Environment International 119 (2018) 536–543

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Review article

Leveraging the Canadian Health Measures Survey for environmental health research

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ARTICLE INFO

Keywords:
Environmental health
Human biomonitoring (HBM)
Canadian Health Measures Survey (CHMS)
Air quality
Built environment
Chemical exposures

ABSTRACT

Since 2007, the nationally representative, cross-sectional Canadian Health Measures Survey (CHMS) has collected detailed health and exposure data from more than 25,000 Canadians, including a wide range of chemical biomarkers analyzed in blood, urine, and environmental media. This article highlights the extent to which the CHMS dataset has been used in the peer-reviewed environmental health literature and opportunities for further expanding usage of the dataset. A literature search (2007–2018) was performed to identify peer-reviewed studies that have made substantive use of the CHMS dataset. Studies were analyzed according to the study type, data usage, populations studied, environmental health themes, citation/publication data, and institutional collaborations. A total of 51 environmental-health related CHMS studies were identified, including studies related to indoor and outdoor air quality, the built environment, and chemical and environmental tobacco smoke exposures. Health indicator data are being increasingly exploited, as is the ability to combine cycle datasets over time. Although these studies covered a range of environmental exposures, many CHMS variables remain underutilized. The CHMS dataset provides a valuable portrait of chemical exposures in Canadians of all ages, linked to a wide variety of health indicators. Many opportunities remain to exploit and expand both the use of the dataset and collaborations between Canadian agencies and domestic and international research institutions.

1. Introduction

In 2006, the Government of Canada established the Chemicals Management Plan (CMP), a national initiative aimed at reducing the risks posed by chemical substances to Canadians and their environment. One of the key activities under the CMP is the monitoring and surveillance of chemicals in humans and environmental media including wildlife (Canada, 2012). National human biomonitoring initiatives include the Canadian Health Measures Survey (CHMS) (Health Canada, 2017), the First Nations Biomonitoring Initiative (FNBI) (Assembly of First Nations, 2013), the Maternal-Infant Research on Environmental Chemicals (MIREC) study (Arbuckle et al., 2013), and the Northern Contaminants Program (Canada, 2018). Although MIREC does provide access to its biobank (for a fee), we here focus on the CHMS, as this large dataset has been available to Canadian researchers since 2009 with new data released every two years.

The CHMS, which is carried out in partnership among Statistics Canada, Health Canada, and the Public Health Agency of Canada, was launched in 2007. Similar to the long-running National Health and Nutrition Examination Survey (NHANES) in the US, the CHMS collects detailed health, lifestyle, and exposure information for a representative sample of the population (Tremblay et al., 2007). Exposure data collected in the CHMS include a wide range of chemical biomarkers analyzed in blood and/or urine, as well as data on select chemicals in indoor air and tap water (Giroux, 2007). The aims of the biomonitoring component are to establish objective, biologically relevant, and nationally representative values for a wide range of biomarkers of environmental chemicals. These data may then be used in further analyses including identification of sub-populations with higher levels of exposure, associations with health outcomes, and the determinants of

Abbreviations: BEs, biomonitoring equivalents; BPA, bisphenol A; CHMS, Canadian Health Measures Survey; PCDD/Fs, dibenzo-*p*-dioxins and dibenzofurans; FNBI, First Nations Biomonitoring Initiative; HBCD, hexabromocyclododecane; NHANES, National Health and Nutrition Examination Survey; PFASs, perfluoroalkyl substances; POPs, persistent organic pollutants; PBDEs, polybrominated diphenyl ethers; PBDEs, polybrominated diphenyl ethers; PCBs, polychlorinated biphenyls; RV95s, reference values; VOCs, volatile organic compounds

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https://doi.org/10.1016/j.envint.2018.07.011
Received 18 May 2018; Received in revised form 5 July 2018; Accepted 6 July 2018

exposure.

An important feature of the CHMS is its responsive design. That is, the data to be collected in future cycles can be expanded or constrained as appropriate based on previous results (e.g., low proportions), regulatory risk assessment or risk management priorities (e.g., metals and trace elements identified as priorities for action under the CMP), and emerging health concerns (e.g., the rise of "vaping" or e-cigarette use). Data collection for cycles 1 (2007–2009), 2 (2009–2011), 3 (2012–2013), 4 (2014–2015), and 5 (2016–2017) is complete, and data collection for cycle 6 (2018–2019) is underway. Stakeholder consultations have been completed to identify priorities for cycles 7 (2020–2021) and 8 (2022–2023). At this point, we deemed it timely and useful to: 1) identify the body of peer-reviewed environmental health-related CHMS literature; 2) describe how CHMS data have been used to examine environmental health issues; and 3) identify other potential uses for this data that are not currently being explored.

2. Materials and methods

2.1. Brief overview of the CHMS

The rationale, sampling strategy, implementation, and data analysis for the CHMS have been described in detail elsewhere (Giroux, 2007; Haines et al., 2017b; Tremblay et al., 2007). Briefly, this biennial, cross-sectional survey collects self-reported and directly measured health data from at least 5000 respondents from 3 to 79 years of age (with the exception of cycle 1, which did not include respondents aged 3 to 5 years). Basic documentation (e.g., clinic and household questionnaires) for the first five cycles can be accessed via the Statistics Canada website (Health Canada, 2017; Statistics Canada, 2007). More detailed information on methodology and variables analyzed is made available through the summary reports for each cycle (Health Canada, 2017) or can be requested via email (infostats@statcan.ca). In each cycle, data is collected at an average of 16 sites across Canada selected such that the dataset covers about 96% of the general population; residents of Crown lands, First Nations reserves or other Aboriginal settlements, institutions, certain remote regions, and full-time members of the Canadian Forces are excluded. The survey involves two components: an at-home interview that collects detailed information on sociodemographics, health history, and the home environment (including tap water and indoor air sampling for some cycles), as well as a visit to a mobile examination centre (MEC) for anthropometrics, assessment of fitness and accelerometer-based physical activity, eye and dental examinations, and biological sample collection (blood and urine; hair and saliva will be collected in later cycles). A document summarizing all survey and MEC data planned for cycles 1 to 8 is available upon request from Statistics Canada. Ethical oversight for the CHMS is provided by the Health Canada and Public Health Agency of Canada Research Ethics board and participants are given the option to receive all their results (Haines et al., 2011).

2.2. Literature search and review

Details on the literature search and review protocol used here are provided in Appendix A. Briefly, an *a priori* search strategy and inclusion/exclusion criteria were designed with the assistance of an information specialist. The search was targeted to identify all peer-reviewed, environmental health-related studies making substantive use of the CHMS dataset, in French or English. In total, 51 studies met these criteria and are summarized in Appendix B (Table B.1).

2.3. Bibliometric analysis

Bibliometric data (2007–2018) were used to analyze where the environmental health-related CHMS studies have been published and their usage, as indicated by average citations per year, as well as collaborations among research institutes. Web of Science was used to generate detailed text records and citation data for the 51 CHMS publications identified as relevant to this review. Studies that lacked complete records were added manually. Web of Science bibliometric data were also used to visualize collaborations among institutions using VOSviewer (v. 1.6.5; Leiden University, Netherlands), a bibliometric mapping tool (van Eck and Waltman, 2010).

3. Results

In total, 51 environmental health-related studies were identified from approximately 250 peer-reviewed CHMS studies published between 2007 and 2018. A complete listing of all environmental health-related peer-reviewed studies, as well as study details and references, are available in Appendix B (Table B.1). In addition, a summary all environmental health-related exposure variables (Cycles 1–6) and their use (or lack of) are shown in Table B.2.

3.1. CHMS studies by study type and population

When the 51 CHMS studies were classified according to study type, 25 studies (49%) sought to link exposure data to specific health indicators, 16 (31%) examined the prevalence of and/or risk factors for specific biomarkers of exposure, and 5 (10%) studies focused on characterizing exposure based on environmental data alone. Four studies were related to chemical risk prioritization (i.e., ranking lower vs. higher risk chemicals for management or study), and one presented a health economics analysis. From 2008 to 2014, studies were evenly distributed between the biomarker and health indicator categories, but the proportion of health indicator studies has increased relative to all other study types in 2014–2017 (Fig. 1). This shift to more health association studies is also occurring in the literature generated from the NHANES chemical biomarker dataset (Sobus et al., 2015).

The health indicator studies cover a range of measures and included 10 lung function studies, four cardiovascular indicator studies, eight studies examining various aspects of metabolic function, four studies using data related to mental health and behavior, and one oral health study related to fluoridation (Fig. 2A, Table B.1). Regarding study populations, the majority of studies (50%) analyzed data across all participants, whereas others have focused specifically on children, adolescents, and/or adults (Fig. 2B). Although the CHMS collects some information on women's sexual and reproductive health, only one study has specifically examined women in an environmental health context, which revealed an association between plasma polybrominated

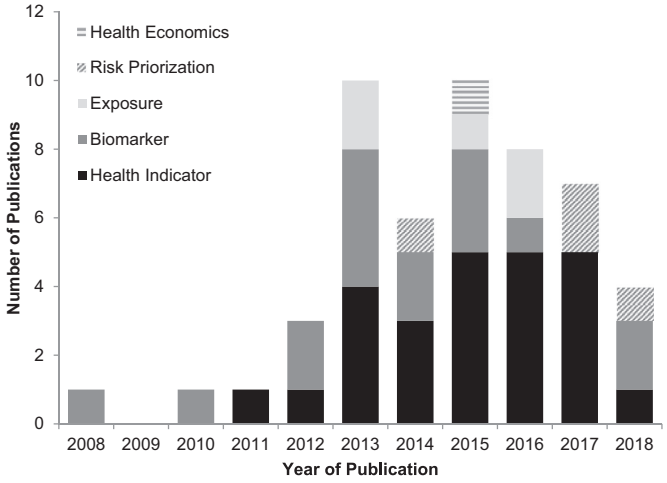

Fig. 1. Environmental health-related CHMS publication by study type, over time. A shift toward health indicator studies (those examining potential relationships between biomarker data and health outcomes) is observed.