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April 29, 2022

Senate of Canada ~

On behalf of Prevent Cancer Now, I am pleased to submit the following comments and recommended amendments, regarding Bill S-5 amending the *Canadian Environmental Protection Act*.

I would also be grateful for the opportunity to address the ENEV Committee to assist in this important matter for environmental health and, indeed, our future.

Prevent Cancer Now (PCN) congratulates the Government of Canada for advancing important amendments to the *Canadian Environmental Protection Act, 1999* (CEPA) in Bill S-5. The Right to a Healthy Environment is the goal that, practically, morally and ethically, we must target.

Bill S-5 addresses many concerns of the decades since CEPA, 1999 was passed. The legislation must be strengthened, however, to achieve the environmental imperatives of 2022 and beyond.

CEPA is a central statute to address increasing incidence of some cancers, developmental problems and chronic diseases among Canadians (see Appendix 1), as well as environmental degradation. Substantial reductions in environmental releases and consumption are necessary to meet the necessity to limit greenhouse gases and other pollution, causing declines and extinctions of habitats, keystone species and essential pollinators, as well as climate chaos.

The forest fires, droughts and diminished crops of 2021 show how environment, economy and health are inextricably linked, confirming the under-appreciated, albeit prohibitive, costs of pollution to Canadian families, businesses and governments. The International Institute for Sustainable Development reported $36 billion costs for smog impacts on health and well-being in Canada in 2015, and greater costs from other toxicants (e.g., green-house gases and toxic metals) affecting human health, crops, forests, business and natural capital.[1] In 2021, Health Canada attributed 15,300 premature deaths in 2016, and $120 billion in costs (6% of Canada's GDP) to air pollution.[2]

Climate-related disasters are becoming commonplace and threaten land-based foundations of Canadian economy and settlements such as agriculture and urban centres. Thus, environmental protection is recognized as being increasingly urgent, at a greater scale and degree than broadly acknowledged even a year ago. In this submission, we recommend that Bill S-5:

1. **Broaden characteristics of CEPA-toxic substances to prioritize and regulate toxicants** to include endocrine disruptors, immunotoxicants, neurotoxicants, substances toxic to specific organs, and respiratory sensitiser substances *for (group) restrictions,* for all uses. This scrutiny is necessary for

robust scientific assessments as animal testing is reduced, and is consistent with the ongoing rolling list of (groups of) substances for restrictions in Europe.[3]

2. **Implement *alternatives assessment*** using a **climate lens**, as well as "**essentiality"** to inform **substitution.** This approach approximates Canada's approach to plastic items, and could formalize and broaden applicability to other non-essential, potentially wasteful and polluting options in commerce. Alternatives assessment could also operationalize regulation of **classes** of chemicals, to avoid regrettable substitution.
3. **Initiate examination of radiofrequency electromagnetic radiation by amending S. 44**. A 2018 publication in The Lancet Planetary Health reported that levels of this bioactive radiation were approximately 1,000,000,000,000,000,000 times natural background. A White Paper by Prevent Cancer Now and Canadians for Safe Technology summarizes the science, regulatory background, and solution.[4] Fortunately performance, resilience and sustainability of fibre-optic cable is superior to wireless telecommunications.
4. **Identify and confederate data**, applying FAIRER principles (Findable, Accessible, Interoperable, Reproducible, Ethical and Revisable)[5] and **conduct ongoing analyses of exposure and health data** to facilitate identification of exposures that contribute to morbidity, disability and premature mortality in Canada (and associated burdens on society and costs to the public purse).

Outline

1. Broaden characteristics of toxicities of concern for substances, and prioritize regulation of toxicants to be consistent with the ongoing rolling list of (groups of) substances for restriction under REACH, in the European Union.[3] 3

2. Implement *alternatives assessment* using a "climate lens," as well as "essentiality" to implement "substitution." 5

3. Address radiofrequency electromagnetic radiation in an amendment to CEPA S. 44 7

4. Develop capacity for data collection, analyses and early detection of harms resulting from environmental exposures, including those regulated under CEPA. 9

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1. Broaden characteristics of toxicities of concern for substances, and prioritize regulation of toxicants to be consistent with the ongoing rolling list of (groups of) substances for restriction under REACH, in the European Union.[3]

Toxic endpoints are insufficient and require updating

CEPA 1999, Section. 44 states:

> **Hormone disrupting substances**
>
> (4) The Ministers shall conduct research or studies relating to hormone disrupting substances, methods related to their detection, methods to determine their actual or likely short-term or long-term effect on the environment and human health, and preventive, control and abatement measures to deal with those substances to protect the environment and human health.

In the interim, decades of research demonstrate overwhelming scientific evidence that endocrine disruption is a key mode of action leading to cancers, obesity and related chronic diseases, and developmental harms. Testing methodologies have been developed and repeated expert consensus statements by the Endocrine Society[6,7] and others[8] in the public domain. It is inexplicable why hormone disruption (often termed endocrine disruption) has not yet been advanced to being considered "toxic" in Bill S-5. The science is established and Canadians are not well served by inaction to protect our health and the trajectory of human development, from these numerous, ubiquitous toxicants in everyday products.

Consideration of additional endpoints is necessary to reduce animal testing, and to modernize assessments

In order to reduce animal testing, there will have to be greater reliance on *in vitro* testing and modelling. These tests examine endpoints such as endocrine disruption, immunotoxicity and other "toxic" endpoints. On the other hand, carcinogenicity must be tested in animals and/or unfortunately discerned after harms have occurred in humans (over decades or generations).

We cannot move beyond animal testing if outcomes from other testing as being used in Europe are not included in Bill S-5.

On April 25, 2022, the European Union released its proposed **Restrictions Roadmap under the Chemicals Strategy for Sustainability**,[3] prioritizing substances that are: carcinogenic, mutagenic and reprotoxic (CMR); persistent, bioaccumulative and toxic (PBT); and very persistent and very bioaccumulative (vPvB). This is consistent with CEPA.

> *In addition* the EU is prioritizing endocrine disruptors, immunotoxicants, neurotoxicants, substances toxic to specific organs, and respiratory sensitiser substances *for (group) restrictions,* for all uses.

This wider scope also mirrors the spectrum of increasing chronic diseases, and known adverse effects of chemicals (see Appendix 1 for a brief overview).

Assessments addressing classes of chemicals under Canada's Chemicals Management Plan have typically been narrowly scoped to single endocrine outcomes (e.g. phthalates were examined for androgenic but not estrogenic effects), may omit substances that are likely to exhibit effects, and are often limited by inadequate compilation of scientific information (see PCN responses to consultations

on Naphthalene Sulfonic Acids, Phthalates, Fragrances, PFAS on food contact materials, Informed Substitution, Endocrine Disrupting Chemicals: A Roadmap for Action, and CEPA Review, available from: preventcancernow.ca/submissions/).

Europe has taken a lead, with a stronger scientific basis and framework. Detailed Guidance on assessment of endocrine disruption, the result of extensive consultation by the European Commission, was published in 2018,[9] stipulating that EATS (estrogenic, androgenic, thyroidal and steroidogenic) modes of action must be investigated. A case study demonstrating application of this guidance found that bisphenol AF (a BPA substitute) inhibited both estrogen and androgen receptors, causing reproductive dysfunction in both females and males.[10] Work is proceeding on adverse effects and safer substitutes for endocrine-disrupting families of chemicals such as phthalates, bisphenols, and halogenated chemicals including anti-stick, anti-stain, waterproofing and fire resistant products.

PCN recommends that CEPA be amended to match priorities for assessment (characteristics of toxicants) applied in the European Union to identify and restrict toxic substances:

> carcinogenic, mutagenic and reprotoxic substances (CMR), **endocrine disruptors**, persistent, bioaccumulative and toxic (PBT), and very persistent and very bioaccumulative (vPvB) substances, **immunotoxicants, neurotoxicants, substances toxic to specific organs, and respiratory sensitiser substances *for (group) restrictions,* for all uses**.

Thresholds requiring biological effects to be "adverse" to trigger action leave Canadians and the environment at risk.

CEPA replaced and in many ways improved upon the *Environmental Contaminants Act (ECA)*. The ECA, however, had a clearer and less equivocal metric for evaluation, acting upon a biological "change" without the ill-defined requirement for the change to be "adverse." Long delays and inaction on chemicals despite knowledge of biological effects have occurred in recent years equivocating over the possibility that known biological or biochemical effects are "adverse." Actions that were taken on triclosan, bisphenol A (BPA) and flame retardants were limited following such debates. PCN recommends amending CEPA to give weight to biological changes resulting from environmental exposures:

> require data and to investigate as to the nature, presence, dispersal, accumulation, persistence, methods of control and testing, as well as
> "**the ability of the substance or of any class of substances of which it is a member to become incorporated and to accumulate in biological tissues or to cause biological *change***";
>
> **The definition of "class of substance" is:**
>
> "class of substances" means any two or more substances that:
>
> (a) contain the same chemical moiety, or
>
> (b) have similar chemical properties and the same type of chemical structure.

2. Implement *alternatives assessment* using a "climate lens," as well as "essentiality" to implement "substitution."

PCN broadly supports Bill S-5 and amendments proposed by the Canadian Environmental Law Association (CELA). We recommend clarifications regarding alternatives.

Among its roles to protect the environment, CEPA is used to limit or proscribe uses of substances or technologies either broadly or for particular applications. To date CEPA has been used to set a maximum bar to address the most toxic substances, but implementing The Right to a Healthy Environment will require *a shift to broader requirements for best practices*. Greenhouse gas emission reduction will require reductions in substances in commerce, with rapid transitions to improve durability, waste reduction and elimination, and resilience.

Alternatives may be identified at different levels, such as a *drop-in substitute* (this can result in unfortunate substitutes as seen for example with bisphenols, halogenated chemicals and phthalates), a *functional substitute* (e.g. non-halogenated water-proofing options to replace PFAS), a *fundamental design change* (e.g. use of non-flammable substances for insulation products instead of flame retardants incorporated in plastic), *improvements in durability and recyclability* to lower life cycle impacts, or *prohibition* such as happened with plastic microbeads in personal care products.

"Essentiality"/"Essential Use" is a provocative, potentially game-changing and, in the context of climate imperatives, essential criterion to advance — to effectively and equitably reduce Canadians' greenhouse gas footprint and to become a global environmental leader.

Applications of "highest and best use" and "essential use" are powerful tools, and are not new concepts. The Montreal Protocol to limit ozone-depleting substances is an early example, and now reduction and elimination of single-use plastic items is another. Canada has done it before, but it would be helpful to codify these concepts in CEPA.

Alternatives assessment, including consideration of essentiality and substitution would apply to substances and durable goods, as well as to telecommunications technologies to minimize "wireless"emission of radiofrequency electromagnetic radiation (RF-EMR) (see below).

PROPOSED AMENDMENTS

PCN supports amendments proposed by CELA, and highlights the following [*PCN italics are added to CELA recommendations]*:

4(2) Subsection 3(1) of the Act is amended by adding the following:

> **analysis of alternatives** means an assessment of whether safer, suitable alternative substances or technologies are available including: (a) whether the transition to an alternative would result in reduced overall risks to human health and the environment, taking into account the appropriateness and effectiveness of risk management or risk removal measures; (b) the technical and economic feasibility of the alternatives; *and (c) total life-cycle resource use and greenhouse gas releases associated with alternative substances, products or technologies. Alternatives include the null alternative, based upon the essentiality of the substance, product or technology.*
>
> ***essentiality assessment** means an assessment of the extent to which benefits associated with*

the substance, product or technology are essential for human or environmental health, in particular applications. Essentiality is a consideration for selecting the null alternative, in alternatives assessment.

safer alternative means an option that includes input substitution as well as including a change in chemical, material, product, process, function, system or other action, whose adoption to replace a toxic substance *or technology* would be the most effective in comparison with another chemical, material, product, process, function, system, or other action*,* and the phrase "alternatives that are safer" has the same meaning;

substitution principle means toxic substances listed in Schedule 1 *and technologies that pose risks to human or environmental health* are progressively replaced by non-hazardous or less hazardous *alternatives*, including non-chemical alternatives, or safer technologies where these are technically and economically feasible;

technically feasible means that the technical knowledge, equipment, materials and other resources available in the marketplace are expected to be sufficient to develop and implement a safer alternative, and the phrase "technically viable" has the same meaning;

Bill S-5 includes an implementation framework, which could include development of alternatives assessment, essentiality and substitution with an additional clause.

Implementation framework

5.1 (1) For the purposes of paragraph 2(1)(a.2), the Ministers shall, within two years after the day on which this section comes into force, develop an implementation framework to set out how the right to a healthy environment will be considered in the administration of this Act.

(a) the principles to be considered in the administration of this Act, such as principles of environmental justice — including the avoidance of adverse effects that disproportionately affect vulnerable populations — and the principle of non-regression;

(b) research, studies or monitoring activities to support the protection of the right to a healthy environment referred to in paragraph 2(1)(a.2); and

(c) the balancing of that right with relevant factors, including social, economic, health and scientific factors

ADD

(d) *alternatives assessment, including consideration of essentiality and implemented via substitution, to improve transparency and to advance and support best practices for a healthy environment, in scientific assessments and pollution prevention.*

3. Address radiofrequency electromagnetic radiation in an amendment to CEPA S. 44

There is no law, regulation, or involvement of Environment and Climate Change Canada to address environmental effects of radiofrequency electromagnetic radiation (RF-EMR). An amendment is proposed below, to study this issue with a view to regulating RF-EMR to protect environmental as well as human health. It is recommended that this be included also under the Implementation Framework subsection (b), referenced above.

The issue of environmental effects of RF-EMF is described thoroughly with scientific references in the accompanying White Paper, "Protect Birds, Bees and Trees. Include Anthropogenic Radiofrequency Electromagnetic Radiation in Canadian Environmental Protection Act Amendments" (Updated April 2022).[11] Summary points are as follows:

- Flora and fauna, including insects and birds, can be affected adversely by radiofrequency electromagnetic radiation (RF-EMR) used for wireless telecommunications. Species' collapse lends urgency to assessment and environmental protection from anthropogenic RF-EMR. Canadian assessment and regulation focuses solely on human health.
- Unlike toxic substances, RF-EMR from modern technologies is not addressed as a risk to the environment under the *Canadian Environmental Protection Act* (CEPA), or other national laws.
- Health Canada's Safety Code 6 "Limits for human exposure to radiofrequency electromagnetic energy" guidelines are implemented by Innovation, Science and Economic Development (ISED) to protect humans from "established," adverse effects, specifically nerve stimulation at lower frequencies and over-heating of tissue at frequencies for telecommunications.
- In other species, biological effects of RF-EMR have been identified in all taxa that were adequately studied. Effects have been observed at ambient and low-intensity levels of exposure, such as from Wi-Fi and cell towers (base stations) at a distance.
- The dramatic worldwide decline of populations of birds, insects and other biota makes this an urgent issue. According to scientists who specialize in this field, exposure to RF-EMR at ambient levels may well be a co-factor, along with pesticides, habitat loss and climate change.
- The rollout of novel technologies is increasing RF-EMR levels, as well as introducing frequencies and modulations not previously used.
- Increasing numbers of structures with multiple cellular network antennas (specifically designed to emit RF-EMR) are being installed across Canada, in urban, rural and wilderness areas. These antennas will support the operation of hundreds of thousands additional smaller antennas (e.g., 4G, 5G) being mounted on non-tower structures (e.g., street furniture, buildings, lamp-posts and other utility poles). At the same time, tens of thousands more telecommunications satellites are being launched to emit RF-EMR.
- RF-EMR is clearly an environmental agent that is potentially harmful, as a pollutant. Exposure to wireless radiation has serious implications for biodiversity and ecosystem health.
- Cumulative and synergistic effects may occur with wireless radiation plus chemical substances.[12,13]

Natural background levels of RF-EMR are very low, but peak ambient levels have increased over recent decades up to 1,000,000,000,000,000,000 times natural background levels for frequencies used in telecommunications, according to a 2018 report in *The Lancet Planetary Health*.[14] Scientific research indicates that this environmental agent affects all biota that have been adequately studied, including birds, insects and trees.[15,16,17] RF-EMR also magnifies the toxicity of chemicals, according to numerous laboratory studies, as well findings of interaction between mobile phone use and lead on child neurodevelopment.[12,13]

RF-EMR used for telecommunications is managed to protect human health according to Health Canada "Safety Code 6" guidelines.[18] This document is referenced in other guidance and regulations regarding telecommunications equipment/infrastructure. As discussed in the White Paper, CEPA and other environmental laws are referenced, yet all of these laws are silent on the topic of RF-EMR.

PCN recommends that Bill S-5 be amended to initiate review of RF-EMF to protect both human and environmental health as follows:

6.1 Section 43 of the Act is amended by adding the following after the last definition in the section:

"radiofrequency electromagnetic radiation" means:

> radiated energy arising from accelerating electrical charges, having the form of electromagnetic waves and a stream of photons, and in a vacuum travels at the speed of light. The rate of oscillation of the waves is in the range between 3 kilohertz (kHz) to 300 gigahertz (GHz), which corresponds to the frequency of the non-sinusoidal radio waves typically used in radio communications.

7 Section 44 of the Act is amended by adding the following after subsection (4):

Radiofrequency electromagnetic radiation

(5) The Ministers shall conduct research or studies relating to radiofrequency electromagnetic radiation, methods related to its detection, methods to determine its actual or likely short-term or long-term effect on the environment and human health, and preventive, control and abatement measures to deal with it, and alternatives to its use, to protect the environment and human health.

PCN recommends that this review of RF-EMR be included in the Implementation Framework

4. Develop capacity for data collection, analyses and early detection of harms resulting from environmental exposures, including those regulated under CEPA.

Decisions made under CEPA that allow releases of and exposures to environmental agents are based on available information, which is generally (and necessarily) incomplete. For example, residues from new and existing substances and uses may take time to accumulate, effects may be delayed, interactions with other exposures may be seen locally, and thus harms may not be detected for considerable time. As such, initial decisions are essentially hypotheses.

Having proposed hypotheses in the course of administering CEPA, ethically it is incumbent upon the government to require data and research to address hypotheses that environmental agents in Canada are not causing harm.

Findings of long-term or delayed effects or harms, often seen first in susceptible or vulnerable populations, may ultimately result in decisions being amended and substitutes coming into commerce. This typically occurs many years following initial introduction of the exposure, following repeated cases of harms that eventually come to public attention. Awareness and evidence in scientific publications using data from jurisdictions with richer data resources may be of limited or delayed impact as Canadian applicability of the research is contested.

Thus, there is an ethical imperative to ensure that:

1) initial information from proponents is provided at early stages and is as robust as possible;
2) precautionary approaches are utilized in order to prevent harms; and
3) when adverse effects occur, that regrettable consequences are detected and addressed as rapidly, effectively and efficiently as possible.

This requires data, systematic and ongoing and routine analyses, and what Dr. Michael Gilbertson characterises as “forensic analysis” to piece together causal pathways.

Canada makes limited health data public, and replacements for some online resources that were cut during a previous government are not as rich as decades ago. More data, data sources and electronic infrastructure is needed to support CEPA decision-making. Appendix 2 includes an overview of some current data sources, and describes linking of health information with data addressing exposures, to gain capacity to discern effects.

We Must Not Fail

The International Panel on Climate Change reported in April 2022 that the world must urgently *reverse* the ongoing increases in greenhouse gases by 2025 – a mere three years from today – to have an even odds for a liveable world for today’s children (1.5 to 2 degrees Celsius warming).[19] The world our descendants inherit will be shaped by measures we implement today, and by the leadership to achieve urgent, rapid action in everyone’s best interests.

About Us

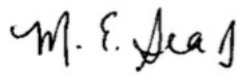
Prevent Cancer Now (PCN) is Canada's national non-governmental organization focused on primary cancer prevention – "stopping cancer before it starts." This includes actions to reduce and eliminate exposures that contribute to development of cancer, many of which are regulated under CEPA. Over more than a decade we have been directly involved with actions and programs under *Canadian Environmental Protection Act, 1999* (CEPA):

- participating in and observing numerous consultations and meetings;
- following pollution and public health topics both in the scientific literature and regulatory contexts in Canada and internationally;
- making numerous submissions to consultations under the Chemicals Management Plan and Parliamentary studies of CEPA and Safety Code 6; and
- advancing the science and ethics for regulatory decision-making, including laboratory studies, epidemiology and methodology to detect and to prevent harms from environmental exposures.

Please do not hesitate to ask for clarification or further information, or if we may be of further service.

On behalf of Prevent Cancer Now I would be grateful for the opportunity to assist the ENEV Committee in person.

Respectfully Submitted,



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Appendix 1: Environmentally-linked adverse health conditions are increasing in Canadians

If CEPA was indeed protecting public health, we would expect declining diseases associated with anthropogenic exposures. Instead, consistent with Canadian-led research on low dose mixtures of chemicals,[20] we see increasing conditions associated with changed signalling in endocrine systems (e.g., sexual development and reproduction; eating behaviours and metabolism; and neurological development and function), and some cancers. As well, intergenerational effects occur even when the genetic code is not mutated; rather, epigenetic changes that affect expression and suppression of particular genes, can alter susceptibility to dysfunction and disease. Higher prevalence is seen in racialized[21] and more highly exposed populations. Examples of adverse trends in public health linked to toxicants include:

- Extensive basic research illuminates **interacting mechanisms**[22] of chemicals in cellular signalling,[6,7] gene expression (epi-genetic effects),[23] metabolism (including oxidative stress), development and health as a result of environmental exposures and the microbiome,[24,25] from pre-conception and across the life span.[26]
- Although historically exceedingly rare in children, prevalence of **type 2 diabetes** now exceeds that of type 1 diabetes in Canadian youth. In Manitoba, where rates are up to 20-fold higher than in some other areas of Canada, type 2 diabetes increased from 9 to 21 per 100,000 children <18 years of age between 2006 and 2011.[27] Type 2 diabetes is also increasing rapidly in Ontario children.[28] Potentially informing aetiology, a prospective nurses' study report and review describes associations between plasma levels of persistent toxicants and diabetes, as well as interactions with weight changes (Fatty tissue is thought to be protective because it sequesters lipophilic toxicants, that are released into the bloodstream and other tissues during weight loss).[29]
- Storage of toxic chemicals in fat, evident with increased blood levels of toxicants with weight loss, may underlie numerous adverse conditions.[30,31,32] The "**obesity paradox**" where adipose tissue appears to be protective against disease has been noted for cancer (with cautions regarding analytical complexities),[33] heart failure and mortality in patients with diabetes,[34] and increasing population-adjusted rates of certain cancers, many of which are hormone-related;[35]
- **Obesity** increases risks for about a dozen cancers.[36,37] In Canada, smoking-related cancers are decreasing as smoking rates have fallen, but obesity- and endocrine-related cancers are increasing,[35] although early detection and treatment can help to avert severe disease;
- **Male genital birth defects** clustered in agricultural regions of Nova Scotia, in contrast with non-endocrine mediated congenital abnormalities that were not clustered;[38]
- **Lymphoid leukemia** incidence rate in Manitoba children increased between 1984 and 2013, with variations by geographic area (suspected to be related to unidentified environmental agents);[39]
- **Autoimmune disease** is increasing rapidly in developed countries.[40] Canada ranks globally among the **highest rates of inflammatory bowel disease in children**, driven by increasing incidence in the youngest children of 6.5% annually;[41]
- **Inflammatory bowel disease** predisposes to **colorectal cancer**, which is increasing 7% annually in Canadian adolescents and young adults[42] (the similar rates are thought to be associated);

- **Neurological development** can be impacted by many toxicants,[43] such as metals lead,[44] mercury [45] and manganese,[46] and endocrine disruptors such as bisphenol-A (BPA),[47] to name a few. Increases in prevalence and incidence of treated attention-deficit hyperactivity disorder (ADHD) were not uniform across Canadian provinces, suggesting non-uniform contributors to the condition;[48]
- Recent research reviews **life-changing biological impacts of volatile chemicals** and the myriad of scented products in daily use.[49]

Appendix 2: Data and analyses to detect harms from toxicants in Canadians – a brief discussion

Concluding that environmental exposures cause harms poses scientific challenges, that may be met with modern data capabilities and sophisticated methods with powerful computers. Ethical issues also arise as to the burden of proof of harm versus safety, in the context of the social and private benefits associated with environmental exposures, and The Right to a Healthy Environment.

Determining causality in human epidemiology is complex, with many possible routes of arguments. It requires a combination of longitudinal exposures and health data, and forensic investigations of exposures and mechanisms of harms, as outlined by Michael Gilbertson to the Senate ENEV Committee, in the Halifax Project[50] and investigation of workers' breast cancer.[51]

Longitudinal studies capture temporality – that an exposure preceded a health outcome – so these resource-intensive datasets may provide powerful evidence that certain exposures cause related outcomes. Canada has some longitudinal studies with limited data on well-known toxicants as well as biobanking, including the national Maternal-Infant Research on Environmental Chemicals (MIREC), as well as regional studies such as the Ontario Health Survey and Atlantic PATH (with its helpful collection of toe nail samples), and some efforts with Aboriginal (particularly northern) populations.

The **Canadian Health Measures Survey** (CHMS) was initiated after it was decided that Canada would not join the larger National Health and Nutrition Examination Survey (NHANES) effort in the US. CHMS "cycles" are periodic "snapshots" in largely healthy people of a particular sample of toxicants in blood and urine for each cycle, as well as some basic health information from a physical examination and questionnaire. Some chemicals or metabolites are repeated in subsequent cycles, and some are one-time assessments. Importantly, unlike longitudinal studies, measures are not repeated in an identified cohort; each cycle is a cross-section of Canadians who have access to the facilities for the testing. Participants are not Aboriginal or in the North; there are separate smaller projects for them.

Caution is warranted in comparing CHMS cycles because detection limits are not always consistent. Finally, the CHMS may not assess regrettable substitutions as seen for example with:

- bisphenol-A (BPA) was recently reported to be decreasing in Canadians, but endocrine-disrupting bisphenol substitutes, that are increasing in use, were not analysed;
- some fluorinated anti-stick and anti-stain chemicals, while production has been moving to smaller (but still persistent and toxic) substitutes that were not analysed;
- some phthalates with many uses, e.g. to soften plastics, in cosmetics, and to make fragrance molecules off-gas more slowly (there are hundreds of phthalate chemicals); and
- some brominated flame retardants.

Additional information sources would be needed beyond the CHMS to establish causality of exposure and health outcome, as temporality cannot be determined in one-off studies, and ongoing state of health is not followed.

Occupational and regional clusters in workers, and vulnerable, disadvantaged, racialized and marginalized individuals and communities, such as investigated by Brophy, Keith, Gilberson, Rochon-Ford and others, can be informative; unfortunately with higher exposures and higher incidence of harms.[,51,52]

Surrogate exposure data may apply locally or according to occupation, such as air quality or drinking water quality determined by postal code (and geological survey data for groundwater), or nutritional

intake with questionnaires. CANadian Urban Environment (CANUE) works on air quality, "greenness" and urban form.

Information infrastructure needs to be developed, to mine data on health outcomes and environmental exposures (beneficial and adverse) – in the air, water, food, at home, work, school and during leisure. Some means to fill "exposure" gaps include accessing under-utilized data sources such as geological groundwater data and legacy lead pipe infrastructure, a clinical environmental exposures questionnaire, and facilitating access to testing for toxicants in certain populations when environmentally-linked conditions are being investigated.[53] Collecting, confederating and conducting ongoing analyses of exposure and health data may facilitate identification of exposures that contribute to morbidity, disability and premature mortality in Canada (and associated burdens on society and costs to the public purse). The **Pan-Canadian Health Data Strategy**[54] is gaining ground, and should include health data that may be related to contaminants.

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