Exposure to Environmental Chemicals in Canada:
Recent Data from the Canadian Health Measures Survey

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YOUR HEALTH AND SAFETY... OUR PRIORITY.
Human biomonitoring data inform and support the federal government in its ongoing monitoring, surveillance, risk management, and regulatory activities, which are required by multiple legislative acts such as

- *Canadian Environmental Protection Act, 1999*
- *Pest Control Products Act*
- *Food and Drugs Act*
- *Hazardous Products Act*

**Biomonitoring data are used**

- as evidence in risk assessment
- to track effectiveness of risk management actions
- as a feeder for re-assessment prioritization
The Canadian Health Measures Survey (CHMS) is a national health survey led by Statistics Canada, in partnership with Health Canada and the Public Health Agency of Canada. The national biomonitoring program is conducted as part of the CHMS.

Survey Objective: Provide information on chronic and infectious disease, physical fitness, nutrition, and other factors that influence health (includes a biomonitoring component).

Components:
- Household component
- Mobile Examination Centre (MEC) component
- Laboratory component
- Biobank component
National Biomonitoring Program

CHMS Sampling Strategy

- Cross-sectional survey carried out in 2-year cycles
- Age groups: 1-2*, 3-5, 6-11, 12-19, 20-39, 40-59, 60-79 yrs
- Collection sites stratified in 5 regions across the country
- Sample size (n = 5,000-6,000) to yield national estimates
- Covers 96% of population

National Biomonitoring Program under the Canadian Health Measures Survey

- Cycle 2 – 18 sites (2009-2011)
- Cycle 3 – 16 sites (2012-2013)
- Cycle 5 – 16 sites (2016-2017)
- Cycle 6 – 16 sites (2018-2019)
National Biomonitoring Program Objectives

- Establish *nationally-representative blood and urine 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 chemicals in blood or urine, other physical measures, and self-reported information*
Environmental Chemicals

- Cycles are paired (to expand sample size)
- Chemicals can be cycled in and out
- New chemicals added as they are identified as priorities or methods become available
Biomonitoring Component of the Canadian Health Measures Survey

- Four national biomonitoring reports published to date - [www.canada.ca/biomonitoring](http://www.canada.ca/biomonitoring)

Reports contain:
- Background information for each chemical
- Descriptive statistics by age and sex (geometric mean, 10th, 50th, 90th, 95th percentiles)
Analysis of National Trends

**LEAD**

**Time:**

- **CHS 1978 to 1979:** 4.79
- **CHMS 2007 to 2009:** 1.3
- **CHMS 2009 to 2011:** 1.2
- **CHMS 2012 to 2013:** 1.1
- **CHMS 2014 to 2015:** 0.95

**Levels Declining Since 1978-79**

**Age:** Concentrations lower in children than in adults; highest in adults aged 60 to 79 years

**Sex:** Concentrations higher in men than in women

- **Geometric Mean**
- **95th Percentile**
**Analysis of National Trends**

**CADMIUM**

**Time:** No significant trend in the average concentration of cadmium in blood.

**Age:** Concentrations highest in adults aged 40 to 59 years and 60 to 79 years.

**Sex:** Concentrations higher in women than in men.

Graph showing:
- **Blood Cadmium (µg/L)**
- Geometric Mean and 95th Percentile markers
Analysis of National Trends

MERCURY

**Time:** No significant trend in the average concentration of mercury in blood

**Age:** Concentrations were higher in adults than in children

**Sex:** Concentrations similar in women and men

- Geometric Mean
- 95th Percentile

<table>
<thead>
<tr>
<th>Year Period</th>
<th>Geometric Mean</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007 to 2009</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>2009 to 2011</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>2012 to 2013</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>2014 to 2015</td>
<td>n/a</td>
<td></td>
</tr>
</tbody>
</table>
Health Effects

Neurotoxicity, scaling and pigmentation changes in the skin, circulatory issues, and increased cancer risk

Regulation in Canada

- Inorganic arsenic compounds are classified carcinogenic and toxic to human health and are listed on the List of Toxic Substances under the Canadian Environmental Protection Act (1999).

- Canadian drinking water quality guideline sets out the maximum acceptable concentration (MAC) for arsenic in drinking water as 0.010 mg/L (10 μg/L) based on treatment considerations. Every effort should be made to maintain arsenic levels in drinking water as low as reasonably achievable (or ALARA).

- Arsenic has been added to the list of Contaminants and other Adulterating Substances in Foods. Maximum Levels have been established for arsenic in fish protein, bone meal, fruit juices, and fruit nectars.
Sources of Environmental Arsenic in Canada

**Natural sources:** arsenic soils, minerals, and ores entering lakes, rivers or groundwater

**Anthropogenic sources:** Smelters, burning of fossil fuels, industrial uses of arsenic

**Historic uses:** Lead arsenate as a pesticide, chromated copper arsenate as a wood preservative. Organic arsenical herbicides, such as MMA and DMA, are no longer registered for use in Canada.

Sources of Arsenic Exposure

- Food, drinking water, soil, and ambient air

- Diet represents a major source with high concentrations of inorganic arsenic in terrestrial foods (e.g., grains, including rice), and organic arsenic in seafood (fin fish, shell fish, and seaweed)
Relationship between urinary biomarkers of exposure to inorganic and organic arsenic species (Hays et al, 2010; Taylor et al. 2017):

**Inorganic Derived Arsenic**
- $\text{As}^{\text{III}}, \text{As}^{\text{V}}$ compounds $\Rightarrow$ MMA & DMA
- Exposure through diet, drinking water, contact with soils, inhalation

**Organic Derived Arsenic**
- Arsenobetaine & arsenocholine (no appreciable metabolism expected)
- As-lipids & As-sugars $\Rightarrow$ DMA
- Exposure through consumption of seafood

**Total Arsenic Exposure**

Urinary excretion

- $\text{iAs}$ (As$^{\text{III}}$ or As$^{\text{V}}$)
- MMA
- DMA
- arsenobetaine
- arsenocholine

**Arsenic – Biomarkers**
## Multiple regression model and LSGMs for urinary $\Sigma$(DMA, MMA, As3+) concentrations

Concentrations were significantly associated ($p<0.05$) with:

<table>
<thead>
<tr>
<th>Factor</th>
<th>$\beta$</th>
<th>LSGM (µg/L)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age groups</strong></td>
<td></td>
<td></td>
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<tr>
<td>6-11</td>
<td>0.40</td>
<td>6.4</td>
<td>$&lt;0.0001$</td>
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<tr>
<td>12-59</td>
<td>Reference</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>60-79</td>
<td>0.21</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td><strong>Rice consumption</strong></td>
<td></td>
<td></td>
<td>0.0230</td>
</tr>
<tr>
<td>Less than once per day</td>
<td>Reference</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Once per day or more</td>
<td>0.41</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td><strong>Arsenobetaine and arsenocholine</strong></td>
<td></td>
<td></td>
<td>$&lt;0.0001$</td>
</tr>
<tr>
<td>Non-detected</td>
<td>Reference</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>Detected</td>
<td>0.45</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
<td></td>
<td>0.0002</td>
</tr>
<tr>
<td>White</td>
<td>Reference</td>
<td>4.3</td>
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</tr>
<tr>
<td>Black</td>
<td>0.27</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>0.45</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0.21</td>
<td>5.1</td>
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<tr>
<td><strong>Smoking status</strong></td>
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<td>0.0100</td>
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<tr>
<td>Smoker</td>
<td>-0.21</td>
<td>3.9</td>
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</tr>
<tr>
<td>Non-smoker</td>
<td>Reference</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>Ate shellfish over the past month</td>
<td></td>
<td></td>
<td>0.0038</td>
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<tr>
<td>Yes</td>
<td>0.2</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Reference</td>
<td>4.1</td>
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</tr>
<tr>
<td>Creatinine (g/L)</td>
<td>0.64</td>
<td>$&lt;0.0001$</td>
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<tr>
<td>$R^2$</td>
<td>0.48</td>
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</tbody>
</table>

- 6-11 > 12-59 years
- 6-11 > 60-79 years
- Eating rice once or more per day > eating rice less than once per day
- Higher concentrations in individuals with detected levels of arsenobetaine and arsenocholine
- Asian > White
- Black > White
- Non-smokers > Smokers
- Ate shellfish in the last month > did not eat shell fish in the last month

Not significantly associated with:
- Source of drinking water (municipally treated tap water, private well tap water, bottled water or other)
- Sex
- Milk and juice consumption
Conclusion

• This nationally-representative dataset reflects background concentrations for the Canadian general population

• Dietary sources of exposure to inorganic arsenic are quite varied but regression modelling indicates that rice and shellfish may be among the larger contributors

• Further analysis will be conducted with more recent data from combined CHMS cycles 3 and 4

• This data supports Health Canada in the overall management of arsenic exposure in Canada
Additional Information

- Canada’s National Biomonitoring Program
  - www.canada.ca/biomonitoring
  - www.open.canada.ca

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- Statistics Canada CHMS information
  - www.statcan.gc.ca/chms