



# Human biomonitoring of environmental chemicals: current uses and future directions

National Collaborating Centre for Environmental Health  
Webinar

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Environmental Health Science and Research Bureau

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## WHY ARE WE HERE?



CONTEXT

**WHAT IS HUMAN  
BIOMONITORING?**



PRESENT

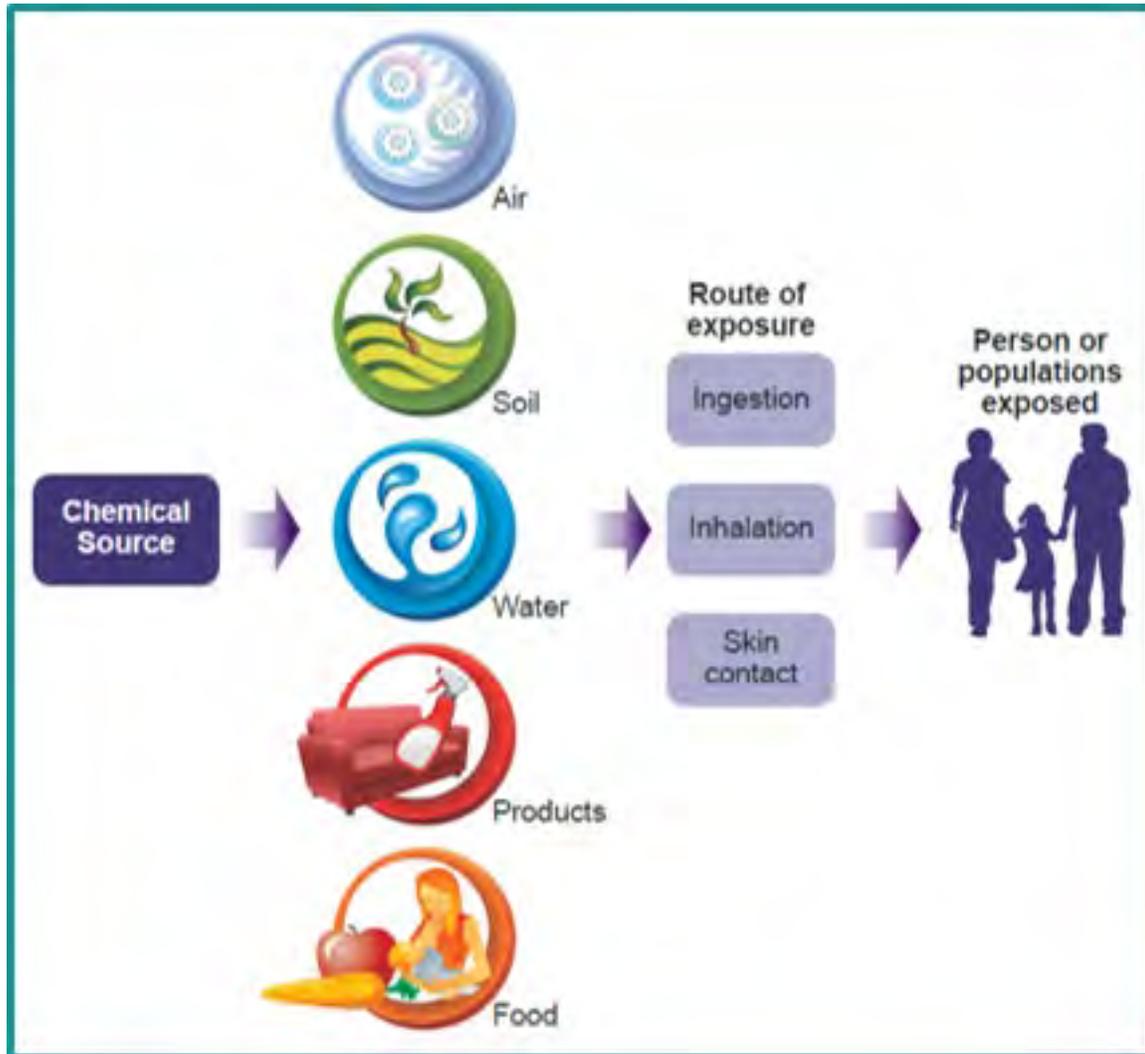
**HOW CAN YOU USE  
THE DATA?**



FUTURE

**WHAT MORE CAN  
BE DONE IN THE  
FUTURE?**

# WHAT IS HUMAN BIOMONITORING?

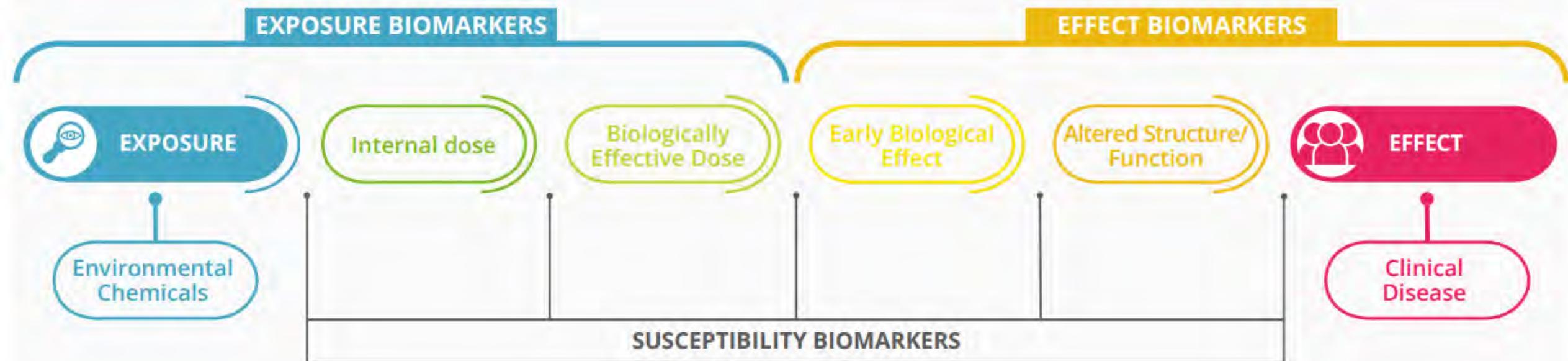


- Human exposure to chemicals can be:
  - *Indirectly estimated* by measuring levels in the environment, food, water or products, or
  - *Directly measured* in people (**biomonitoring**)
- Biomonitoring:
  - Measurement of levels of chemicals and their metabolites in human populations
  - Provides a measure of exposure from all sources and routes
  - Commonly uses samples of blood, urine, human milk, hair and other tissues

# BIOMARKERS: EXPOSURE & EFFECT

Chemicals, or their metabolites, measured in a person

Biochemical, physiological, behavioural or other alteration measured in a person that is associated with a health impairment or disease



# WHAT KIND OF DATA DO WE HAVE IN CANADA?

## General population: CHMS

6

### CYCLES OF DATA

- 1: 2007-2009
- 2: 2009-2011
- 3: 2012-2013
- 4: 2014-2015
- 5: 2016-2017
- 6: 2018-2019

### PARTICIPANTS

- Aged 3 to 79 years

35,000+

90+

### COLLECTION SITES

- 5 regions across Canada (BC, AB, Prairies, ON, QC, Atlantic)

### ENVIRONMENTAL CHEMICALS

- Metals and trace elements
- Pesticides
- Self-care and consumer product chemicals

250+



### TREND ANALYSIS

- Cadmium declined by 26%
- Lead declined by 38%
- various PFAS declined by 36 to 67%
- BPA declined by 43%

## Pregnant people & children: MIREC

10+

### YEARS OF DATA

- MIREC
- MIREC-ID
- MIREC-CD PLUS
- MIREC ENDO

### BIOSPECIMENS

- Stored in biobank

30,000+

6000+

### VARIABLES

- Collected via questionnaire

### BIOMARKERS

- Chemical exposures
- Nutritional status
- Health effects

300+



### LIFESTAGES

- Fetal development
- Infancy
- Childhood
- Adolescence
- Pregnancy
- Perimenopause

## Targeted populations: various

30+

### YEARS OF MONITORING & RESEARCH IN ARCTIC

- 7000+ participants
- 3 territories + 4 Inuit regions
- 70+ communities
- engagement, collaboration and partnership

### TREND ANALYSIS IN INUIT

- Mercury declined by 44%
- Lead declined by 71%
- PCB153 declined by 75%
- some long chain PFAS increased by 19%



15

### FIRST NATIONS BIOMONITORING INITIATIVE

- up to 42 participants per community
- 5 ecozones across Canada

### COMPARISONS TO THE GENERAL POPULATION

- No differences for many chemicals
- Higher mercury, lead, PFAS, BPA and phthalates in some regions



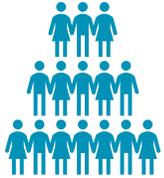
### OTHER TARGETED POPULATIONS

- child DEET users (DEET usage study)
- pregnant plastics and personal care product users (P4 study)

CHMS: Canadian Health Measures Survey

MIREC: Maternal Infant Research on Environmental Chemicals

# WHAT KIND OF DATA DO WE HAVE IN CANADA?



General population: CHMS



Pregnant people & children: MIREC



Targeted populations: various

Provides estimates of exposure to a broad range of chemicals at specified time and life stage

Enables analyses of time trends in a population

Enables analyses of time trends in a population

Enables monitoring of levels in an individual over time

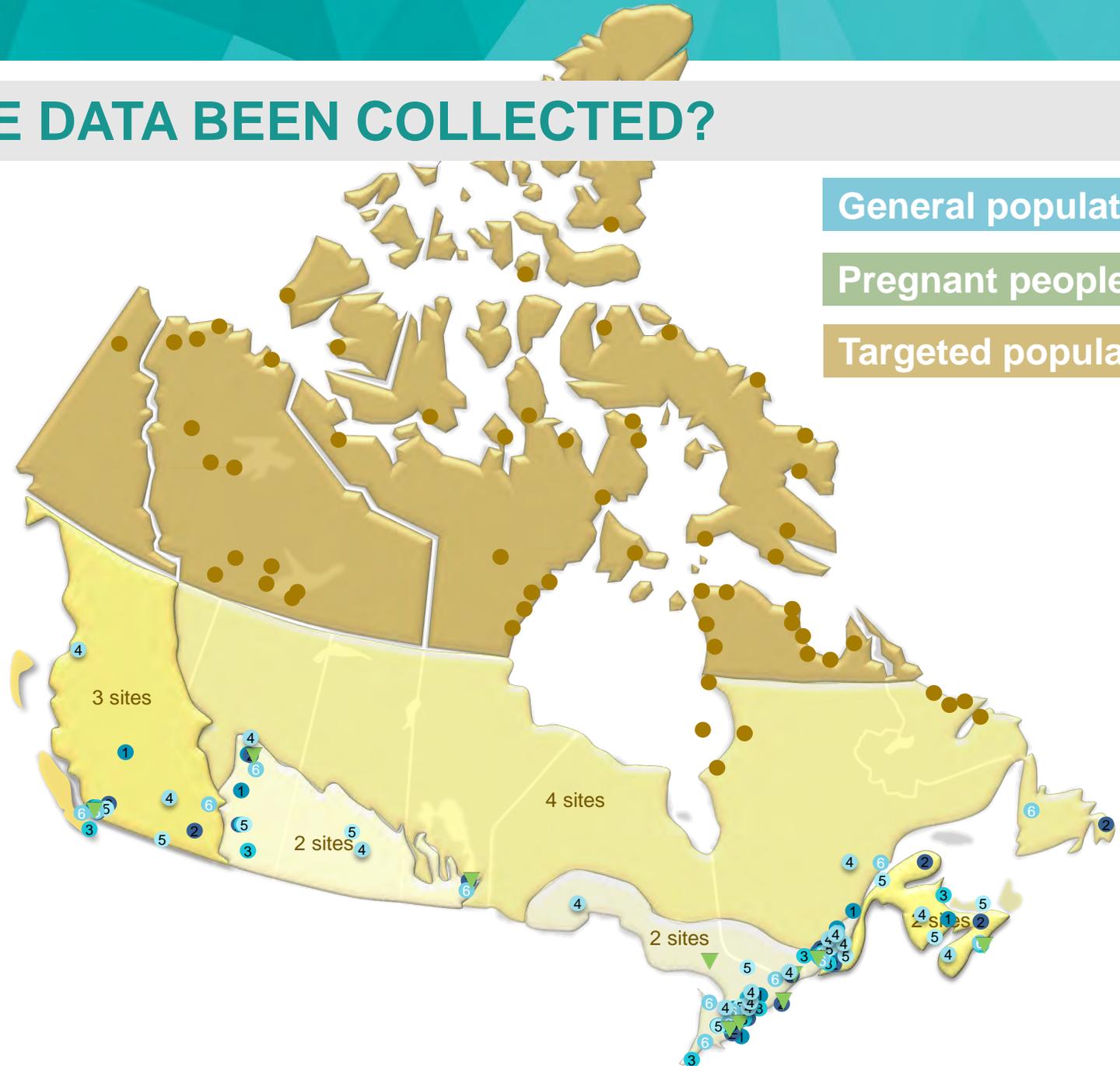
Allows establishment of baseline levels for the general population

Allows establishment of baseline levels for a specific population group

Allows investigation of exposure determinants and potential health risks

Examines the effects of prenatal exposures to the health of pregnant parents and their children through sensitive life stages

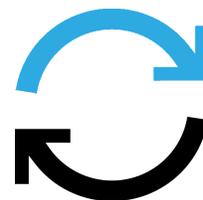
# WHERE HAVE DATA BEEN COLLECTED?



- General population: CHMS
- Pregnant people and children: MIREC
- Targeted populations: various

## NATIONALLY-REPRESENTATIVE

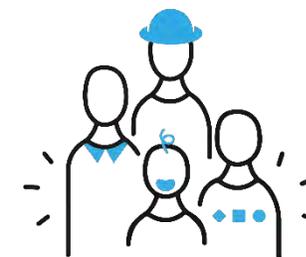
- Canadian Health Measures Survey (CHMS)
- Conducted by Statistics Canada in partnership with Health Canada and the Public Health Agency of Canada
- Ongoing cross-sectional survey conducted in 2-year cycles
- Samples between 5,000 and 6,000 people living in Canada aged 3 to 79 years to produce national estimates per cycle
- Representative of 96 to 97% of the Canadian population



**6 cycles  
(2007–2019)**



**~ 100 sites**



**~ 35,000 people**



## LONGITUDINAL COHORT

- Maternal-Infant Research on Environmental Chemicals (MIREC)



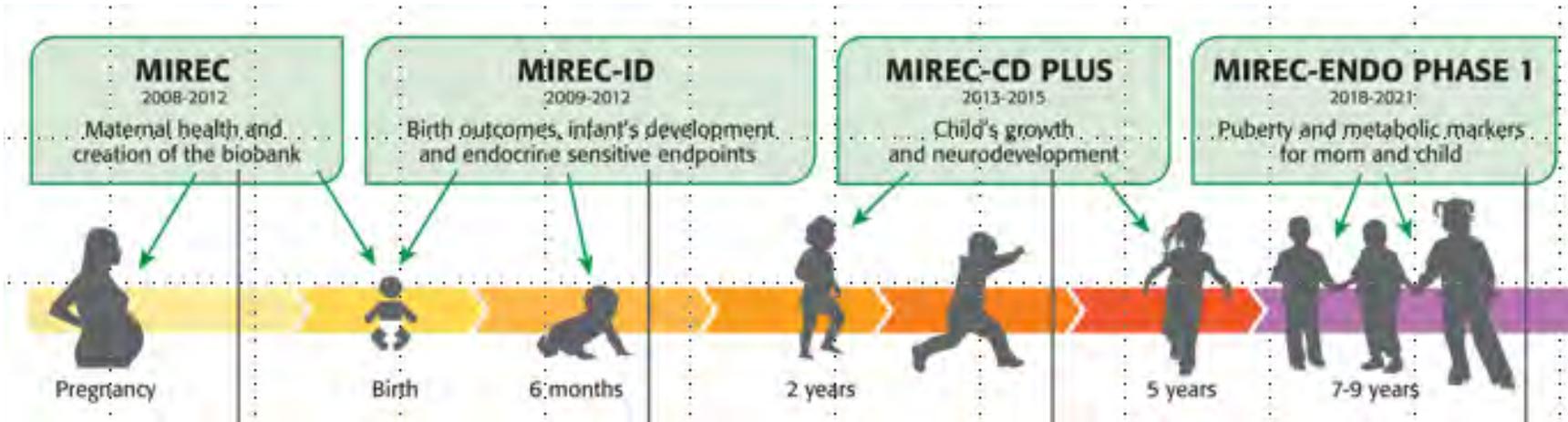
### Why follow a cohort of pregnant mothers and their children?

- Pregnant women are vulnerable to adverse effects of chemical exposures due to the physiological changes of pregnancy. Pregnancy has a profound impact on long-term postpartum health.
- Developing fetuses & babies are more vulnerable to the adverse effects of chemical exposures than other subgroups as their organ systems are not fully developed and they are growing rapidly.
- Early life chemical exposures can have long-lasting health effects that may be passed to the next generation

**All Canadians are exposed to chemicals and *when* we are exposed matters.**

## EXPOSURE BIOMARKERS

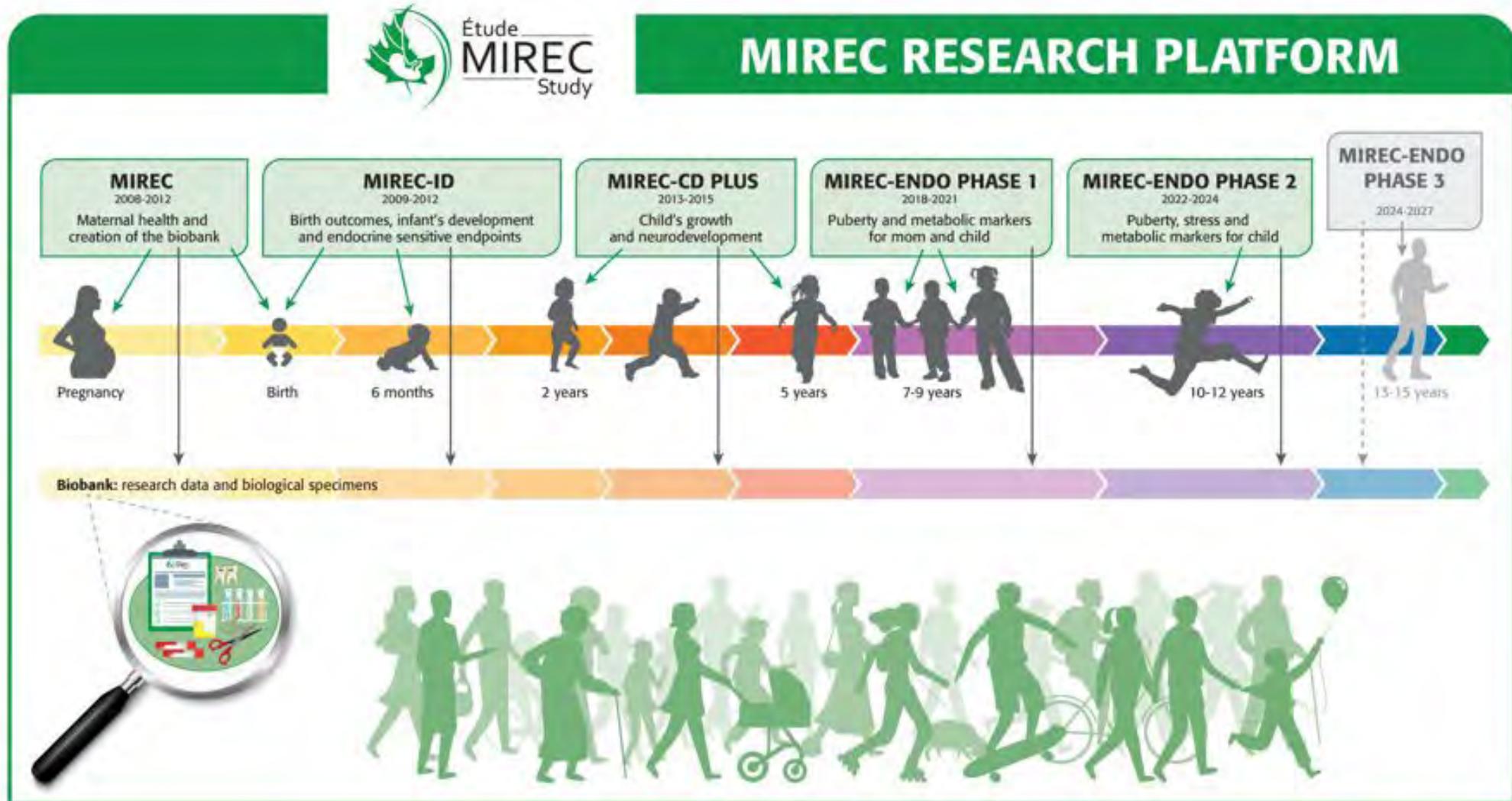
- > 200 chemicals measured with continued analyses of biobanked samples



**Matrices:** blood , urine    milk, cord blood, hair, meconium    blood, urine    blood, urine

**Key chemical classes measured:**  
Phthalates  
Bisphenols  
Perfluoroalkyl substances  
Metals  
Pesticides  
Flame retardants  
Polychlorinated biphenyls

# EFFECT BIOMARKERS



## STUDIES IN TARGETED POPULATIONS

- Not all questions can be answered by large surveys
- Large surveys may highlight populations of particular interest
- Targeted studies may help us to better understand
  - Exposures in specific areas or regions
  - Exposures in specific populations, including occupational exposures
  - Behaviourally-associated exposures

# ARCTIC CONTAMINANTS RESEARCH IS IMPORTANT

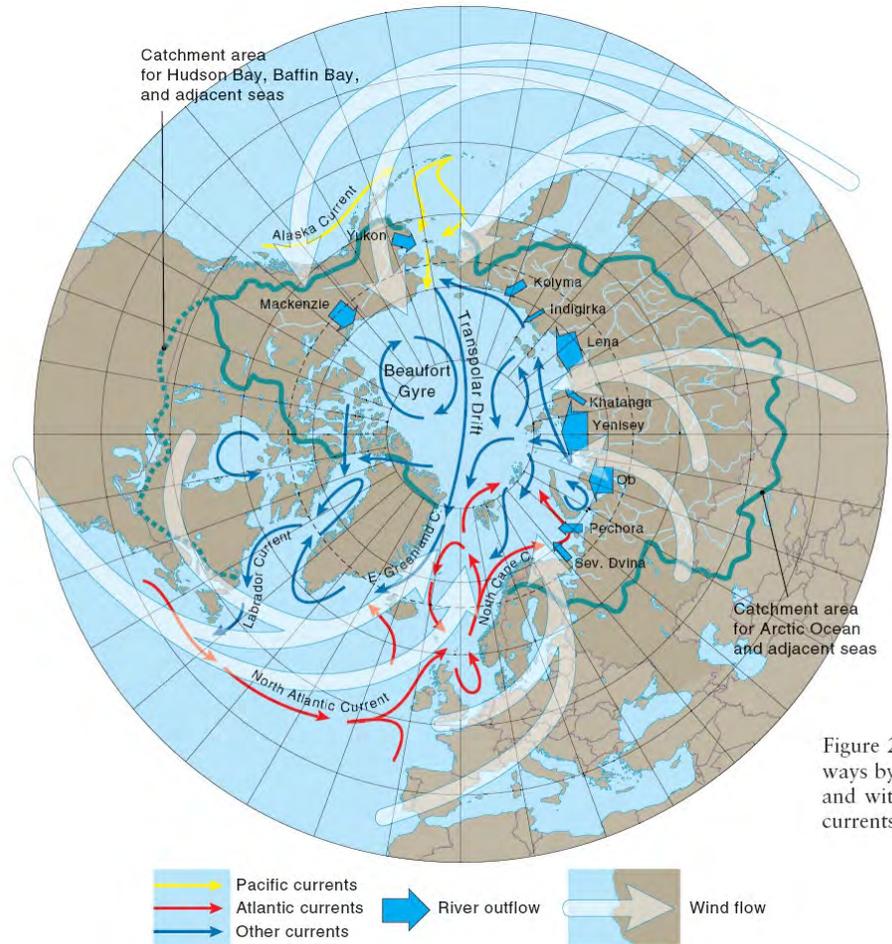


Figure 2-1. ways by wh and within, currents, riv

- Contaminants can affect people and wildlife far from where they are used and released. Most pollution in the Arctic is generated at southern latitudes and reaches the Arctic from long-range transport via air/ocean currents.
- Accumulation of these contaminants in food is a primary source of contaminants in the Arctic. This issue is complex because foods are culturally important and dietary alternatives are not preferred and/or difficult to find.
- Projects funded by The Northern Contaminants Program (NCP) support human biomonitoring in northern populations.

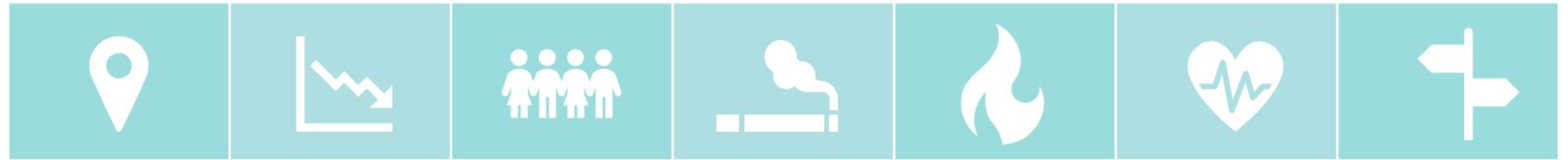
## OCCUPATIONAL EXPOSURES & CANCER RISK

- Cancer is responsible for over 85% of duty-related deaths of firefighters in Canada
- August 2021 – [Government of Canada announced](#) a comprehensive action plan to protect firefighters from harmful chemicals released during household fires
- June 2022 – International Association for Research on Cancer (IARC) evaluated "Occupational Exposure as a Firefighter" and classified it as a known human carcinogen (group 1)
- June 2023 – Royal Assent of the "National Framework on Cancers Linked to Firefighter".
- January 2024 – first Firefighter Cancer Awareness Month
- 2015 to present – ongoing collaborative biomonitoring research



# HUMAN BIOMONITORING DATA

## WHY WOULD YOU USE THEM?



- Geographical trends – understand how exposure levels in your area compare to the rest of Canada
- Time trends – see how levels of chemicals of interest have changed over time
- Greater exposure – identify highly exposed subgroups of interest
- Health effects – increase knowledge of health effects associated with internal exposure to chemicals
- Contextualize findings

# PFOS ACROSS CANADA

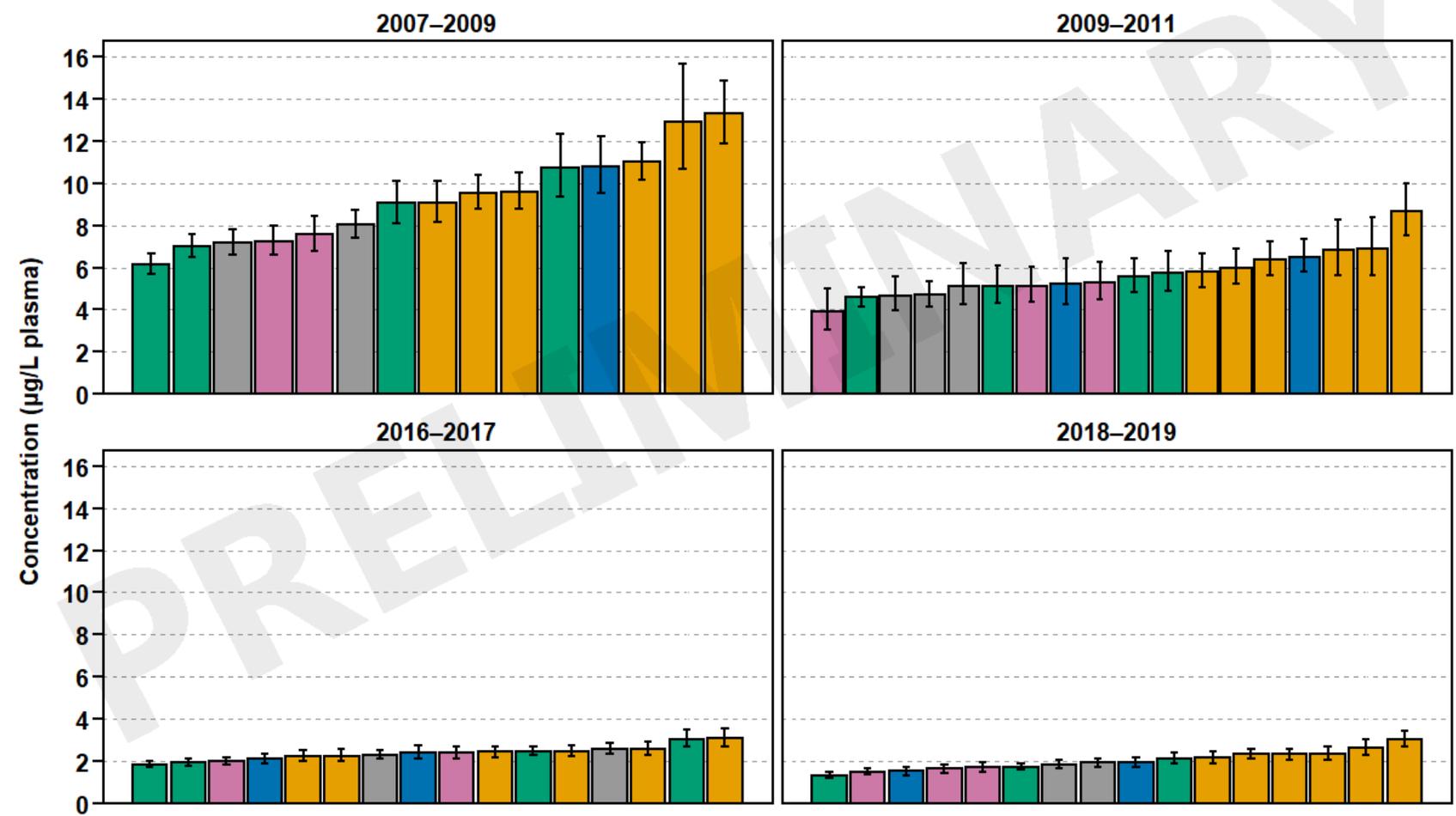
## GEOGRAPHIC TRENDS



### PFOS Concentrations by Cycle and Site

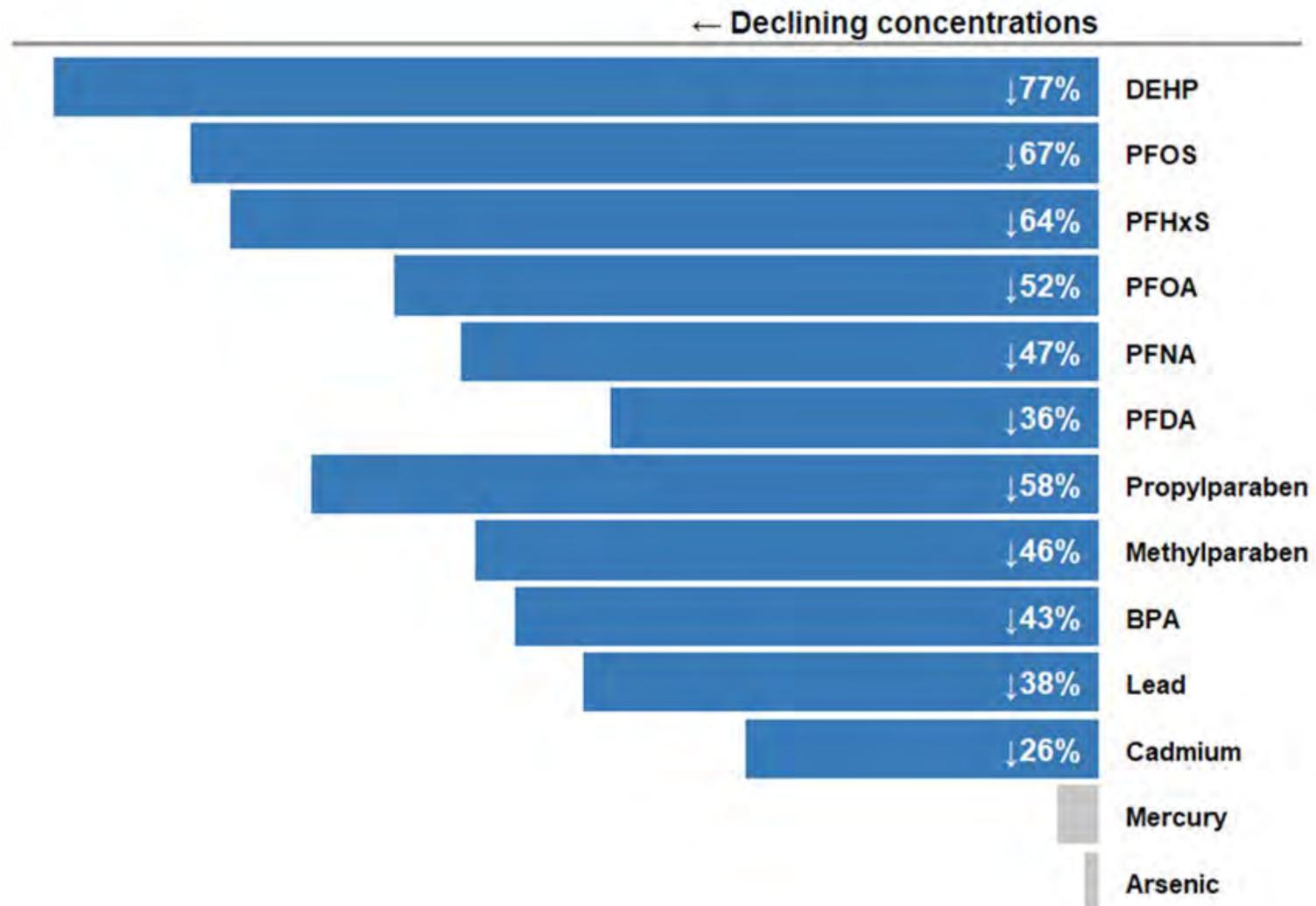
Unweighted Geometric Means and 95% Confidence Intervals

BC    Prairies    Ontario    Quebec    Atlantic



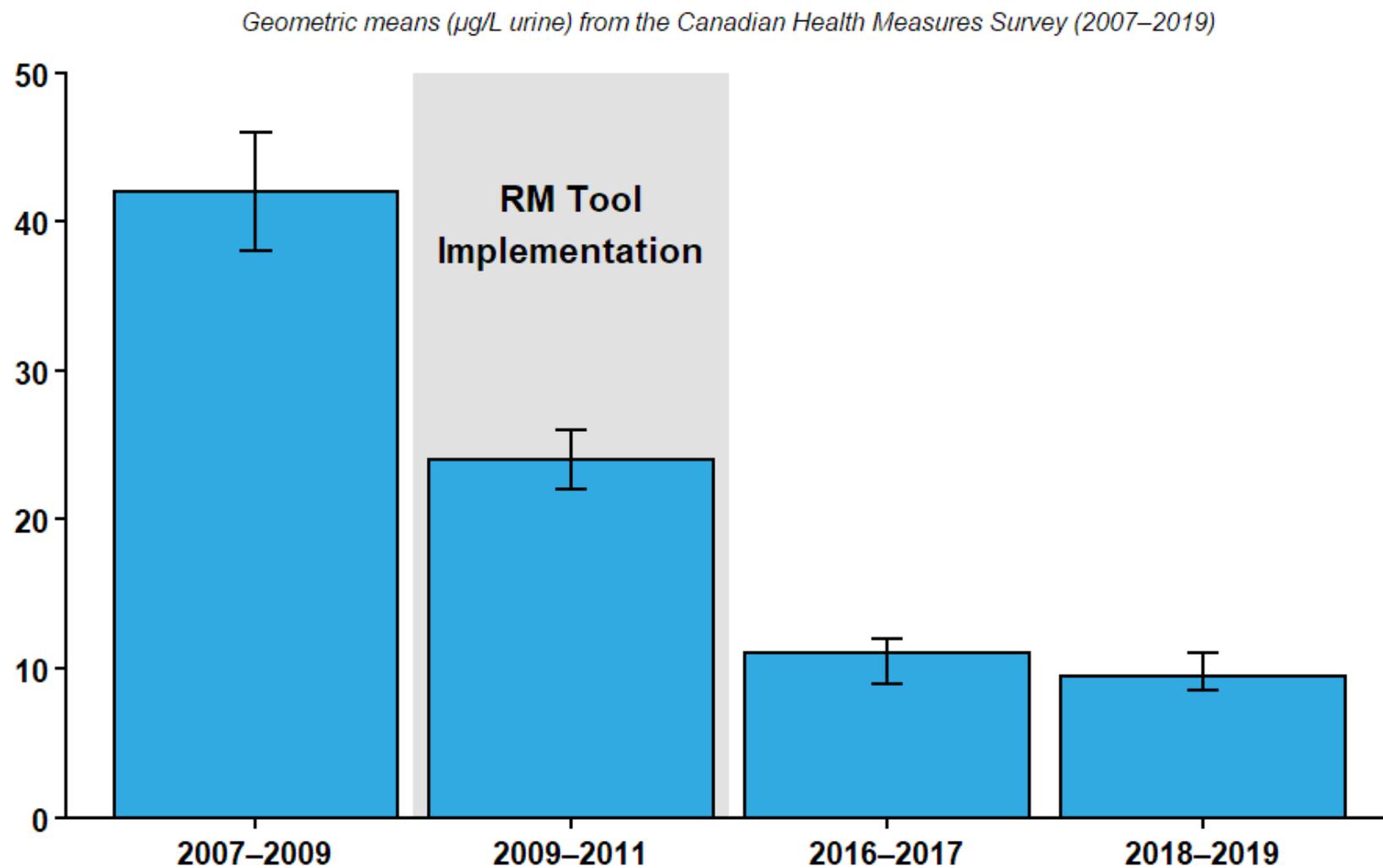
# DECREASING CONCENTRATIONS IN THE CANADIAN POPULATION

## TIME TRENDS

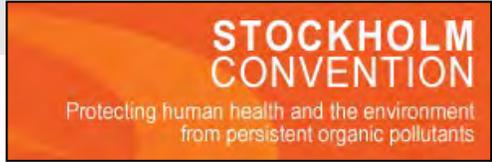


## DEHP TRENDS

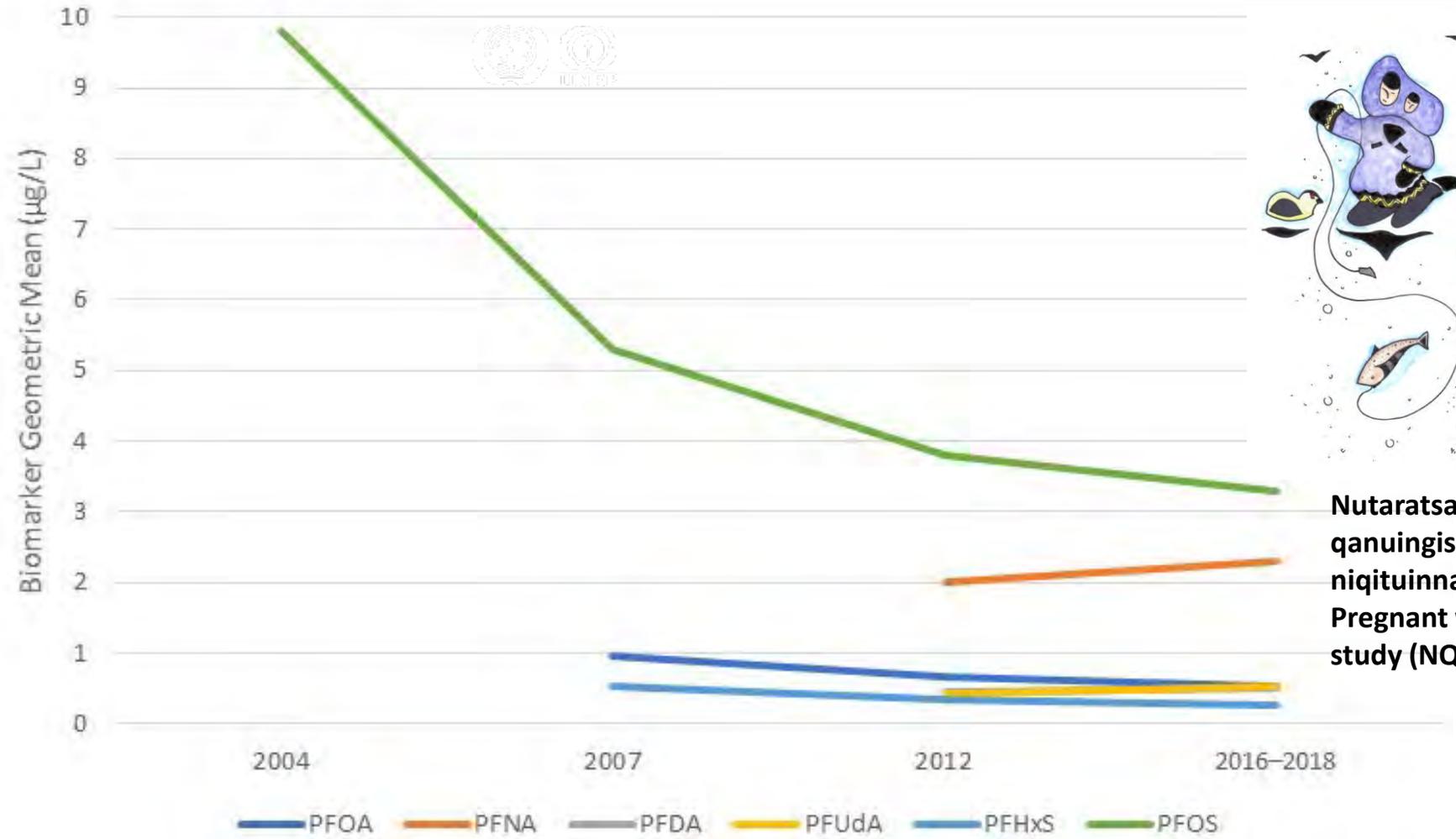
### TIME TRENDS



# TRENDS OF PFAS IN PREGNANT INUIT WOMEN



Nutaratsaliit qanuingisiarningit niqituinnanut Pregnant women study (NQN)

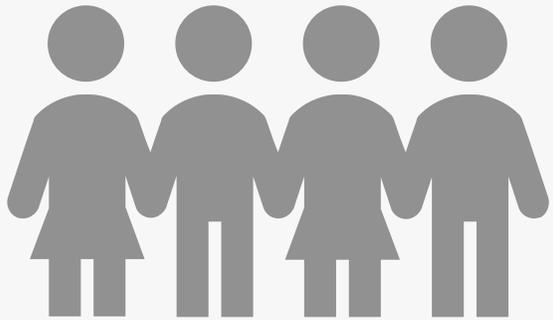


## TIME TRENDS

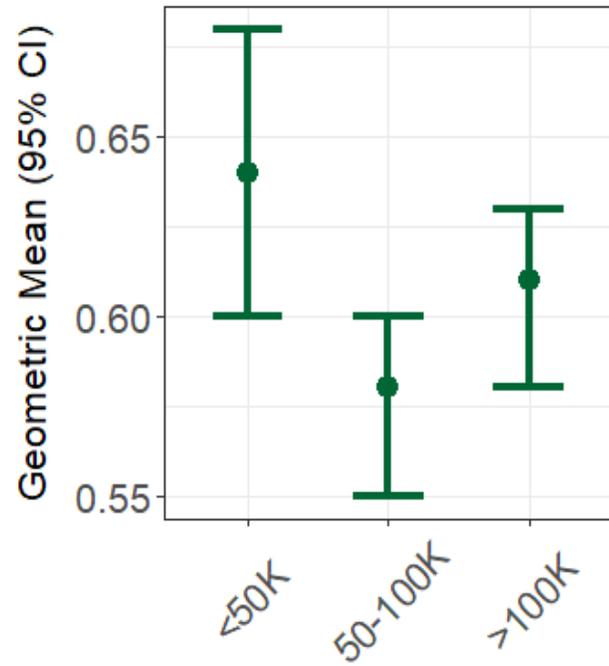


# LEAD LEVELS IN PREGNANT WOMEN

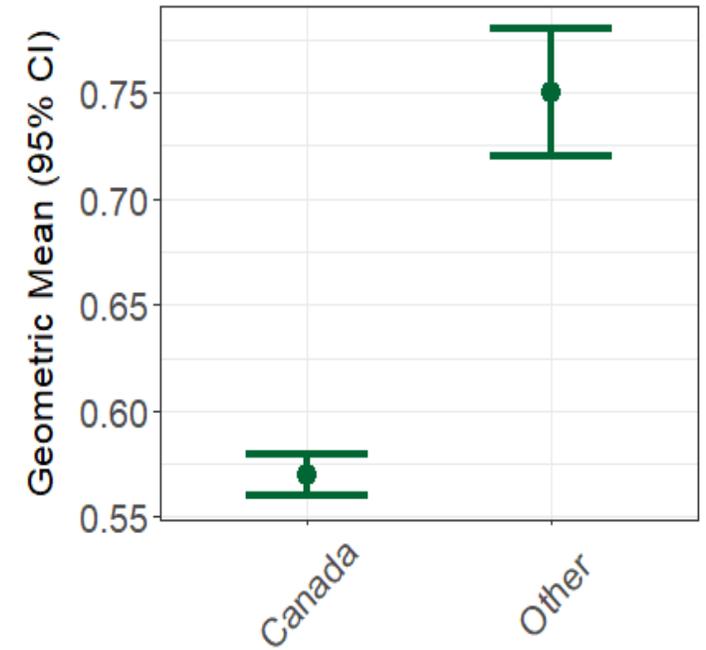
GREATER  
EXPOSURE



Household income (\$)

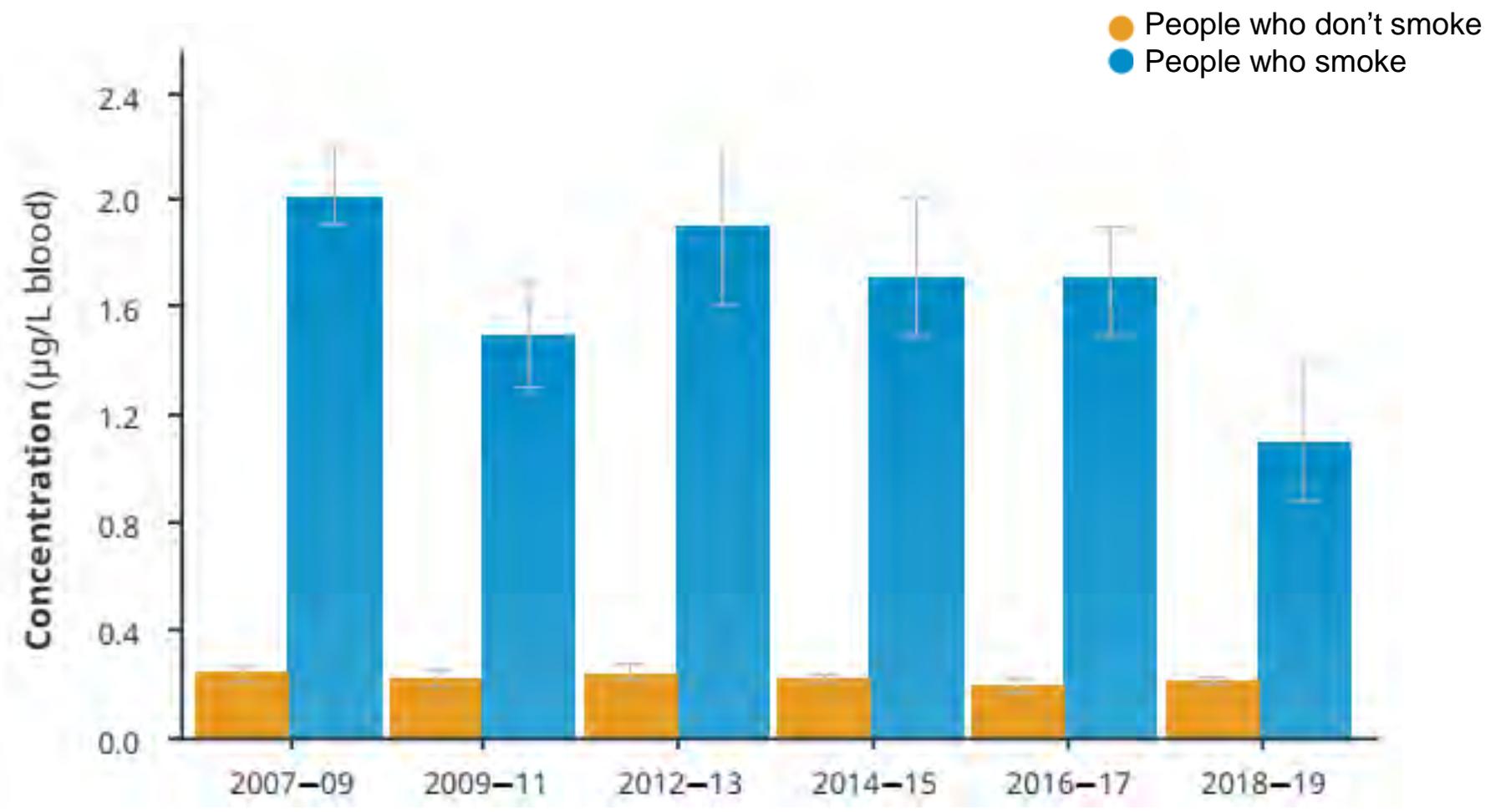
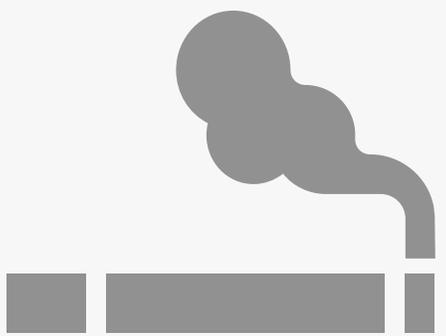


Country of Birth



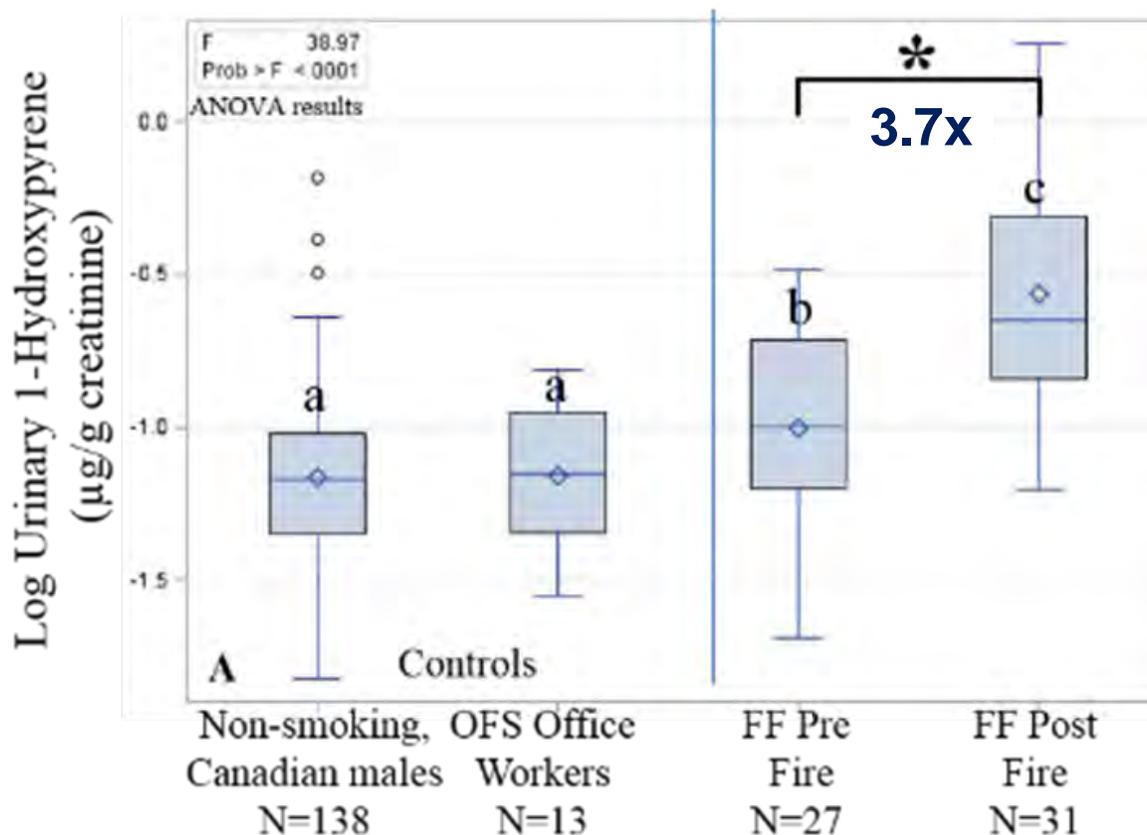
# CADMIUM LEVELS, BY SMOKING STATUS

**GREATER EXPOSURE**



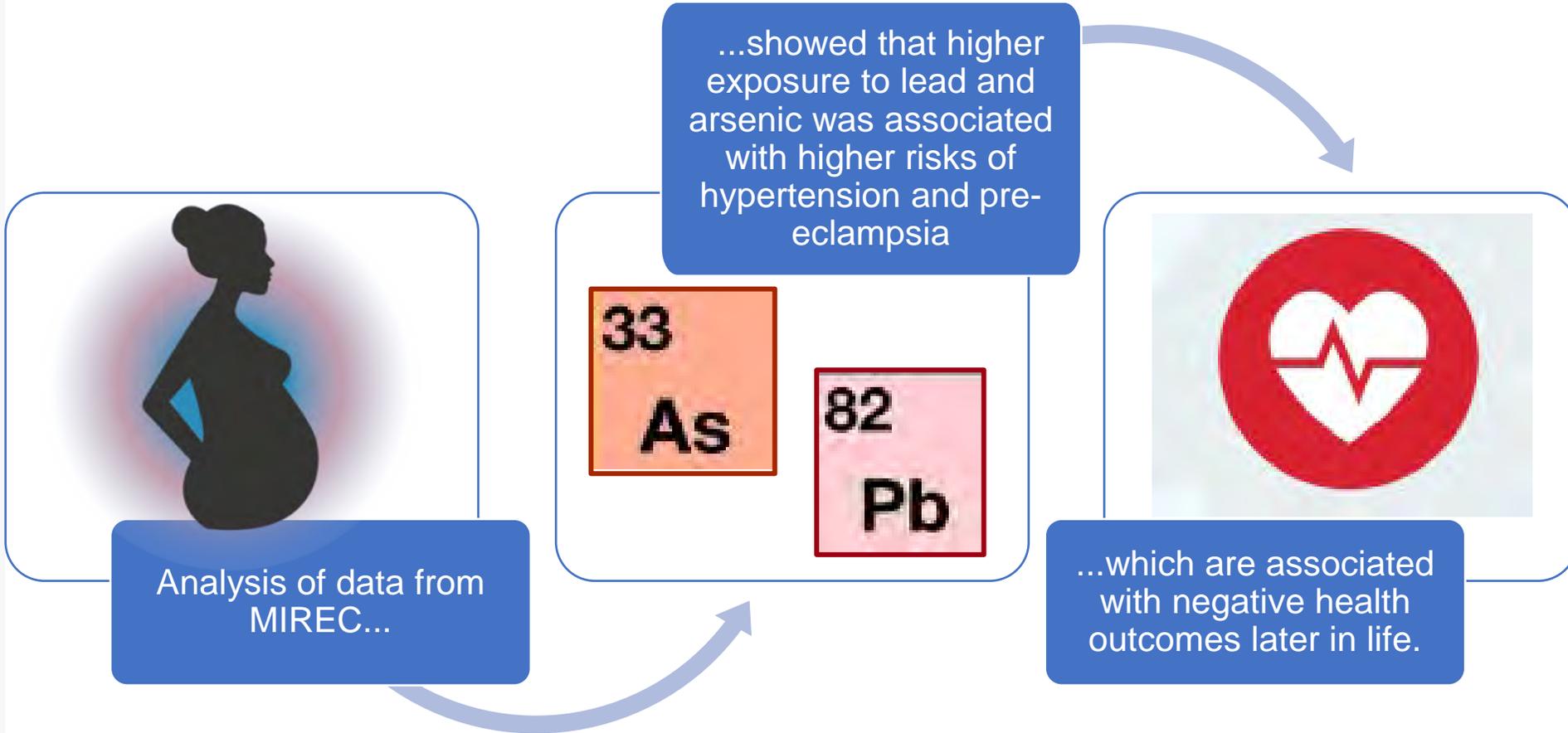
# PAH (1-OH-PYRENE) EXPOSURE DURING EMERGENCY FIRE SUPPRESSION

GREATER EXPOSURE



## TOXIC METALS AND HYPERTENSIVE DISORDERS

### HEALTH EFFECTS



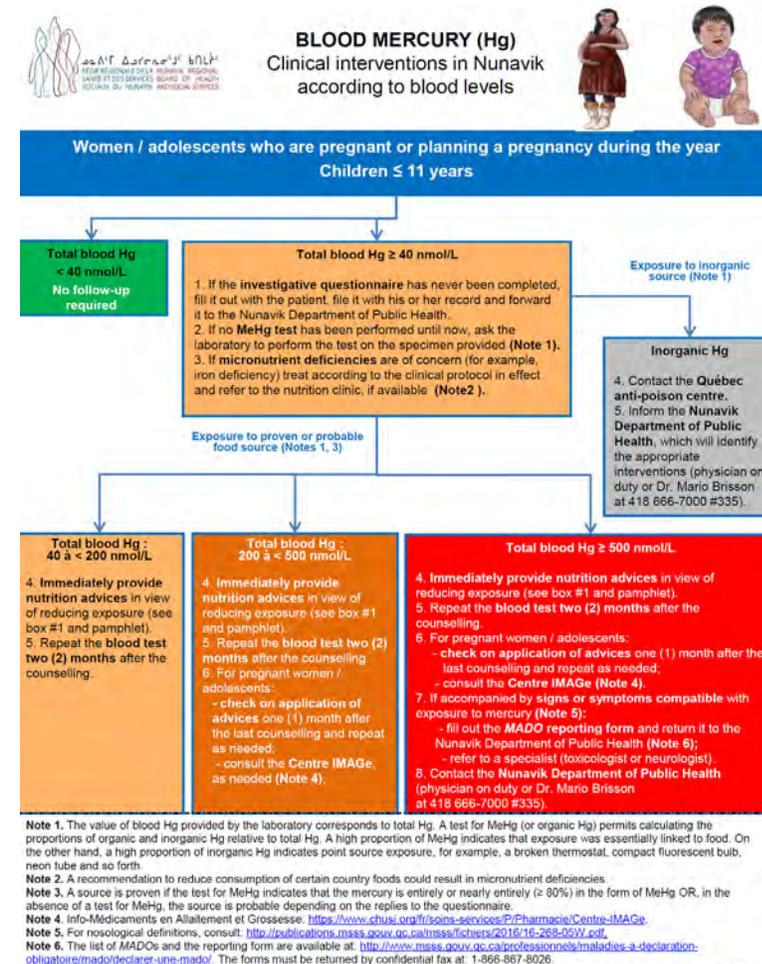
# GUIDANCE: BLOOD MERCURY

## FINDINGS IN CONTEXT

- Blood Hg levels have declined by 60% since 1992 but >20% of pregnant Inuit women still presented blood Hg values above the Canadian reference value of 8 µg/L (40 nmol/L)

- Clinical follow-up (currently in revision) was developed by the Nunavik Regional Board of Health and Social Services (NRBHSS) for Nunavik clinicians to inform and support pregnant women in undertaking actions to reduce their exposure

- Retest of blood Hg
- Investigative questionnaire
- Nutritional counselling



# CANADIAN BIOMONITORING DASHBOARD

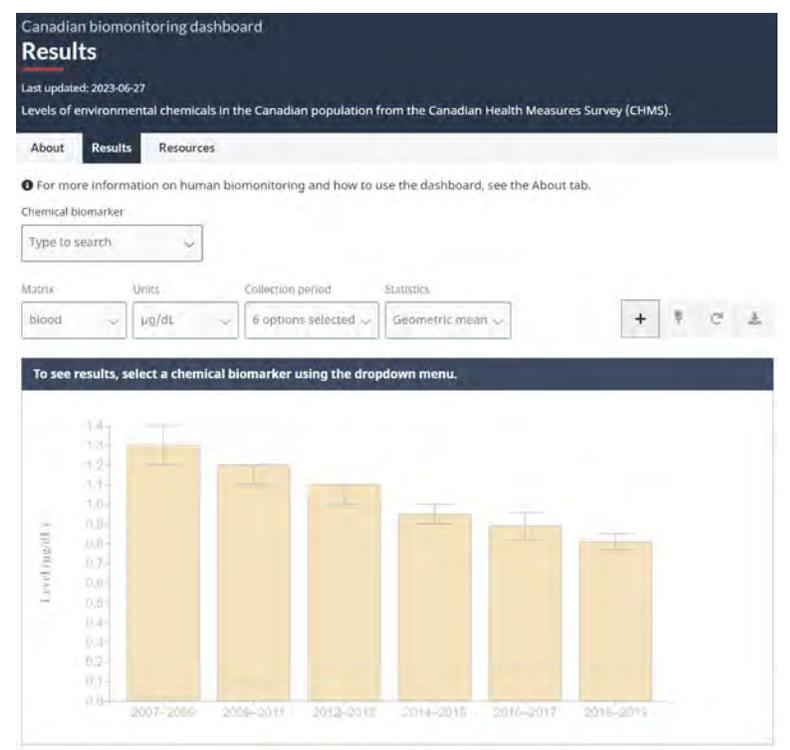
## FINDINGS IN CONTEXT

**2010–2021**  
*Reports on Human Biomonitoring of Environmental Chemicals in Canada*

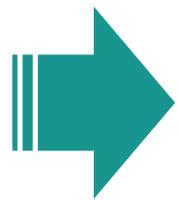
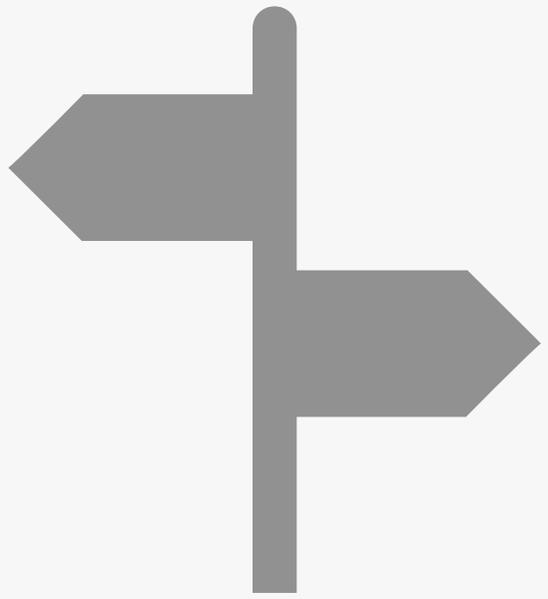


[canada.ca/biomonitoring](http://canada.ca/biomonitoring)

**2023 and beyond**  
*Canadian Biomonitoring Dashboard*

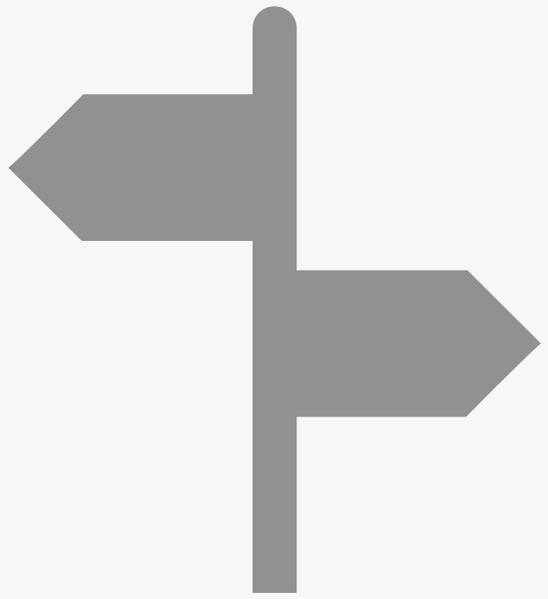


[health-infobase.canada.ca/biomonitoring/](http://health-infobase.canada.ca/biomonitoring/)



# CANADIAN BIOMONITORING DASHBOARD

## FINDINGS IN CONTEXT



[About](#) **Results** [Resources](#)

ⓘ For more information on human biomonitoring and how to use the dashboard, see the About tab.

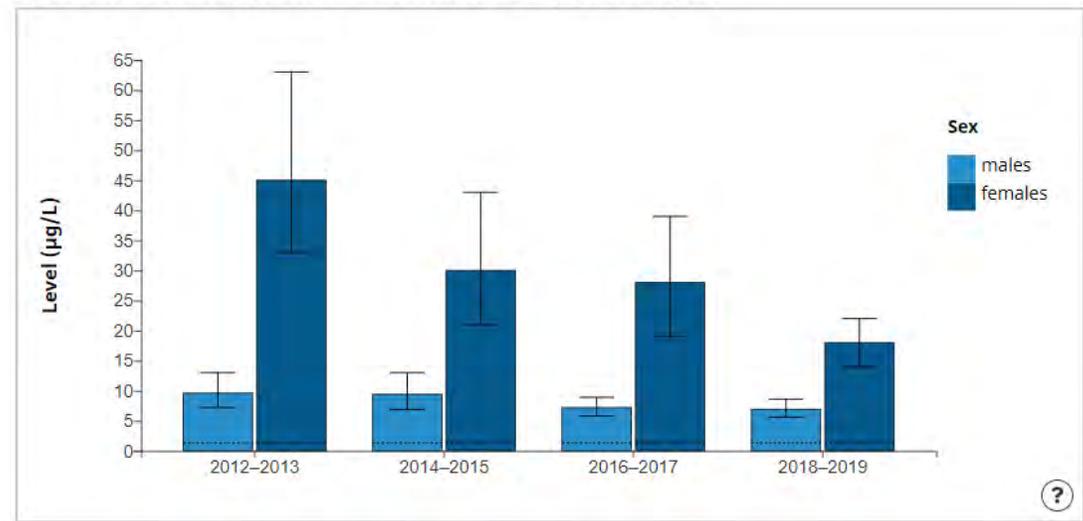
Chemical biomarker: methyl paraben

Matrix: urine    Units: µg/L    Collection period: 4 options selected    Statistics: Geometric mean

+    📄    ↻    📄

Results by collection period    Results by age    Results by sex

Figure 3: Levels of methyl paraben in urine in the Canadian population, by sex



- Search by chemical name
- Select **matrix, units, collection period, and statistics** of interest
- Can view results by **collection period, age, or sex**
- Data available as figures and data tables

▼ Data table

Showing 1 to 10 of 36 entries | Show 10 entries

Biomarker	Matrix	Age range	Group	Collection period (CHMS cycle)	Number of samples	Percent of samples below limit of detection	Detection frequency (95% CI)	Geometric mean (95% CI)	10th percentile (95% CI)	50th percentile (95% CI)
methyl paraben	urine	3 to 79	total	3 (2012-2013)	2,399	8.42	91.0 (87.4-93.7)	21 (17-25)	<LOD (<LOD-1.8)	19 (16-23)
methyl paraben	urine	3 to 5	total	3 (2012-2013)	463	6.70	91.7 (86.8-94.8)	20 (14-28)	1.5 (<LOD-2.2)	16 (11-21)
methyl paraben	urine	6 to 11	total	3 (2012-2013)	481	12.47	87.9 (82.5-91.8)	7.7 (5.7-10)	<LOD	6.0 (4.4-7.7)
methyl paraben	urine	12 to 19	total	3 (2012-2013)	469	8.53	93.7 (89.3-96.4)	15 (10-22)	1.5 (<LOD-2.3)	10 (5.1-18)
methyl paraben	urine	20 to 39	total	3 (2012-2013)	328	7.01	91.3 (77.9-96.9)	21 (13-34)	<LOD (<LOD-2.7)	21 (6.4-36)
methyl paraben	urine	40 to 59	total	3 (2012-2013)	284	8.10	90.5 (79.6-95.7)	25 (14-43)	1.3 (<LOD-2.1)	26 (8.0-44)
methyl paraben	urine	60 to 79	total	3 (2012-2013)	314	6.37	91.6 (84.7-95.8)	25 (16-37)	1.7 (<LOD-2.7)	30 (8.1-51)
methyl paraben	urine	3 to 79	males	3 (2012-2013)	1,171	10.93	85.1 (78.3-90.0)	9.6 (7.2-13)	<LOD	5.9 (3.5-8.3)
methyl paraben	urine	3 to 79	females	3 (2012-2013)	1,168	5.91	97.1 (95.2-98.3)	45 (33-63)	3.7 (2.4-4.9)	53 (21-85)
methyl paraben	urine	3 to 79	total	4 (2014-2015)	2,564	8.39	89.6 (85.4-92.7)	17 (13-22)	<LOD	15 (9.8-20)

1    2    3    4    Next →

Abbreviations: LOD (limit of detection), NA (not applicable), NC (not calculated)

# CANADIAN BIOMONITORING FACTSHEETS

## FINDINGS IN CONTEXT

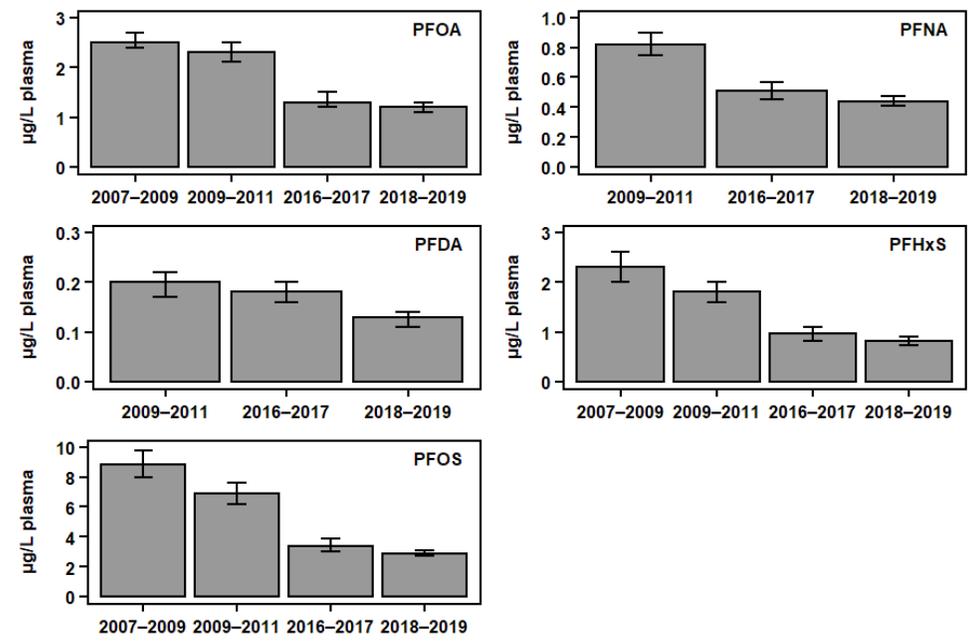


[health-infobase.canada.ca/biomonitoring/resources.html](http://health-infobase.canada.ca/biomonitoring/resources.html)

- Trends over time, age, sex
- National population + specific sub-groups
- Text summaries

There was a statistically significant decreasing trend over time ( $P < 0.001$ ) in PFOA, PFNA, PFDA, PFHxS and PFOS concentrations in the Canadian population aged 12 or 20 to 79. Between 2007–2009 and 2018–2019, PFOA concentrations declined by 52%, PFHxS concentrations declined by 64% and PFOS concentrations declined by 67%. Between 2009–2011 and 2018–2019, PFNA concentrations declined by 47% and PFDA concentrations declined by 36%.

### Charts



## FUTURE DIRECTIONS

### WHAT MORE CAN BE DONE?



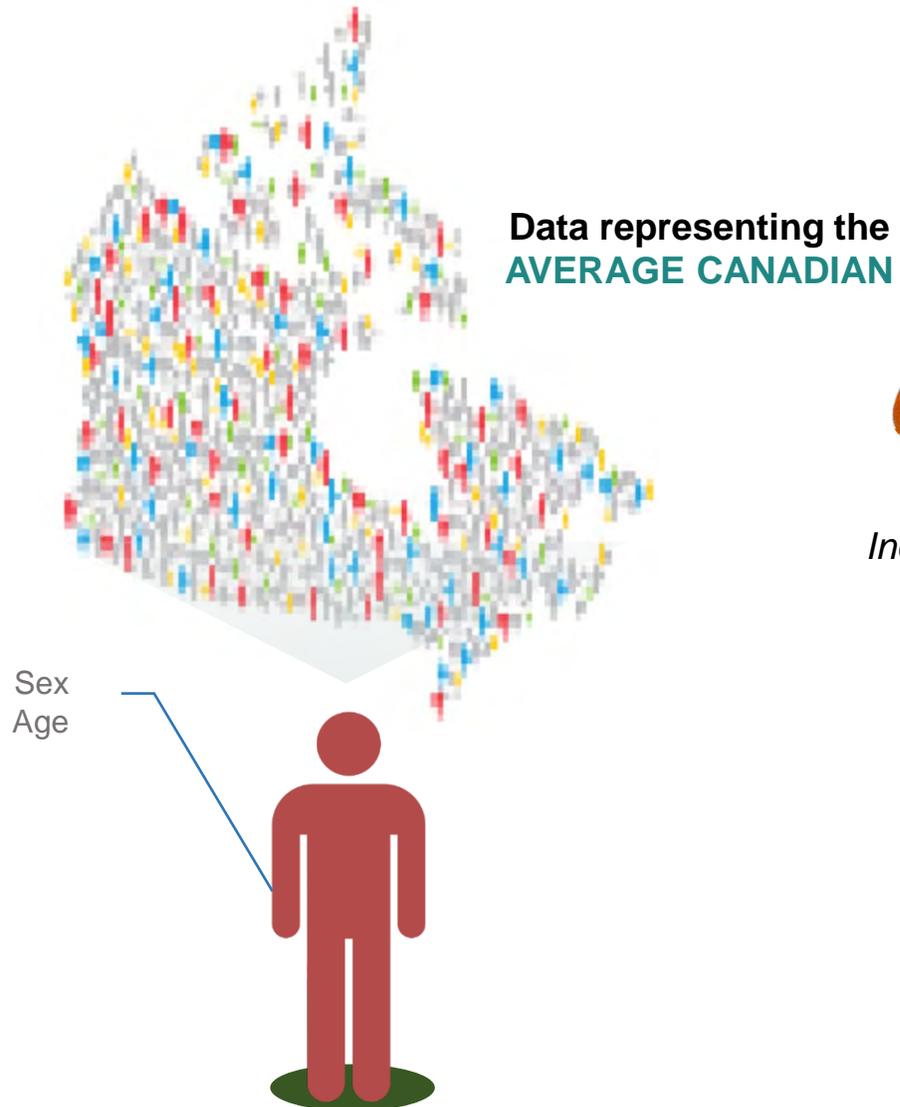
- Changing priorities and new legislation
- Identify needs
- Framework for existing and future work

# LEGISLATION

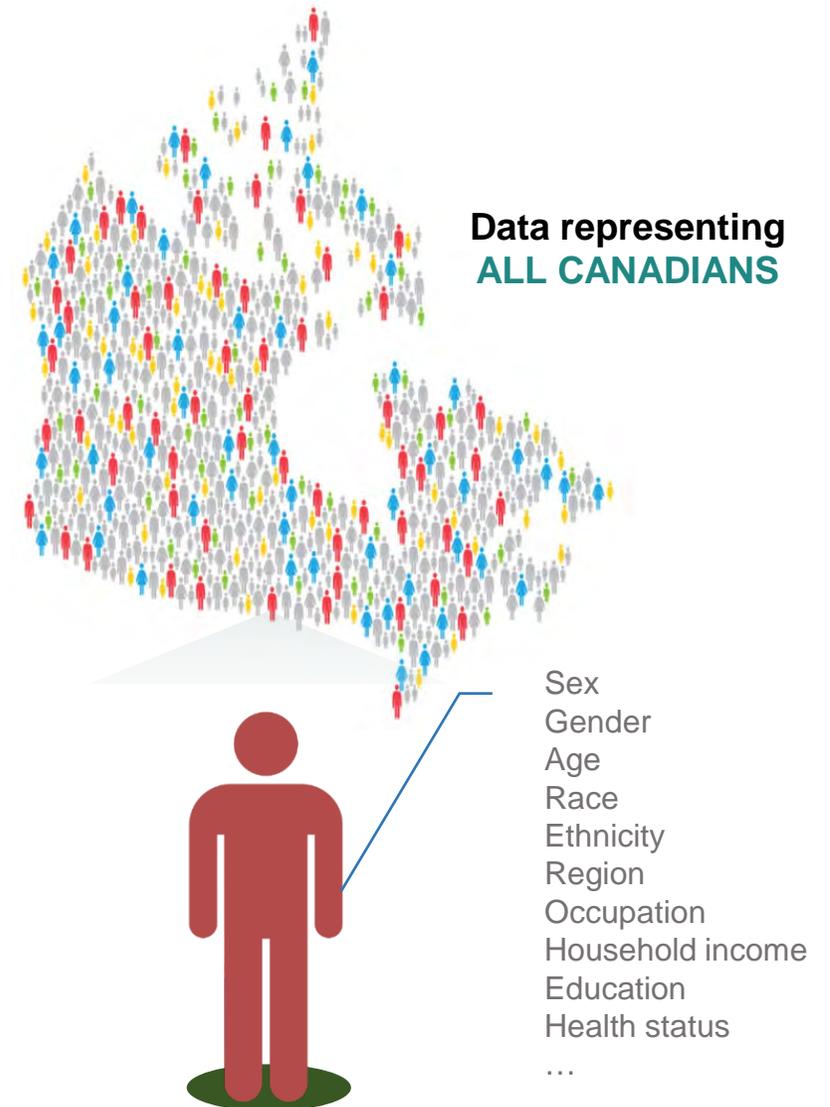
- The Canadian Environmental Protection Act, 1999 (CEPA) is an important part of Canada's federal environmental legislation aimed at protecting the environment and human health
- June 13, 2023, [Bill S-5, \*Strengthening Environmental Protection for a Healthier Canada Act\*](#) became law
- The Bill made important changes to CEPA for the first time in over 20 years including amendments aimed at protecting vulnerable populations\*
- Implementation will:
  - include work to identify populations that may be disproportionately impacted due to greater susceptibility or higher exposure to environmental and health risks
  - require the Government to administer the Act in ways that minimize risks to the health of vulnerable populations, i.e. **conduct research and studies, including [biomonitoring surveys](#), specifically in relation to the role of substances in illnesses or in health problems, which may relate to vulnerable populations**
  - include work to develop an implementation framework to set out how the right to a healthy environment under CEPA, recognized for the first time in federal law, will be considered in administering the Act.

\*Terminology is evolving – the Bill defines vulnerable populations as “a group of individuals within the Canadian population who, due to greater susceptibility or greater exposure, may be at an increased risk of experiencing adverse health effects from exposure to substances.” These populations may include pregnant people, children, people in poor health, workers, and those living in areas where levels of pollution are particularly high.

# EVOLVING FOCUS



*Increasing demands  
for data and  
analyses*

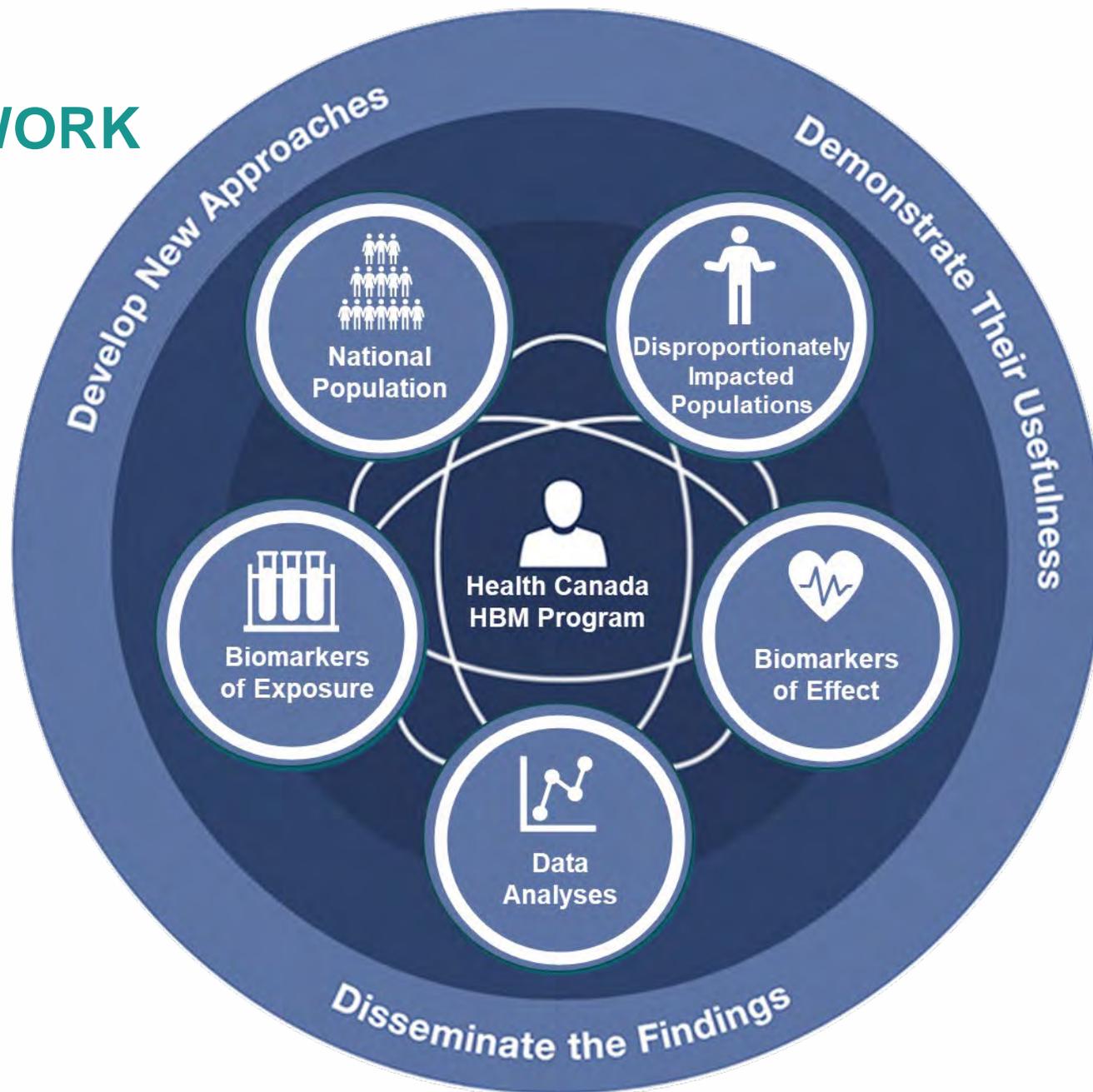


# FUTURE DIRECTIONS: WHAT WE'VE HEARD FROM PARTNERS

Several themes have been identified from consultations with internal partners:

- Biomonitoring data are needed across program areas
- Existing biomonitoring data have more to tell us – What can we learn from what we have?
- Biomonitoring data would be used more, if there were more tools to interpret biomonitoring data
- More data are needed to address
  - Health effects
  - Source attribution
  - Vulnerable populations / Disproportionately impacted populations

# DRAFT FRAMEWORK



# WHAT'S NEXT

## Near term:

- Look at data we have
- Look for partnerships to leverage existing data sets
- Explore ways to be more inclusive

## Medium term:

- More consideration of biomarkers of effect
- Develop more tools to disseminate and share information
- Leverage existing biobanks

## Long term:

- Initiate new studies

### Related activities

Health Canada and Environment and Climate Change Canada will publish a **discussion document on Right to a Healthy Environment implementation framework** in early February 2024. This is an opportunity for any interested individuals to provide comment and feedback to inform the development of the implementation framework.

You will be able to find the document [here](#) when available as well as any key updates. Please send any comments to this email: <mailto:HealthyEnv-EnvSain@ec.gc.ca>.

# DO YOU HAVE QUESTIONS? IDEAS?

How are biomonitoring data valuable to you?

What gaps exist in biomonitoring in Canada?

Where/how do you use biomonitoring data?

What biomonitoring data are missing?  
...for who?

What barriers do you have to using biomonitoring data?

General Population: CHMS

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Pregnant people and children: MIREC

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Targeted populations

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