The challenge of pollution and health in Canada

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Abstract

The Lancet Commission on Pollution and Health, which conducted a comprehensive assessment of the health and economic impacts of key forms of toxic pollutants in air, water, and soil, estimated that 9 million people die annually from the impact of pollution, which represents 16% of all deaths worldwide. Over 90% of these pollution-related deaths occur in low- and middle-income countries. While Canada ranks seventh lowest in the world, the burden is still too high; many pollutants were not considered in the Commission's work, and vulnerable populations—including the poor, women, children, and Indigenous peoples—are disproportionately affected by pollution in Canada. As Canadian co-authors in the Lancet Commission, here we consider the impact of pollution on the health of Canadians and discuss how best to address the problem.

Résumé

La *Lancet Commission on Pollution and Health*, qui a mené une évaluation complète des impacts des principales formes de pollution de l'air, de l'eau et du sol sur la santé et l'économie, a estimé que 9 millions de personnes meurent chaque année des conséquences de la pollution, ce qui représente 16 % de tous les décès dans le monde. Plus de 90 % de ces décès liés à la pollution ont lieu dans les pays à revenu faible ou intermédiaire. Bien que le Canada se classe 7^e parmi les pays du monde ayant le moins de décès, le fardeau que la pollution impose aux Canadiens et Canadiennes est tout de même imposant. Notamment, plusieurs combinaisons polluant-maladie ne sont pas incluses dans les travaux de la Commission, et les personnes pauvres, les femmes, les enfants et les Autochtones sont atteints de manière disproportionnée par la pollution au Canada. En tant que co-auteurs canadiens du rapport de la Commission, nous examinons dans cet article les impacts de la pollution sur la santé des Canadiens et Canadiennes et discutons de la meilleure façon de régler le problème.

Keywords Public health · Pollution · Review · Canada · Disease · Environment

Mots-clés Santé publique · Pollution · La revue · Canada · Maladie · Environnement

Introduction

The Lancet Commission on Pollution and Health, which conducted a comprehensive assessment of the health and economic impacts of key forms of toxic pollution of our air, water, and

soil, estimated that 9 million people die annually from the impact of pollution, which represents 16% of all deaths worldwide (Landrigan et al. 2017). Over 90% of these pollution-related deaths occur in low- and middle-income countries, and in many areas pollution is getting worse.

The Lancet Commission on Pollution and Health calculated that pollution accounts for three times the number of premature deaths that result annually from malaria, tuberculosis, and HIV combined; pollution accounts for more deaths than those caused by smoking, hunger, and natural disasters. Yet international development assistance directs more than \$25 billion to malaria, tuberculosis, and HIV, and less than \$1 billion for pollution control and mitigation. Furthermore, pollution is a human rights issue, although we seldom consider it in such terms.

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Pollution is costly. The Lancet Commission estimated that pollution-related diseases may reduce the GDP of some countries by up to 2% per year. The report also outlined how pollution endangers planetary health and is tightly linked with global climate change.

The Lancet Commission estimated that 14,738 (5.3%) of 277,420 deaths among Canadians in 2015 were attributable to pollution. While Canada ranks seventh lowest in the world, the burden is still too high; many pollutants were not considered in the Commission's work, and the poor, women, children, and Indigenous peoples are disproportionately affected by pollution. As Canadians who co-authored the Lancet Commission, here we consider the impact of pollution on the health of Canadians and discuss how best to address the problem.

What is the burden of pollution in Canada?

Health burden

The recent Lancet Commission estimated that the 5.3% of Canadian deaths attributable to pollution in 2015 were linked to exposure to particulate matter (PM_{2.5} levels) in ambient air (7076 of 14,738 pollution-related deaths) and exposure to carcinogens, such as second-hand smoke (5934 deaths) (Landrigan et al. 2017). For comparison, in 2014, 4254 deaths were due to intentional self-harm and 439 deaths were due to homicide (CANSIM 2014).

Pollution's impacts on Canadians' health are under-estimated. The Lancet Commission studied the tip of the iceberg; we only calculated the burden of disease for well-established pollution-disease pairs with a large body of scientific evidence. We are exposed to many other pollutants for which we lack evidence to make robust linkages to death, disease, and disability. Even for the pollutants we know well, newer studies are revealing. For example, Health Canada estimated that air pollution alone caused 14,400 premature deaths each year (Health Canada 2017); a higher estimate than the Lancet Commission's.

Economic burden

Pollution also impacts the economy. The International Institute for Sustainable Development performed a systematic review and calculated that air pollution alone cost the Canadian economy \$36B in 2015; the total costs of all forms of pollution are perhaps twice this number (IISD 2017). This report notes that pollution's costs are realized in terms of human welfare, production and consumption of market goods, and value of assets that underpin wealth. Similar to health, the economic costs are under-estimated, largely owing to incomplete data and understanding.

To which pollutants are Canadians chiefly exposed?

Our national survey

Canadians are routinely exposed to many pollutants in our homes, schools, and workplaces. Since 2007, the Canadian Health Measures Survey (CHMS) has measured 270+ chemicals in the blood and urine of 29,000 Canadian participants aged 3–79 years old (CHMS 2017; Haines et al. 2017).

Chemicals of concern

The CHMS selects chemicals to biomonitor through multisectoral stakeholder consultations followed by deliberations on exposure potential, health risks, regulatory needs, analytical methods, and anticipated health policy considerations (CHMS 2017; Haines et al. 2017).

We can examine the top causes of death for Canadians (CANSIM 2014) and link many with notable pollutants on the CEPA list of Toxic Substances (Toxic Substances List 2018). For example, malignant neoplasms (no. 1 cause of death) may result from exposure to IARC Group 1 chemicals (carcinogenic to humans) like benzene, benzo(a)pyrene, hexavalent chromium, or asbestos. Causes of death ranked nos. 2–4 (heart disease, cerebrovascular diseases, chronic lower respiratory diseases, respectively) may result from exposure to particulate matter, lead, elemental carbon, and NO₂ (Brook et al. 2010; Hoek et al. 2013).

An unresolved issue

Our lack of toxicological knowledge for tens of thousands of pollutants is troubling (Judson et al. 2009). Simply put, we are flying blind. The number of chemical substances for which toxicity data are required is tremendous and backlogged (e.g., 23,000 initially in Canada with 1550 remaining now being addressed through our government's Chemicals Management Plan program). In response to this reality, there have been stern calls to modernize toxicity testing (NRC 2007). We are now starting to witness changes in how we test chemicals with new approaches, technologies, and regulatory change gaining traction in Canada (Chemicals Management Plan Science Committee 2016) and worldwide (ECHA 2017).

Which Canadians are particularly vulnerable to pollution?

We have a right to live in a healthy environment (Boyd 2012). We take for granted that our air, water, and food are safe, but the notion of environmental justice (Box 1) distresses many of our citizens and communities. Here we highlight three groups of Canadians who remain particularly vulnerable to pollution.

Box 1 Coming to “Terms.” Key pollution-related terms are detailed below. Definitions are drawn from the Government of Canada’s “Chemical Substances Glossary” unless otherwise indicated (<https://www.canada.ca/en/health-canada/services/chemical-substances/chemical-substances-glossary.html>; last accessed January 18, 2018).

Canadian Environmental Protection Act, 1999 (CEPA 1999): the purpose of the Act is to protect the environment, and the health and well-being of Canadians. A major part of the Act is to sustainably prevent pollution and address the potentially dangerous chemical substances to which we might be exposed. The Ministers of Environment and Health are responsible for CEPA 1999.

Chemicals Management Plan (CMP): the Government of Canada’s initiative at reducing risks posed by chemicals to Canadians and the Canadian environment. The CMP (overseen by both Environment and Climate Change Canada and Health Canada) addresses environmental and human health risks posed by chemical substances, and develops and implements measures to prevent or manage those risks. In 2006, the Government completed a triage of 23,000 chemicals that had been in commercial use, and from this activity identified 4300 priority substances that required attention. Now in its third phase, the CMP will address the remaining 1550 priority chemicals (of the original 4300).

Environmental Justice: as defined by the US EPA and widely accepted by the field is “the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. It will be achieved when everyone enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work.”

Exposure: the degree to which the environment or living things, including people, come into direct or indirect contact with a chemical substance. Health Canada assesses potential exposure of the general population to chemical substances from all routes (inhalation, ingestion, and contact on the skin) and all possible sources (ambient and indoor air, food, breast milk, soil, and household and consumer products). Environment and Climate Change Canada assesses exposure of ecosystems (water, air, soil, and wildlife).

Pollution: defined in the Lancet Commission “as unwanted, often dangerous, material that is introduced into the Earth’s environment as the result of human activity, that threatens human health, and that harms ecosystems.” This was based on a definition of pollution developed by the European Union (<http://eur-lex.europa.eu/eli/dir/2010/75/oj> last accessed January 6, 2018).

Risk: the risk a chemical substance poses is a function of its hazardous properties and the way people and the environment are exposed to those properties. The hazardous properties and exposure for people or the environment is determined through a scientific evaluation or risk assessment.

Toxic: a substance is defined as toxic by CEPA 1999 (Section 64, Part 5) “if it is entering or may enter the environment in a quantity or concentration or under conditions that (a) have or may have an immediate or long-term harmful effect on the environment or its biological diversity; (b) constitute or may constitute a danger to the environment on which life depends; or (c) constitute or may constitute a danger in Canada to human life or health”.

First, children and infants are at high risk of pollution-related disease (Landrigan and Goldman 2011). For example, lead (Lanphear et al. 2005) and methylmercury (Ha et al. 2017) are linked with intellectual deficits. MIREC, Maternal Infant Research on Environmental Chemicals, has been established by Health Canada as a birth cohort to uncover Canadian-specific evidence of links between early-life chemical exposures and later-life health outcomes (Arbuckle et al. 2013).

Second, evidence is mounting that some pollutants impair reproductive health and thus the rights of pregnant women and fetuses (Sutton et al. 2012). Based on strong evidence (mechanistic, experimental, animal, and epidemiological studies), societal concerns and advocacy about endocrine disrupting chemicals in baby bottles (bisphenol-A) and household materials (certain flame retardants) have spurred regulatory actions. The Endocrine Society released their second scientific statement in 2015 on endocrine disrupting chemicals based on translational evidence of impacts on seven physiological systems (obesity and diabetes, female reproduction, male reproduction, hormone-sensitive cancers in females, prostate cancer, thyroid, and neuroendocrine and neurodevelopment) (Gore et al. 2015).

Third, many of our Aboriginal communities are burdened with pollution. For example, 134 First Nations communities had drinking water advisories in place at the end of 2017 (Short-term drinking water advisories 2018). Open dumping and open burning of wastes is rampant in many communities, with Iqaluit’s “dumpcano” having gained widespread attention. Finally, a number of communities neighbour notorious

industrial complexes with infamous cases, including the Aamjiwnaang First Nation (> 50 facilities in “Chemical Valley”) (Cryderman et al. 2016), Grassy Narrows First Nation (mercury from a nearby paper mill) (Takaoka et al. 2014), and the Yellowknives Dene First Nation (arsenic trioxide from the Giant Mine) (Jardine et al. 2013).

Many Aboriginal peoples retain traditional lifestyles in which a safe and functioning ecosystem is essential for social, cultural, economic, and nutritional well-being. Yet pollution, especially in traditional diets, has caused many individuals to shift away from long practiced traditional lifestyles (Kuhnlein and Chan 2000). Unfortunately, this shift has been associated with rising rates of obesity, diabetes, and cardiovascular disease (Kuhnlein et al. 2004). The situation is particularly striking among Inuit communities in Canada’s North who have among the highest body burdens of persistent chemicals in the world, such as mercury and PCBs, despite being far removed from key sources (Donaldson et al. 2010).

So how can we meet this challenge?

Pollution clearly disrupts the health of Canadians and our society. We cannot view it solely as an environmental issue because it spans public health, human rights, economic prosperity, and global security. The impact and scope of pollution needs to be taken up by decision-makers and the public, and we need to

shift our efforts to prevent death, disease, and disability linked with pollutants. Here we offer five recommendations.

First, we need to establish or enhance surveillance for monitoring pollutants and communicate findings. Evidence-based, reliable, and open source spatial and temporal data on pollution levels at the local and national level are needed to inform the public and decision-makers and monitor our progress towards stated goals. We are fortunate to have several systems in place (e.g., CHMS, National Pollutant Release Inventory, CARcinogen EXposure-CAREX), but we need to expand their geographic coverage and resolution, the number of pollutants measured, and enhance ways the public can access the information. We advocate for a Canadian Commission on Pollution and Health to assemble and scrutinize the evidence base and regularly update such a report.

Second, directed research funding is sorely needed to identify and confirm the health impact of toxic chemicals across the lifespan, including chemical mixtures, gene-environment interactions, and transgenerational impacts. Canada, which has world-class scientists, is ready to meet this challenge. For example, a simple bibliometric search in Scopus of the terms “pollution,” “environmental epidemiology,” and “toxicology” reveals that Canadian academic and government researchers are among the top five worldwide in terms of publication numbers. Still, most of the funded research is focused on air pollution and the built environment.

It is time to establish a dedicated funding mechanism for pollution. In particular, we need to establish an Institute for Environmental Health (akin to the US National Institutes of Environmental Health Sciences) within the Canadian Institute for Health Research (CIHR). For our colleagues studying the epidemic of chronic diseases, we need instruments to ensure that pollution is included as a core risk factor in their research agendas.

Third, we must enable interdisciplinary and intersectoral engagements, and thus address pollution through a public health approach. The traditional fields of toxicology, occupational medicine, and epidemiology must be educated, incentivized, and supported financially to expand their coalitions to include, among others, economists, ecologists, legal scholars, veterinarians, and engineers. Transdisciplinary frameworks and modes of thinking such as One Health and EcoHealth may prove useful here (Aguirre et al. 2016). To truly understand, document, and prevent the adverse effects of pollution on Canadian society, we need to catalogue pollution’s burden of disease and socio-economic costs as well as understand the opportunities and barriers concerning pollution prevention across all stakeholders.

A fourth and urgent way is to demand that the health impacts of pollution be moved to the heart of public policy

agendas in both Canada and around the world. Normally, this would be a most difficult task. Fortunately, there is cause for optimism.

In Canada, for instance, the majority Report of the House of Commons Standing Committee on the Environment and Sustainable Development in June 2017 set out 87 recommendations to amend *CEPA* to protect human health and natural ecosystems from pollution and toxic chemicals, putting the precautionary principle front and centre (Schulte 2017). This would shift the legal burden of proof and require that chemicals used in commerce or proposed for use must be shown to not be toxic to human health and ecosystems prior to their introduction and use. The Federal Environment Minister has promised legislation to address these (and other) recommendations, including legally binding and enforceable national air and water quality standards. The Canadian Council of Ministers of the Environment (CCME) provides a forum for action.

Internationally, the G-7 Health Ministers at their meeting in Milan, Nov 5–6, 2017, acknowledged the importance of global pollution. This was followed by the Third United Nations Environmental Assembly, entitled “Towards a Pollution-Free Planet” (Nairobi, Dec 4–6, 2017); the first time that pollution was considered exclusively by this UN assembly. The final declaration was clear and decisive:

“We the world’s ministers of the environment, believe that every one of us should be able to live in a clean environment. Any threat to our environment is a threat to our health, our society, our ecosystems, our economy, our security, our well-being and our very survival. That threat is already upon us: pollution is cutting short the lives of millions of people every year.”

Finally, we endorse amending *CEPA* to include the recognition of a right to a healthy environment. The proposed framework principles set out by the UN Special Rapporteur on human rights and the environment offers one way forward (UN 2018). While there is no legal right to a healthy environment under Canada’s Constitution, multilateral environmental agreements, of which Canada is a signatory, recognize the many linkages between the environment and human rights (Compendium of Canada’s Engagement in International Environmental Agreements, 7th Edition updated for 2017). Further, Canada has signed and ratified the Paris Agreement, which explicitly calls for States “to respect, promote, and consider” human rights in its actions involving climate change (Paris Agreement to the United Nations Framework Convention on Climate Change 2015); and has adopted the UN 2030 Agenda for Sustainable Development, in which States explicitly agree that the Sustainable Development Goals (SDGs) seek to realize the human rights of all (UN 2015).

Compliance with ethical standards

Competing interests Dr. Lanphear is serving as an expert witness in a case of lead poisoning in Milwaukee and Flint, Michigan, but he receives no personal compensation for these services. Over the past 5 years, Dr. Lanphear has served as an expert witness in California for the plaintiffs in a public nuisance case of childhood lead poisoning, a Proposition 65 case on behalf of the California Attorney General's Office, a Canadian tribunal on trade dispute about using lead-free galvanized wire in stucco lathing, and cases of lead poisoning in Milwaukee, WI, and Flint, Michigan, but he receives no personal compensation for these services. Dr. Lanphear has served as a paid consultant for the California Department of Toxic Substance Control.

Dr. Basu is a member of the Government of Canada's Chemicals Management Plan (CMP) Science Committee. Dr. Basu has received research funding from diverse sources to study chemical pollution, and over the past 3 years, these have included NSERC, IDRC, US NIH (Fogarty International Center, US NIEHS), US EPA, Genome Canada, Genome Quebec, First Nations Environmental Contaminants Program, the Northern Contaminants Program, the World Health Organization, and McGill University.

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