Human Biomonitoring in the Canadian Health Measures Survey – Progress and Uses

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Healthy Environments and Consumer Safety Branch
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Objectives

- Describe the human biomonitoring component of the Canadian Health Measures Survey (2007 to 2019)
- Highlight the uses of biomonitoring data
- Describe tools for interpretation of biomonitoring data
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.
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.

Human biomonitoring is an element of the CMP.
Health-Related Monitoring: Chemicals Management Plan

- Targeted Population Biomonitoring
  - Targeted Environmental Monitoring
    - Children’s exposure to lead
  - Plastics & personal care products in pregnancy
  - Arsenic in targeted geographic areas
  - Exposure of recent Canadians’ to metals

- Biomonitoring Supportive Research

- National Human Biomonitoring
  - Canadian Health Measures Survey
  - Maternal Infant Research on Environmental Chemicals
  - Northern Contaminants Program
  - First Nations Biomonitoring Initiative

- Toxico-kinetic
- HBM Values
- New Chemicals analysis
Canadian Health Measures Survey (CHMS)

Nationally representative survey on the general health and lifestyle of Canadians

Design
- Cross-sectional survey carried out in 2 year cycles
- Age groups: 3-5, 6-11, 12-19, 20-39, 40-59, 60-79 years
- Covers 94% of the Canadian population

Household Component
- Interview
- Indoor air (≥ cycle 2) and tap water (≥ cycle 3) sampling

Mobile Examination Centre Component
- Direct physical measures, including blood, urine, hair
- Clinic questionnaire

Partners:
Statistics Canada
Health Canada
Public Health Agency of Canada
Direct Measures (Mobile Examination Centre)

- Field staff: accredited and qualified health specialists and technicians
- 12 dedicated Statistics Canada interview staff
- Medical advisor working from central office

**Measures**

- Physical measurements (i.e. height, weight)
- Physical activity and fitness tests
- Oral health exam (cycle 1)
- Blood measures
  - Environmental chemicals, nutritional status, chronic & infectious disease, blood chemistry, DNA, biobank
- Urine measures
  - Environmental chemicals, iodine, microalbumin, creatinine
- Hair measures
  - Environmental chemicals
- Audiometry (cycle 3)
- FENO (fractional exhaled nitric oxide) (cycle 3)
Establish nationally-representative blood, urine and hair concentrations for environmental chemicals

Provide baseline data to track temporal trends and to allow for comparisons with sub-populations in Canada and with other countries

Provide data to explore relationships between environmental chemicals, other physical measures, and self-reported information
Selection of CHMS Biomonitoring Chemicals

Based on

• Health Canada program priorities

Criteria

• Public health considerations
• Regulatory needs
• Evidence of population exposures or sources of exposure
• Feasibility of field collection of biospecimens / respondent burden
• Availability of laboratory analytical methods
• Consistency with other surveys
• International commitments
## CHMS Biomonitoring Chemicals

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<tr>
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<td>Acrylamide</td>
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<td></td>
<td>●</td>
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<tr>
<td>Alternate plasticizer</td>
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<td>Carbamate pesticides</td>
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<tr>
<td>Dioxins and furans</td>
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<td>Flame retardants</td>
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<td>Fungicides</td>
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<td>●</td>
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<td>Metals and trace elements</td>
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<td>Organochlorines</td>
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<td>Organophosphate insecticides</td>
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<td>Parabens</td>
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<td>Perfluoroalkyl substances</td>
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<tr>
<td>Phenoxy herbicide</td>
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<tr>
<td>Phthalates</td>
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<td>PCBs</td>
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<td>PAH metabolites</td>
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<td>Pyrethroid insecticides</td>
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<td>●</td>
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<td>Tobacco biomarkers</td>
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<td>●</td>
<td>●</td>
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<td>●</td>
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<td>Triazine herbicide</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td>●</td>
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<tr>
<td>VOCs</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
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</tbody>
</table>

277 chemicals measured over Cycles 1 to 6
CHMS Environmental Monitoring

Indoor Air Analysis:
- Trihalomethanes
- Benzene, Toluene, Ethylbenzene, Xylene
- Siloxanes
- Other Volatile Organic Compounds

Tap Water Analysis:
- Trihalomethanes
- Benzene, Toluene, Ethylbenzene, Xylene
- Fluoride
Mar 2007 – Feb 2009
15 sites
6-79 years (n = 5,600)
148 chemicals

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

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

Jan 2014 – Dec 2015
16 sites
3-79 years (n = 5,700)
114 chemicals

Jan 2016 – Dec 2017
16 sites
3-79 years (n = 5,700)
184 chemicals
Report planned 2019

Jan 2018 – Dec 2019
16 sites
3-79 years (n = 5,700)
184 chemicals
Report in 2021

CHMS Milestones - Biomonitoring
### Table 8.7.1
Fluoride — Geometric means and selected percentiles of urine concentrations (µg/L) for the Canadian population aged 3–79 years by age group, Canadian Health Measures Survey cycle 2 (2009–2011).

<table>
<thead>
<tr>
<th>Group (years)</th>
<th>Cycle</th>
<th>n</th>
<th>%&lt;LODa</th>
<th>GM (95%CI)</th>
<th>10th (95%CI)</th>
<th>50th (95%CI)</th>
<th>75th (95%CI)</th>
<th>95th (95%CI)</th>
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</thead>
<tbody>
<tr>
<td>Total, 3–79</td>
<td>2</td>
<td>2530</td>
<td>0</td>
<td>500 (460 - 550)</td>
<td>190 (180 - 210)</td>
<td>480 (430 - 540)</td>
<td>840 (750 - 930)</td>
<td>1500 (1300 - 1800)</td>
</tr>
<tr>
<td>3–5</td>
<td>2</td>
<td>510</td>
<td>0</td>
<td>470 (420 - 520)</td>
<td>190 (140 - 230)</td>
<td>510 (440 - 590)</td>
<td>720 (620 - 820)</td>
<td>1300 (920 - 1700)</td>
</tr>
<tr>
<td>6–11</td>
<td>2</td>
<td>514</td>
<td>0</td>
<td>500 (440 - 570)</td>
<td>200 (170 - 240)</td>
<td>490 (410 - 560)</td>
<td>820 (720 - 910)</td>
<td>1500 (1100 - 1800)</td>
</tr>
<tr>
<td>12–19</td>
<td>2</td>
<td>507</td>
<td>0</td>
<td>410 (370 - 460)</td>
<td>170 (150 - 200)</td>
<td>440 (360 - 520)</td>
<td>660 (570 - 750)</td>
<td>1200 (990 - 1400)</td>
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<tr>
<td>20–39</td>
<td>2</td>
<td>354</td>
<td>0</td>
<td>530 (470 - 590)</td>
<td>220 (190 - 260)</td>
<td>500 (380 - 620)</td>
<td>900 (750 - 1100)</td>
<td>1500 (1200 - 1800)</td>
</tr>
<tr>
<td>40–59</td>
<td>2</td>
<td>357</td>
<td>0</td>
<td>510 (430 - 610)</td>
<td>190 (130 - 250)</td>
<td>510 (410 - 620)</td>
<td>880 (740 - 1000)</td>
<td>1800 (1400 - 2300)</td>
</tr>
<tr>
<td>60–79</td>
<td>2</td>
<td>288</td>
<td>0</td>
<td>490 (440 - 560)</td>
<td>190 (120 - 260)</td>
<td>470 (410 - 540)</td>
<td>830 (760 - 910)</td>
<td>1600 (1200 - 2000)</td>
</tr>
</tbody>
</table>

* a If >40% of samples were below the LOD, the percentile distribution is reported but means were not calculated.
* E Use data with caution.
CHMS data use: Establish baseline levels

Acrylamide adduct in blood

Geometric mean acrylamide haemoglobin adduct concentration (pmol/g Hb)

Age Group (years)

3-79 (total population)  3-79 (total population)  3-5  6-11  12-19  20-39  40-59  60-79

NHANES (2003-2004)
Cycle 3 (2012-2013)
CHMS data use: Establish baseline levels

Triclosan in urine
CHMS data use: to establish relationships

Blood BTEX by smoking status

Geometric mean, blood concentration ng/mL

Ages 12-79 years, Cycle 3

- Benzene
- Ethylbenzene
- Toluene
- Xylenes (total)

Non-smokers
Smokers
CHMS data use: effectiveness of regulatory actions

Lead in blood

1978-79 geometric mean blood lead: 4.8 µg/dL (Canada Health Survey)

Canadian Blood Lead Intervention Level – 10 µg/dL
CHMS data use: identify exposed populations

Mercury – women of childbearing age

Percent Exceeding Guidance Value (%)

<table>
<thead>
<tr>
<th>Survey / Region of Sampling</th>
<th>Percent Exceeding Guidance Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHMS Cycle 2 (2009-2011)</td>
<td>2.2%</td>
</tr>
<tr>
<td>FNBI (2011)</td>
<td>2.7%</td>
</tr>
<tr>
<td>Baffin Region (2005-2007)</td>
<td>20% (Down from 53% in 1997)</td>
</tr>
<tr>
<td>Inuvik Region (2005-2006)</td>
<td>1.9% (Down from 10% in 1997)</td>
</tr>
</tbody>
</table>

FNBI: First Nations Biomonitoring Initiative
HBM Values: Tools for Interpretation

- Increasing level of effort & sophistication

- **Intervention Levels**
  - Individual- & population-level
  - Health risk-based

- **Biomonitoring Equivalents**
  - Population-level
  - Derived from existing exposure guidance values (risk assessment based)

- **Reference Values**
  - Population-level
  - Statistically-derived (not health risk-based)
HBM Reference Values (RV\textsubscript{95})

- Upper bound of background exposure of the general population to a substance at a given time.

- statistical reference values; not health-based.

- In Canada:
  - RV\textsubscript{95} for metals and trace elements have been derived using CHMS data
  - Work is underway to derive RV\textsubscript{95} for POPs, VOCs, environmental phenols, PAHs and phthalates

RV\textsubscript{95} can be used to:
- Identify individuals or sub-populations with increased exposures
- Follow changes in exposure over time
- Determine the effectiveness of actions to reduce exposures
Biomonitoring Equivalents (BE)

“Safe” human dose
RfD, TDI: mg/kg-d

Uncertainty Factors

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

Pharmacokinetics

Human urine/blood level
BE: µg/L

Uncertainty Factors

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

Human urine/blood level
BE_{POD}: µg/L
Interpretation of Biomonitoring Data using BEs

Source: LaKind et al., 2008
Use of BEs: assess exposure in a public health risk context

Arsenic in urine

CHMS Data: GM  P95
Use of BEs: as a screening tool across a set of chemicals

**HAZARD QUOTIENT (HQ)**

\[
HQ = \frac{\text{BIOMARKER CONCENTRATION}}{\text{SCREENING VALUE (E.G. BE)}}
\]

HQ > 1
CONC. MEASURED ABOVE SCREENING VALUE (E.G. BE)

HQ < 1
CONC. MEASURED BELOW SCREENING VALUE (E.G. BE)
Use of BEs: Identify chemicals for further action

CHMS Chemicals: Short half-lives

From: St-Amand et al., Toxicol. Lett. (2014)
Use of BEs: Identify chemicals for further action

CHMS Chemicals: Long half-lives

From: St-Amand et al., Toxicol. Lett. (2014)
Uses of CHMS Biomonitoring Data

Inform Risk Assessment

Canadian Health Measures Survey

Contribute to International Agreements and Programs

Inform Risk Management

National Reporting
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 (pending)
- 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 (pending)
- 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 CHMS Biomonitoring Data

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
CHMS Performance: Journal Articles by Year

CHMS Biomonitoring: 252 articles, cumulative

*CHMS bibliography has not been updated beyond January 2016
Concluding Remarks

CHMS provides important nationally representative HBM data

HBM data are being used to:

- Establish baselines of levels of chemicals in the Canadian population and track trends over time
- Assess exposure and health risk
- Inform chemical risk assessment and risk management activities
- Assess effectiveness of regulatory and risk management actions
- Study associations between HBM and other health and lifestyle factors
- Contribute to national and international monitoring and reporting programs
Canadian Health Measures Survey

www.healthcanada.gc.ca/biomonitoring

www.statcan.gc.ca/chms