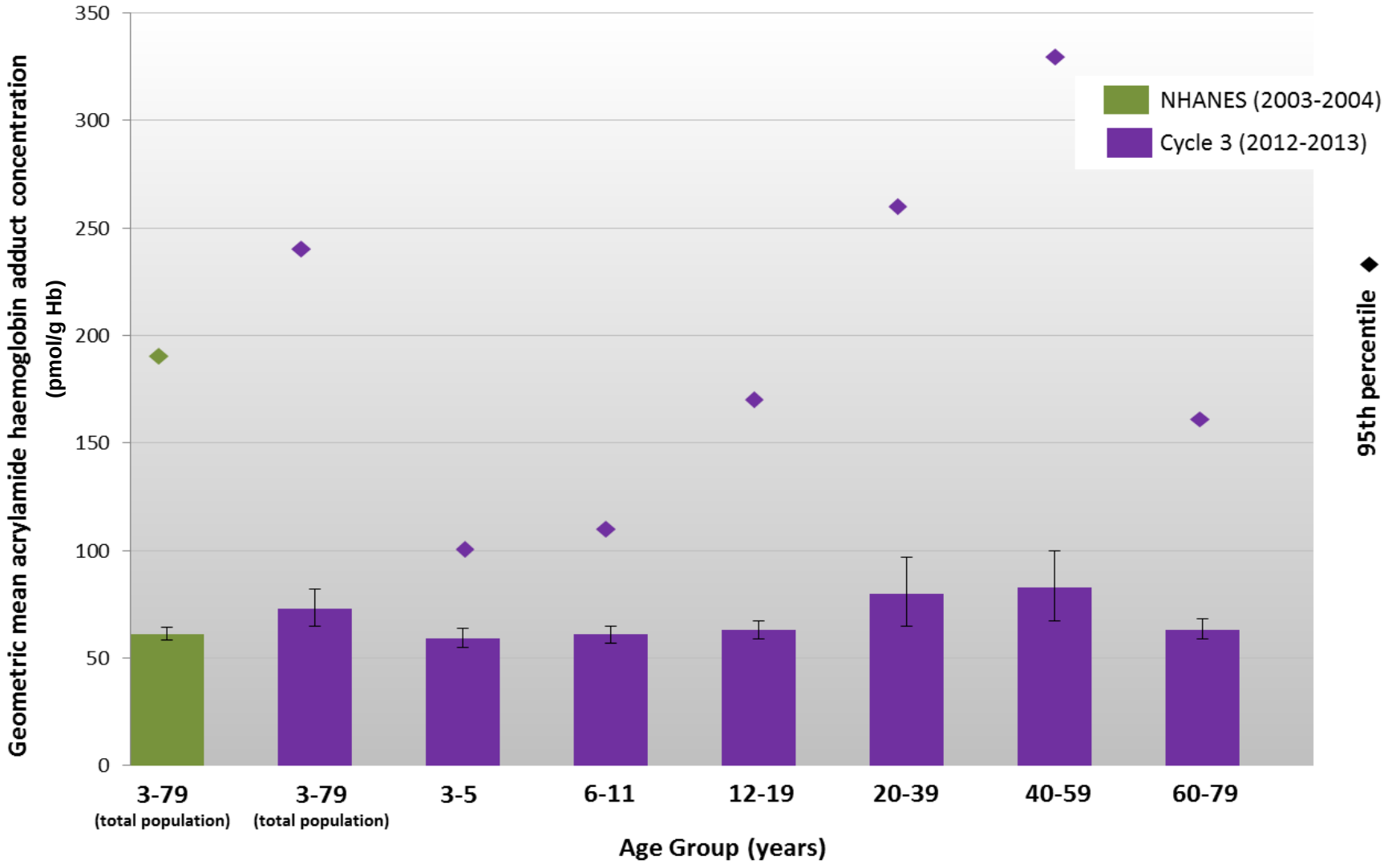
BPA in Urine – Cycles 1-3



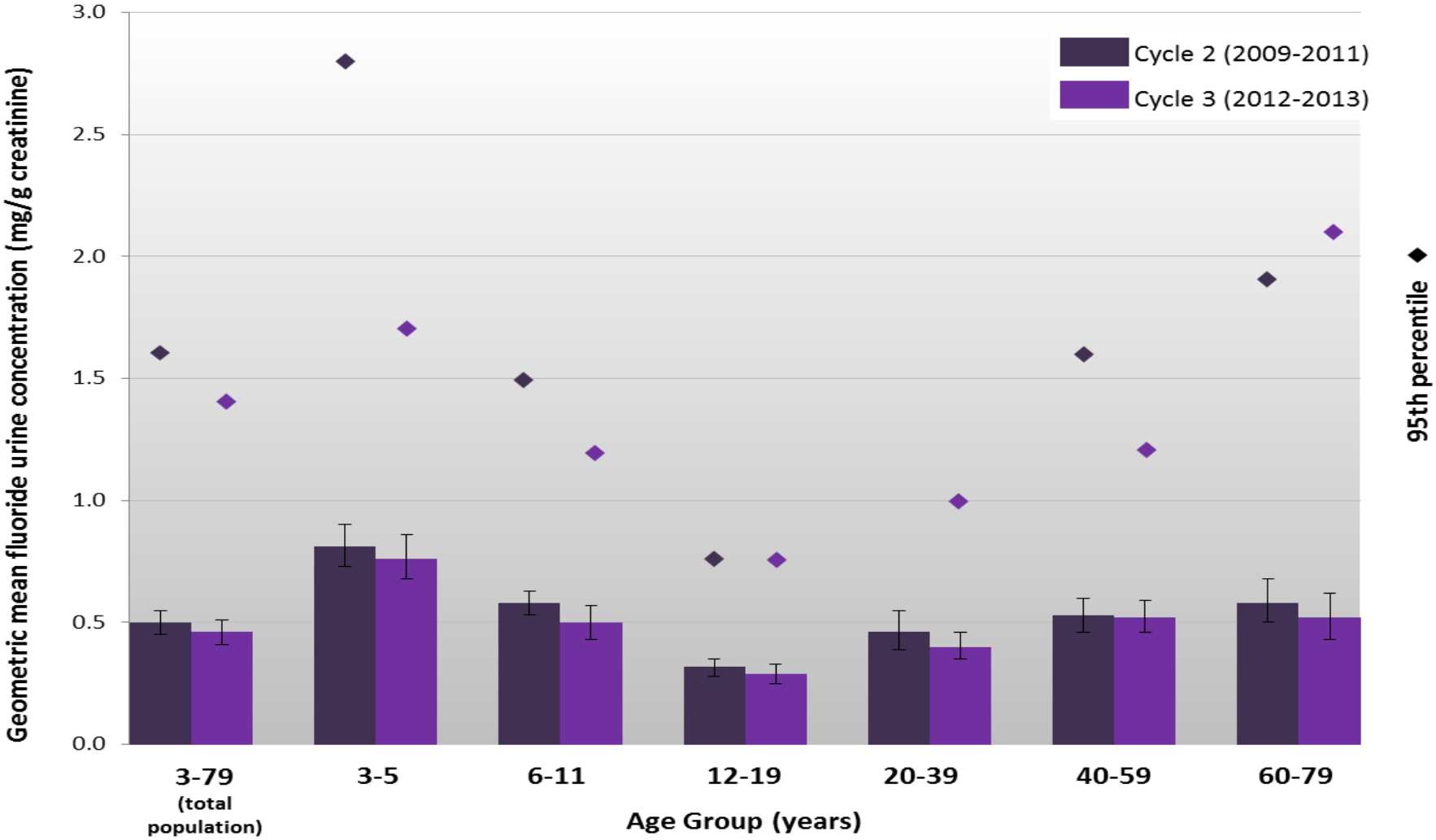
Triclosan in Urine – Cycles 2 & 3



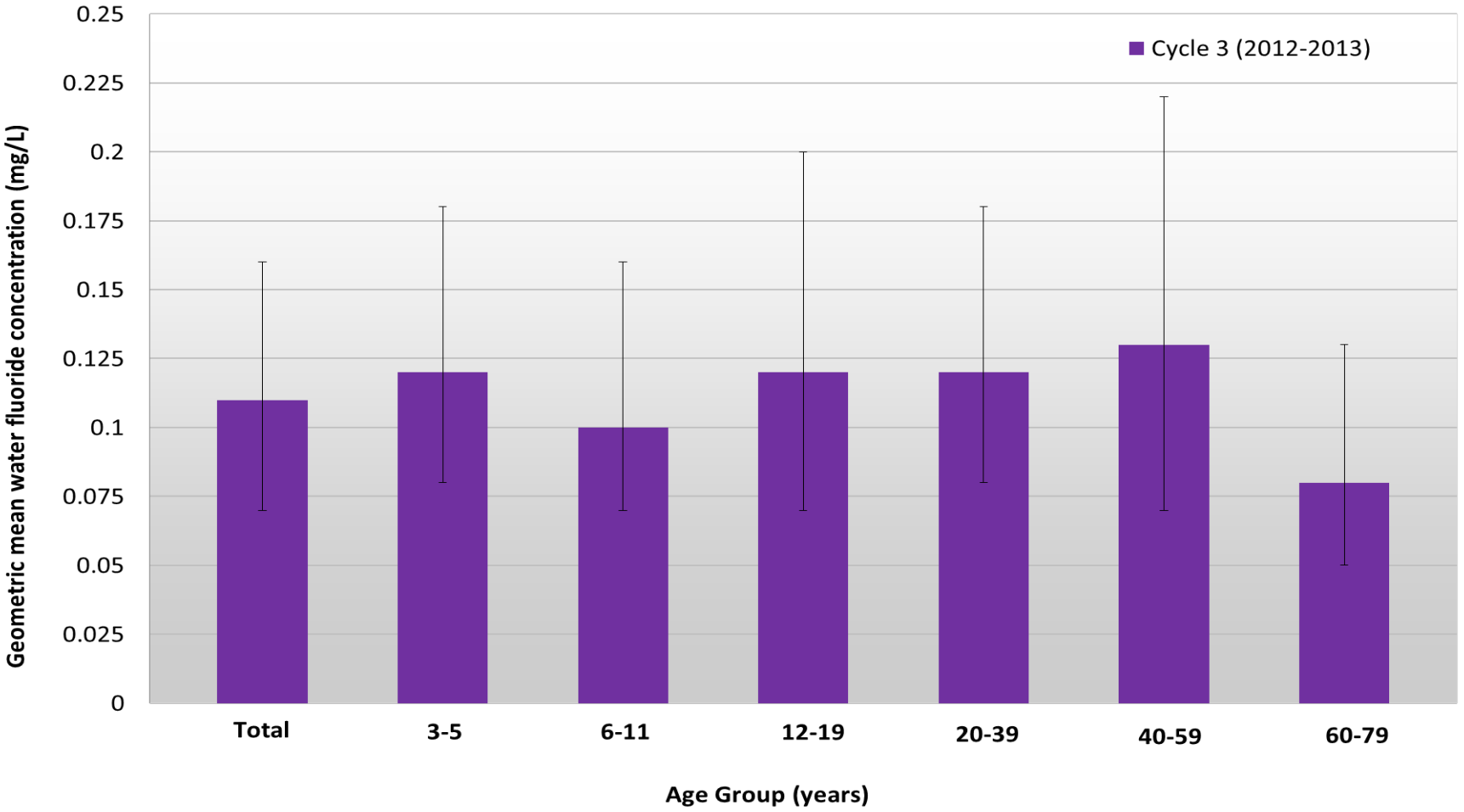
Acrylamide Adduct in Blood – Cycle 3



Fluoride in Urine – Cycles 2 & 3

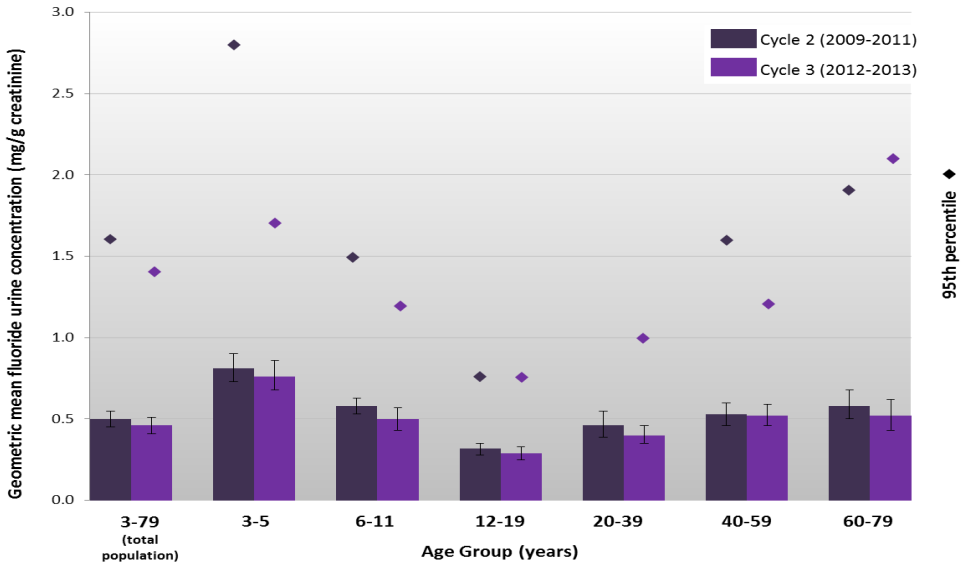


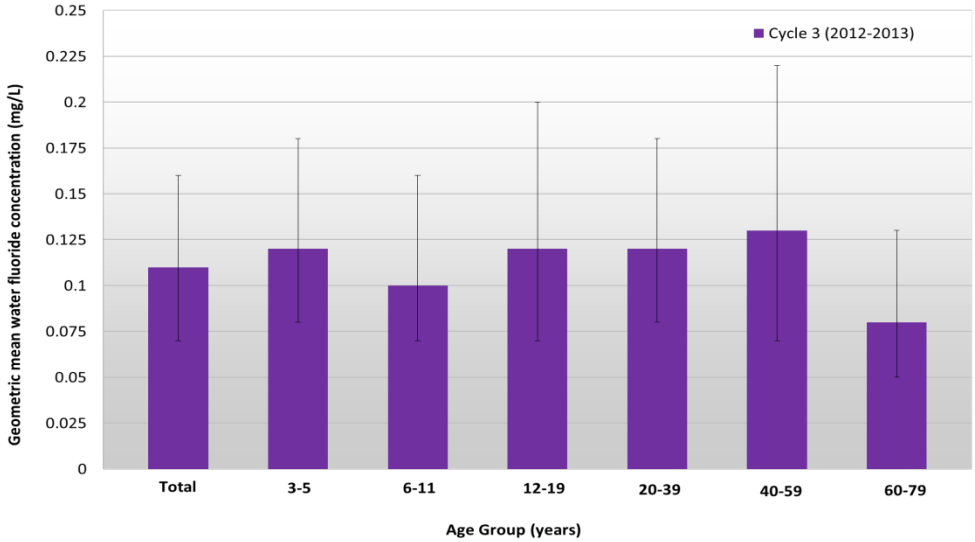
Fluoride in Water – Cycle 3



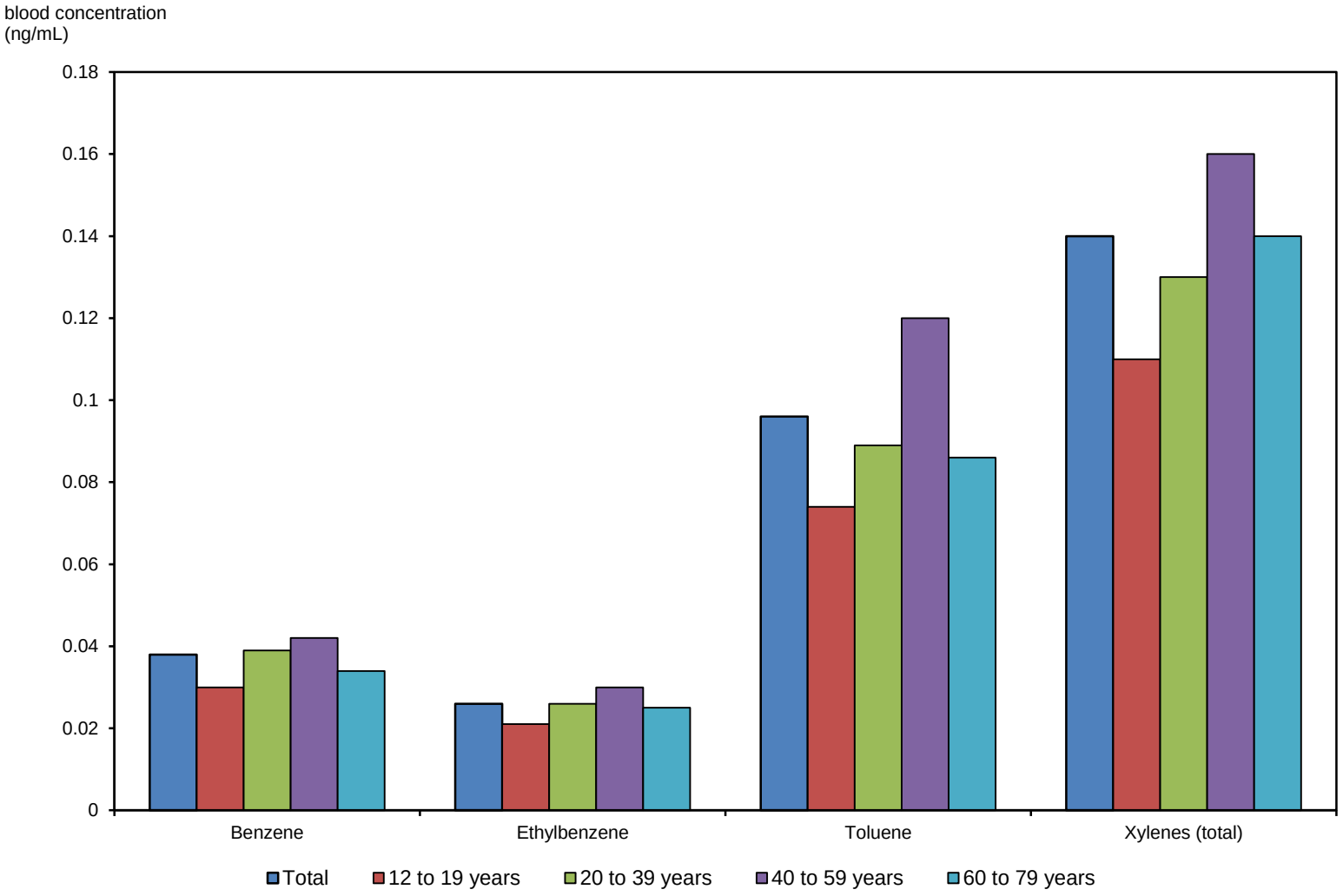
Health Canada Maximum Acceptable Concentration (MAC) for Fluoride in Drinking Water – 1.5 mg/L

Fluoride: Urine vs. Water

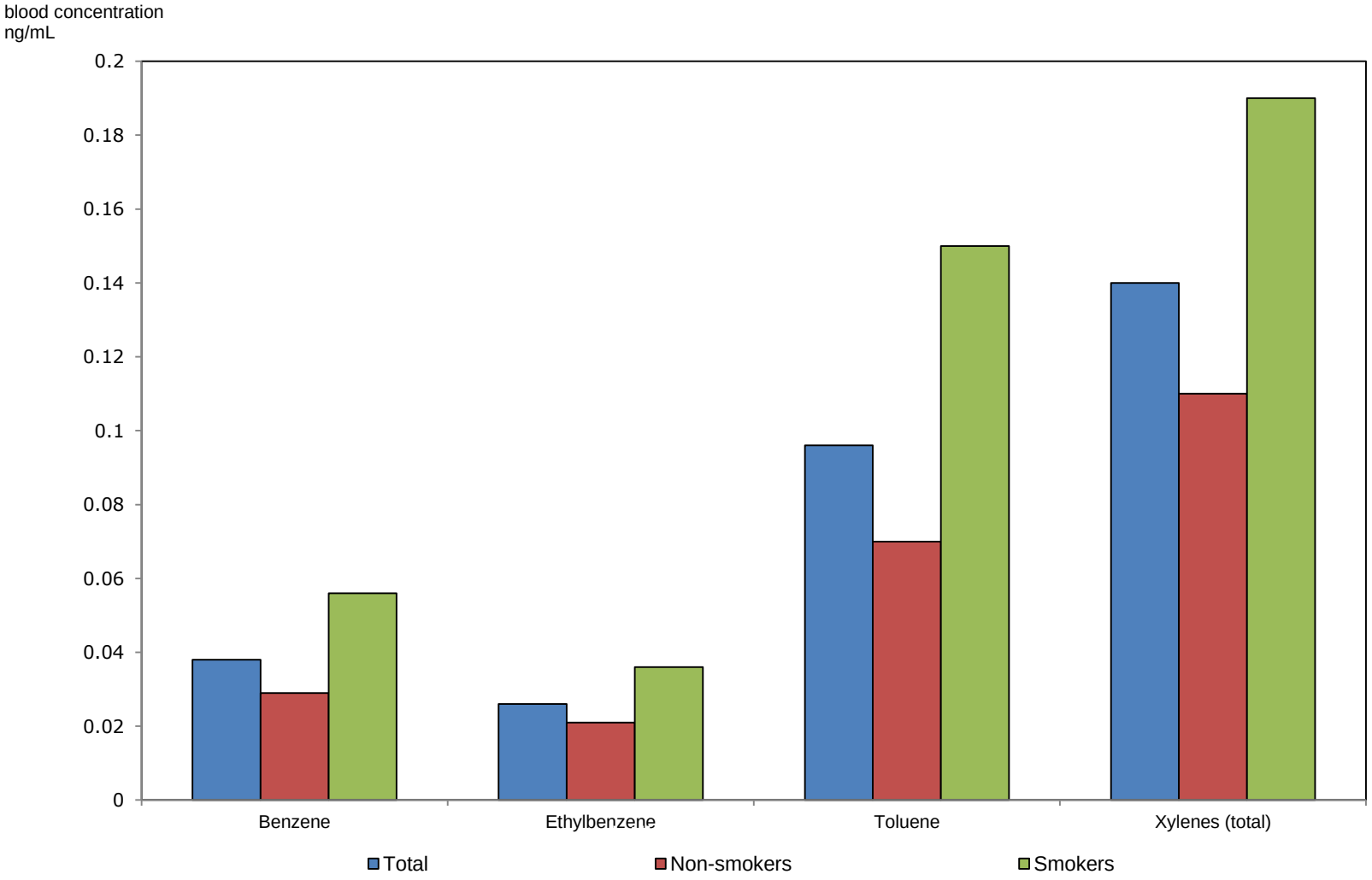




BTEX in Blood – Cycle 3



BTEX by Smoking Status – Cycle 3



Trihalomethanes (Disinfection By-Products)

Trihalomethane	Percentage of Canadians with blood levels below detectable limits	Percentage of households with tap water levels below detectable limits	Average concentration in household tap water (µg/L)
Chloroform	80	18	5.1
Bromoform	94	65	n/a
Dibromochloromethane	97	26	0.46
Bromodichloromethane	98	19	1.6

Parabens & Organophosphate Metabolites

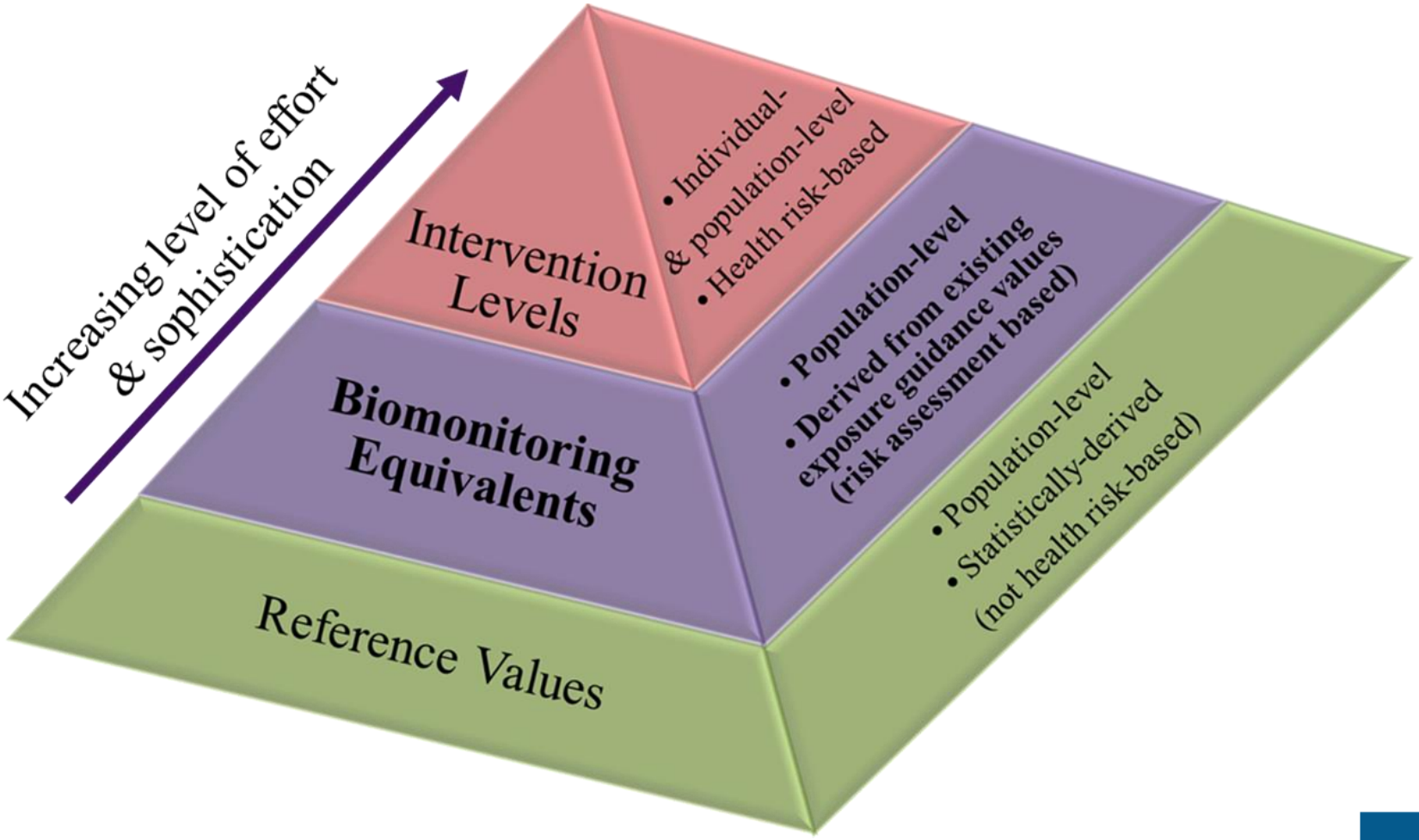
- Parabens (methyl, ethyl, propyl, and butyl) and specific organophosphate (OP) metabolites (3,5,6-TCP and malathion dicarboxylic acid) were included in cycles 3 and 4
- ALS laboratory performed the analysis for cycle 3; CTQ took over analysis of OPs for cycle 4; Health Canada regional lab took over analysis of parabens for cycle 4
- Crossover studies were performed to verify consistency between the two labs
- The release of these data has been delayed pending further verification

Pooled Serum

- PCBs, organochlorines, dioxins, furans, and PBDEs were measured in pooled serum samples
- Pooled serum was used to maximize the sample volume and allow for high-resolution analysis
- Results from cycle 3 pooled serum analysis will be released with cycle 4 results (~Fall 2017)

Uses and Interpretation of Biomonitoring Data

HBM Values: Tools for Interpretation



Reference Values

- Similar to reference values used in Germany
- Allow for comparison of the exposure of individuals or population groups with the background exposure
- Statistically derived (i.e., 95th percentile)
- Not based on adverse health effects
- Reference values based on CHMS cycle 1 data are currently being calculated
- Can be re-calculated as more data become available (e.g., additional cycles of CHMS)

Intervention Levels

- Also known as tissue-based guidance values
- Health Canada intervention levels only exist for lead and mercury
- Blood lead intervention level is currently under review
- Intervention levels for additional substances are currently being considered

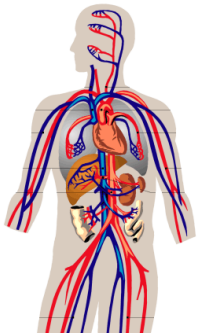
Biomonitoring Equivalents

“Safe” human dose
RfD, TDI: mg/kg-d

Uncertainty Factors

Human (equivalent)
Point of Departure
POD: mg/kg-d

Human Pharmacokinetics



BE - Concentration of biomarker that is consistent with existing exposure guidance or reference values such as RfDs, TDIs, etc.

Human urine/blood level
BE: µg/L

Uncertainty Factors

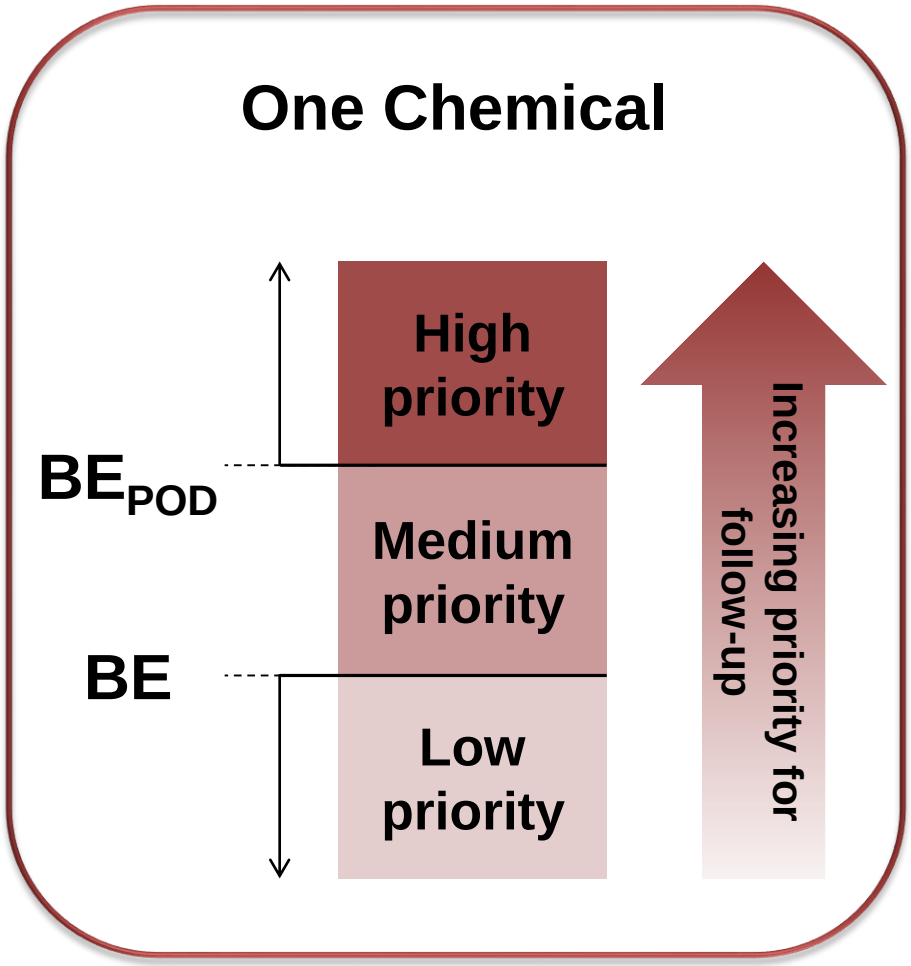
Human urine/blood level
BE_{POD}: µg/L

BEs Developed

Group	# BE values	Environmental Chemical	# of analytes	Reference
Acrylamide	4	Acrylamide	4	Hays and Aylward 2008
Dioxins and furans	1	Dioxin TEQ	29	Aylward et al. 2008c
Environmental phenols	2	Bisphenol A *	1	Krishnan et al. 2010a
		Triclosan *	1	Krishnan et al. 2010b
Flame retardants	2	Hexabromocyclododecane[1]	1	Aylward and Hays 2011
		PBDE-99 *	1	Krishnan et al. 2011
Metals and trace elements	5	Arsenic *	3	Hays et al. 2010
		Fluoride *	1	In development
		Selenium *	1	Hays et al. 2014
		Uranium *	1	In development
		Cadmium	1	Hays et al. 2008b
Organochlorine compounds	2	DDT/DDE *	2	Kirman et al. 2011
		Hexachlorobenzene *	1	Aylward et al. 2010a
Pesticides	4	Cyfluthrin *	1	Hays et al. 2009
		Deltamethrin *	1	Aylward et al. 2011
		3-Phenoxybenzoic acid[1] *	1	In development
		2,4-Dichlorophenoxyacetic acid (2-4D)	1	Aylward and Hays 2008
Phthalates	8	Di-2(ethylhexyl) phthalate *	4	Aylward et al. 2009b
		Diisononyl phthalate *	3	Hays et al. 2011
		Dibutyl phthalate *	1	Aylward et al. 2009a
		Diethyl phthalate *	1	Aylward et al. 2009a
		Benzyl butyl phthalate *	1	Aylward et al. 2009a
		Diisobutyl phthalate *	1	In development
		Diisodecyl phthalate[1] *	1	In development
		Dicyclohexyl phthalate[1] *	1	In development
Volatile organic compounds (VOCs)	38	Toluene	1	Aylward et al. 2008a
		Trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane	4	Aylward et al. 2008b
		Other VOCs	33	Aylward et al. 2010c
	67		102	

* BEs derived with support from Health Canada

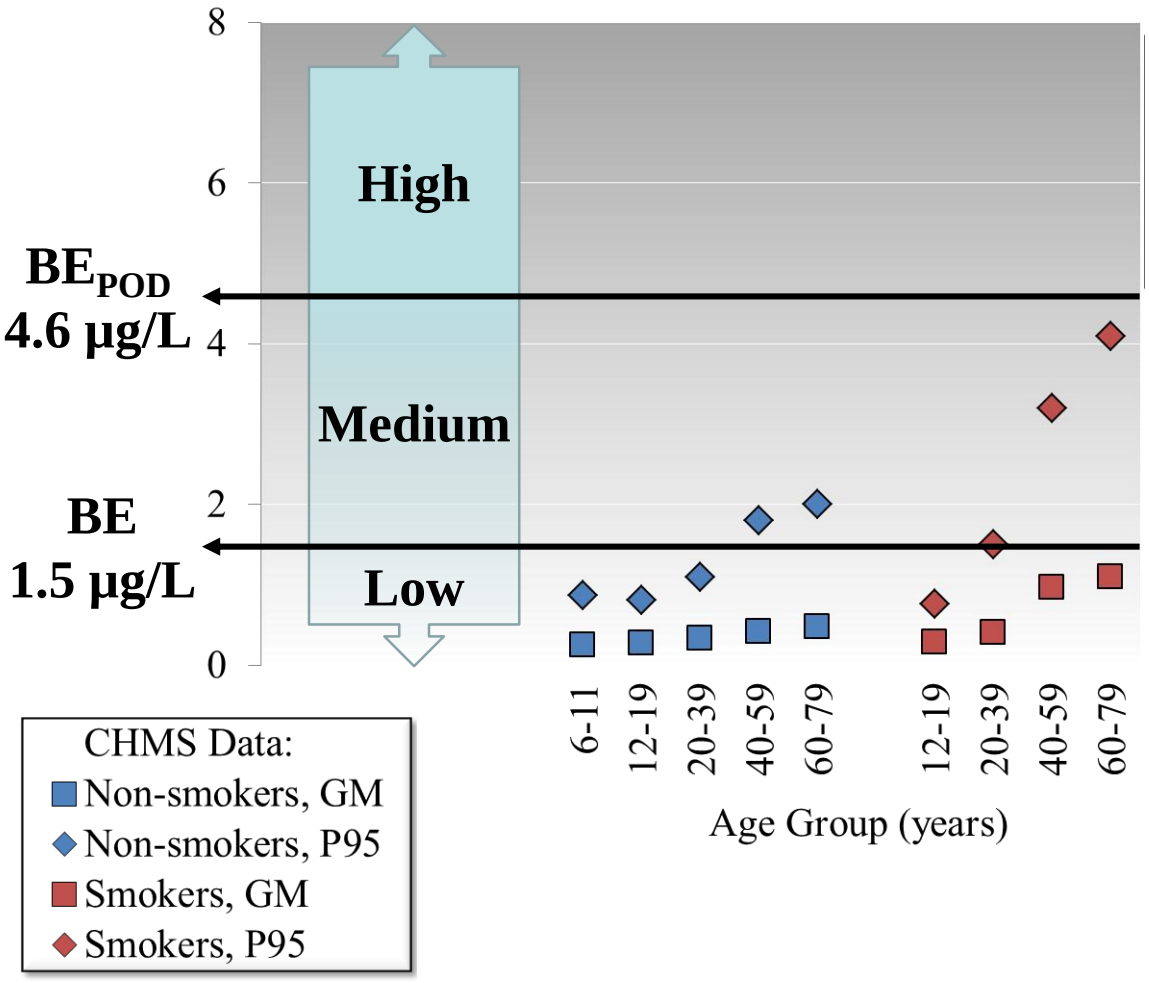
Interpretation of Biomonitoring Data using BEs



Source: LaKind et al., 2008

CADMIUM

➢ Assess exposure in a public health risk context – Use of BEs



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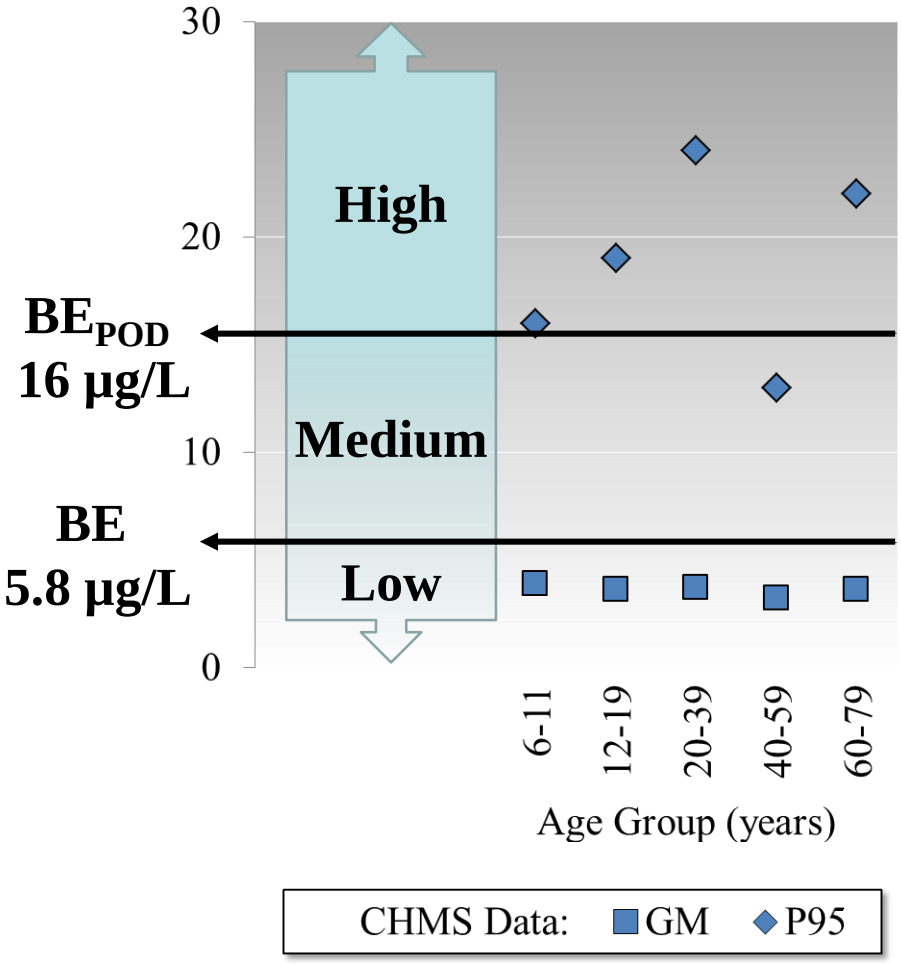


Selected Uses of Biomonitoring Data

Inform Risk Assessment

- Screening Assessment Report on Perfluorooctanoic Acid (PFOA), its Salts and its Precursors
- Screening Assessment Report on Selenium (pending)
- Screening Assessment on Cobalt and Cobalt-Containing Substances
- Assessment Report on Triclosan
- Human Health State of the Science Report on Lead
- Human Health State of the Science Report on Decabromodiphenyl Ether (decaBDE)

Inform Risk Management

- Risk Management Scope for Triclosan
- Proposed Risk Management Approach for BPA
- Risk Management Strategy for Lead
- Performance Measurement Plans for Mercury and Its Compounds, Polybrominated Diphenyl Ethers (PBDEs), and BPA

Selected Uses of Biomonitoring Data

Inform Public Health

- Nunavik Public Health Authority - public health advice for pregnant women and women of childbearing age to decrease beluga consumption in order to decrease their mercury exposure
- Regional Health Authority recommendations for the Inuit population concerning nutrients and environmental contaminants
- Fish advisory messages in the 2011/2012 NWT Sport Fishing Guide

National Reporting

- Federal Sustainable Development Strategy
- Canadian Environmental Sustainability Indicators

Contribute to International Agreements and Programs

- UNEP Stockholm Convention on Persistent Organic Pollutants
- Arctic Monitoring and Assessment Programme (AMAP)
- Minimata Mercury Convention – Canadian Mercury Science Assessment
- North American Commission for Environmental Cooperation

Future of Biomonitoring in CHMS

Increasing the Use of Biomonitoring Data

What are we doing in the Chemicals Surveillance Division?

- Drafted a data analysis strategy
- Developing communication materials to explain the data access process
- Collaborating with external researchers to draft journal articles
- Consulting with stakeholders and researchers to determine data analysis needs

55

Cycle 5/6 – New Chemicals

- Hexavalent Chromium
- Ethylene Thiourea (ETU)
- Ortho-Phenylphenol
- Boron
- Alternate plasticizers (e.g., DINCH, TXIB)
- Additional phthalate metabolites (e.g. 3OH-MBP, MECPP)
- Pyrethroid metabolites (re-introduced)
- Additional volatile organic compounds (VOCs)

56

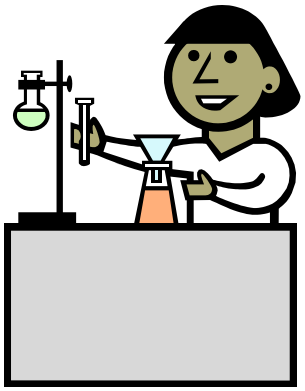
Cycles 5/6 – New Content

- Neighbourhood environment
- Sleep apnea
- Vision
- pQCT and mechanography
- Toxoplasmosis
- Hair (metals)
- Saliva (DNA)
- E-cigarette use

Cycle 7/8 – New Content Consultation Process

- Consultation for new chemical substances and/or content related to chemical substances (e.g., questions pertaining to chemical use/exposure)
- Similar to consultation for cycle 2, carried out in 2008
- On-line questionnaire
- Sent to departmental stakeholders, FPT partners, and external stakeholders
- New content needs to be identified by June 2016 to allow time for method development, validation, etc.

Biomonitoring in the CHMS - Challenges



- Aligning with risk assessment and risk management priorities

- Development of more sensitive/precise analytical methods

- Logistics of working from a mobile clinic

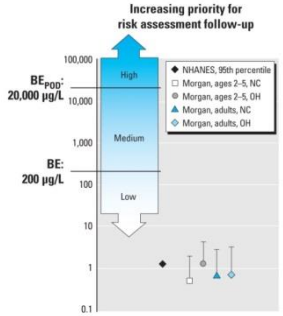
- Including children younger than 3 years

Biomonitoring in the CHMS - Opportunities

•Using different sample collection methods

•Including new chemical substances

•Regional analysis by combining cycles



•Development of new tools for the interpretation of biomonitoring data

Biomonitoring in the CHMS - Opportunities

- Forming partnerships & networks
  - Work with German Biomonitoring Commission
  - Development of international biomonitoring network (led by U.S.)
  - Collaboration with CDC/NHANES on development of new analytical methods
  - Consultation with stakeholders to identify new areas of research

Umwelt Bundesamt

For More Information

Health Canada:

www.healthcanada.gc.ca/biomonitoring

Statistics Canada:

CHMS (info about survey):
www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5071

The Daily (recent CHMS data releases):
www.statcan.gc.ca/dai-quo/index-eng.htm?HPA

Research Data Centres (access to data):
www.rdc-cdr.ca

Questions? ellen.lye@hc-sc.gc.ca