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Environmental pediatrics: an introduction and evaluation of online resources

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Abstract

Introduction: The World Health Organization (WHO) estimates that three million children under the age of 5 die annually from environmentally related disease. In the United States, the cost of environmentally related public health concerns is estimated as greater than $55 billion. Environmental exposure is among parents' top health concerns for children. Yet, the study of the effects of environmental exposure on health outcomes is a developing field, and clinicians feel inadequately prepared to address these concerns. The Children's Environmental Health Clinic (ChEHC) is the first clinic of its kind in Canada. Their website includes a list of online resources on major topics related to child health and the environment. There has not yet been an objective evaluation of the comprehensiveness of the topics or scientific quality of the information on the website. This study seeks to offer an accessible introduction to the field of environmental pediatrics, including an online resource for evidence-based information on key topics in the field. These resources assist in disease prevention, health promotion, education, and the increasing need to balance environmental health risks.

Methods: A scoping review of scientific and gray literature in the field of environmental pediatrics was performed to inform a written introduction to the field and to identify gaps in the content of the ChEHC website. The content of the ChEHC website was then objectively evaluated using the National Network of Libraries of Medicine checklist for health websites.

Results: Ten categories within the field of environmental pediatrics emerged from the literature review. A small number of gaps were identified on the website and in the literature. The content of the ChEHC website was found to be of high quality.

Future directions: The website will be updated using the results of the study as a guide, to make it as relevant, complete, and evidence-based as possible.

Conclusions: Environmental pediatrics is an important, emerging topic. There is a need for accessible, evidence-based pediatric environmental health resources for clinicians and the general public. The products of this study (a publication and website) respond to that need and thus assist in disease prevention and health promotion.

Keywords: environmental health; pediatrics; toxic environmental substances.

Introduction

Human health is an aggregate of protective and harmful environmental exposures, genetic influences, and psychosocial experiences (1). The World Health Organization (WHO) estimates that three million children under the age of 5 die annually from environmentally related diseases (2) and it is impossible to estimate how many more are affected by symptoms triggered by environmental exposures. In the United States, the cost of environmentally related public health concerns was estimated as greater than $55 billion in 1997 (3). Yet, the study of the effects of environmental exposures on health outcomes is a surprisingly new and developing field.

A 2012 American study found that 47% of parents ranked environmental exposure among their top health concerns for children in their community. It was also amongst the most frequently selected health concerns parents reported for their own children (4). It is thus important for health care professionals to be able to provide accurate anticipatory guidance to their patients and for this information to be accessible to the general public. Unfortunately, research suggests that environmental health education is lacking in pediatric residency education, and physicians thus feel inadequately prepared to address these concerns (3). In response, pediatric environmental health specialty units (PEHSUs) have formed all over the world, with the mandate to educate and advise.

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Our research seeks to provide an introduction to their research and practice.

We hypothesize that health professionals and the public will benefit from an accessible introduction to the field of environmental pediatrics and a relevant, evidence-based and accessible environmental health resource that will aid in education and help balance risk. To this end, this paper seeks to 1) introduce the field of environmental pediatrics, 2) identify topics in the field that have gained attention in the last decade, 3) compare these topics to the topics on the Children's Environmental Health Clinic (ChEHC) website to identify gaps in available information, 4) assess the quality of information on the ChEHC website and 5) update the ChEHC website to create a resource of information in the field of environmental pediatrics that is as complete, reliable, and valid as possible.

Part 1: An introduction to environmental pediatrics

A brief history of pediatric environmental health (AAP, 2012)

The WHO created the first international Task Force for the Protection of Children's Environmental Health in 1999. That same year, the first edition of the American Academy of Pediatrics (AAP)'s *Handbook of Pediatric Environmental Health* was published, gathering together available evidence in the field. Three years later, the first formal fellowships in pediatric environmental health were established across the United States and the WHO held the first International Conference on Environmental Threats to the Health of Children. This led to the development of the Bangkok statement, which established priorities and commitment for action. In 2007, the WHO teamed up with the International Pediatric Association and launched the International Pediatric Environmental Health Leadership Institute to train health care providers. In 2012, a group of international experts contributed to the first *Textbook of Children's Environmental Health* (5). The field continues to grow internationally. Canadian researchers and clinicians have been involved since the beginning. CheHC in Edmonton, Alberta, opened in 1999. It is the first clinic of its kind in Canada and seeks to contribute to knowledge translation and new research, clinical assessment and management, as well as education in this growing field.

Key concepts in environmental pediatrics (AAP, 2012)

The AAP defines environmental pediatrics as a new and still developing subspecialty of pediatrics. It is the study of how environmental exposures, genetic influences and psychosocial experiences interact with each other and the helpful or harmful effects they might have on children's health. It is the practice of anticipatory guidance for parents about exposures in their children's environment. Our environment is filled with toxins (biological agents that have the potential to negatively impact human health) and toxicants (chemical agents that have the potential to negatively impact human health). Humans absorb and metabolize these agents. This process is mediated by each person's unique physical and social environment, genotype and phenotype, and developmental stage. To complicate this already complicated relationship, each individual can tolerate a certain amount (a threshold) of exposure to toxins and toxicants before these have harmful effects. In theory, this threshold is unique to each agent and each host, and is thus unpredictable. However, evidence is mounting that certain toxicants may have more toxic effects at lower levels and others no threshold. This makes understanding environmental exposures increasingly complex. We can improve our ability to predict the effects of environmental exposures by improving our understanding of factors within the agent, the host, and the environment that interact to create these effects.

Environmental factors (AAP, 2012)

Human beings are subject to a macro environment, which is shared by the population, and a micro environment, which is unique to each person at each point in time. The environment consists of the atmosphere, including the air we breathe, the soil and ground, bodies of water and rain, the plants and animals that share our environment, and man-made environments where we live, work, and play. It also includes a person's psychosocial situation.

Host factors (AAP, 2012)

There are four principal mechanisms by which humans absorb toxins and toxicants into their bodies. They are absorbed from the environment through skin and via respiration. When ingested, the intestines absorb them. Finally, toxins and toxicants can be transferred through the placenta from mother to fetus. These mechanisms depend on individual host factors.

Table 1: Key stages of child development (1).

Developmental stage	Environment	Key considerations for environmental health
Fetal stage	Womb	– cells differentiating and migrating, organs developing – vulnerable to placental absorption of toxins and toxicants – exterior keratin layer of skin not yet developed = vulnerable to absorption of toxins and toxicants
Neonatal stage (0–2 months)	Bassinet, crib	– respiratory system developing = vulnerable to inhaled toxins and toxicants – surface-area-to-body-mass ratio is three times greater than that of an adult = vulnerable to percutaneous absorption of toxins and toxicants – risk of ingestion of toxins and toxicants in breast milk or formula – if in hospital = exposed to harmful noise, light, inhaled oxygen and other gases, intravenous fluid solutions, and radiation – dependent on adults to remove them from noxious environments
Infant/toddler stage (2 months–2 years)	Gradually move from bed to floor/ground	– respiratory system developing = vulnerable to inhaled toxins and toxicants – surface-area-to-body-mass ratio is three times greater than that of an adult = vulnerable to percutaneous absorption of toxins and toxicants – gradually improved mobility and communication, but still dependent on adults to remove them from noxious environments – primarily oral exploration of environment = vulnerable to ingested toxins and toxicants – risk of ingestion of harmful toxins and toxicants in dairy and fruit – rapid cell differentiation = risk of cancer– rapid brain growth and development = vulnerable to toxic exposures
Preschool stage (2–6 years)	Floor/ground	– respiratory system developing = vulnerable to inhaled toxins and toxicants – surface-area-to-body-mass ratio is twice that of an adult= vulnerable to percutaneous absorption of toxins and toxicants – rapid brain growth and development = vulnerable to toxic exposures – risk of ingestion of harmful toxins and toxicants in dairy and fruit
School age stage (6–12 years)	Breathing space gets higher as children grow taller	– respiratory system developing until age 8 = vulnerable to inhaled toxins and toxicants – surface-area-to-body-mass ratio is twice that of an adult= vulnerable to percutaneous absorption of toxins and toxicants – brain growth and development = vulnerable to toxic exposures
Adolescent stage (12–18 years)	Increasingly diverse environments, increasing control over environment	– brain growth and development = vulnerable to toxic exposures – risk taking behavior = increased risk of toxic exposures

Children tend to be more susceptible to environmental toxins and toxicants than adults. Physical size is inversely related to basal metabolic rate. Thus, smaller hosts have a greater rate of oxygen consumption and, subsequently, production of CO_2 per kilogram of body weight. Children breathe in more toxins and toxicants per minute than adults in the same environment. They are also shorter, and thus their respiratory tract is closer to the ground. This lower breathing zone means greater exposure to toxins and toxicants that are heavier than air, such as mercury, and chemicals in carpet, on lawns, and on the pavement. Children also tend to spend more time outside during the afternoon than adults. This means they are more likely to be exposed to strong ultraviolet light of the sun. They require more calories than adults to maintain homeostasis and to grow; thus, they consume more food per kilogram of body weight and they absorb more of what they ingest via their intestines. Furthermore, differences in activity of enzymes at various developmental stages means differences in metabolism of toxins and toxicants, which can be protective or harmful. Children and adolescents go through a predictable pattern of growth and development and their susceptibility to the effects of toxins and toxicants thus differs throughout their development (Table 1).

Each individual also has unique susceptibility to his or her environment. Susceptibility is defined as "the condition of having one of two or more interacting causes (i.e. risk factors) and, therefore, being either predisposed to, or at enhanced vulnerability to, the effects of another, [which] results in variation in effect of a given exposure in a population when the dose is held constant" (1). This concept is sometimes called effect modulation, interaction, or synergy. Susceptibility is the product of an individual's genetics, epigenetics, and environment at a given point in time.

The genotype of a person is the set of alleles that make up a person's genetic constitution. This genotype makes up a person's phenotype, which consists of observable biochemical, cellular, clinical, and morphological features. Sometimes, a person's genetics can cause a disease, as with cystic fibrosis. This is distinct from the concept of genetic susceptibility, which is the interaction between genes and environment that increases the risk of developing the disease. We must also consider that individuals not only inherit genes from their parents, but also that those genes express themselves to create a phenotype. Additionally, the environment can influence gene expression. These concepts are part of the field of epigenetics (6). In considering an individual's susceptibility to environmental exposures, we must consider their context.

Human beings exist in societies. Thus, they are also subject to social susceptibility. Social factors, particularly socioeconomic status, affect human health outcomes. They also modify the relationship between environmental exposures and health outcomes. The major social determinants of health in Canada include: income and income distribution, education, unemployment and job security, employment and working conditions, early childhood development, food insecurity, housing, social exclusion, the social safety net, health services, Aboriginal status, gender, race, and disability (7). Sometimes, two factors may independently affect an outcome and this relationship can be confusing if a person is exposed to both factors. Research in the field of environmental health aims to control for these confounding variables when observing how environmental and host factors interact with agent factors.

Agent factors (AAP, 2012)

Agents can be broadly thought of as anything that can be protective or harmful to health and development. They are natural or man-made, and exist in the environment. They include toxins and toxicants in our indoor and outdoor atmosphere, air, water, soil, food, consumer products, medicines, and supplements. They also include the social determinants of health, such as socioeconomic status, and the political and cultural atmosphere. Our understanding of the harmful or protective health effects of agents (or lack thereof) depends on ongoing empiric research. Our knowledge of agents and the mechanisms by which they affect our health evolves as the research in the field evolves. Agent factors, like environmental and host factors, can affect the type and rate of absorption into the human body.

Environmental pediatrics is a complex field that explores the relationship between a host, his or her environment, and environmental agents that influence health. An understanding of the key concepts in this field is essential to help families balance risk. As research evolves, so does our understanding. It is, therefore, essential to have an accessible, accurate resource for clinicians and parents that can be easily updated. Our research addresses this need by reviewing the literature to identify topics in the field that are important to modern Canadians, and using the results to update an existing resource (the ChEHC website) for information about pediatric environmental health.

Part 2: Scoping review of the literature

In order to identify gaps in the information available on the CheHC website, we sought to assess (1) which environmental pediatrics topics were of concern to society and (2) the current state of research in the field of pediatric environmental health.

Part 2: Scoping review of the literature: Methods

A scoping review (8) of the gray literature (newspaper articles and other media) and the scientific literature was performed using the following databases: Medline, Embase, Scopus, and Proquest. The keywords "environment*," "health," "toxi*," and "pollut*" were searched. Limits were set to "age 0–18," "Canada", "English", and "2004 to current". The search was modified appropriately for different databases. After deleting duplicated articles, the total number of articles was 1138. We then performed a title and abstract screening to identify articles published in the last decade that reported a possible or known association between a toxic exposure and health outcome in children in Canada. Articles on the subjects of toxic psychosocial stress, the social determinants of health, viral or bacterial or parasitic infections, medication or drug side effects, and climate change were excluded, as were promotional articles and descriptions of community or government projects. We also excluded a small amount of articles that were not available online or via the University of Alberta library. Two hundred and eighteen articles remained. Of these, 90 were from the media, and 128 were from scientific journals. Dr. Irena Buka, an expert in the field, then examined the results,

and added eight more scientific articles that met the inclusion criteria, but were not captured by the scoping review (3, 9–15). This brought the total number of scientific articles to 136, and the total number of articles that met inclusion criteria to 226. These articles were then organized and tallied by subject in order to ascertain which topics were of concern to Canadian scientists and media in the last decade. These topic were then compared to the topics on the ChEHC website to identify gaps in the literature and gaps on the website.

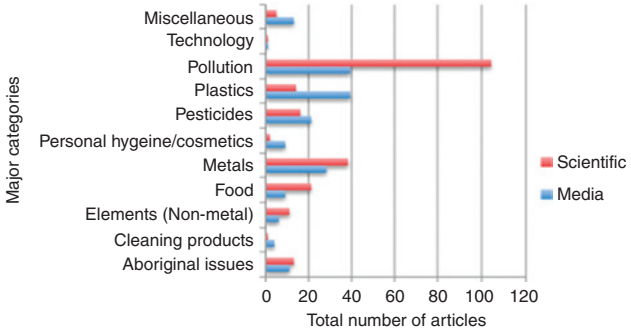

Figure 1: Scoping review overview.

Part 2: Scoping review of the literature: Results

Ten general topics of concern emerged from the scoping review. The scientific and the gray literature differ in terms of popularity of topics. Largely due to scientific interest, the topic of pollution contains the greatest number of articles. Within this topic, air pollution is most represented. Aboriginal issues – in particular, the concern that the Canadian Aboriginal population is disproportionately exposed to and affected by environmental toxins and toxicants – are also conspicuously represented in both types of literature. Both science and the media are interested in metals – most notably heavy metals such as lead and mercury. Non-metal elements were less represented. In the last decade, many media articles have been written about plastics – most notably bisphenol A (BPA). This topic is highly represented in the gray literature and is less represented in the scientific literature. Other topics with notable representation in both the scientific and gray literature include pesticides and food. Compared to the scientific literature, the gray literature seems more interested in the safety of consumer products, including personal hygiene products, cosmetics, and cleaning products. There was a small amount of interest in the safety of technology such as cellular phones, power lines and the electromagnetic fields they emit, and nanoparticles (Figure 1).

Within the topic of pollution, air pollution is most represented. Water pollution is also notably represented. These topics are discussed in more detail below. Other topics that emerged from the literature review include soil pollution, and a small number of articles on light and noise pollution (Figure 2).

Many articles do not distinguish between outdoor and indoor air pollution. When comparing the different topics within the realm of air pollution not otherwise specified (NOS), there is still notable interest in scientific research that elucidates the risks of smoking cigarettes. In

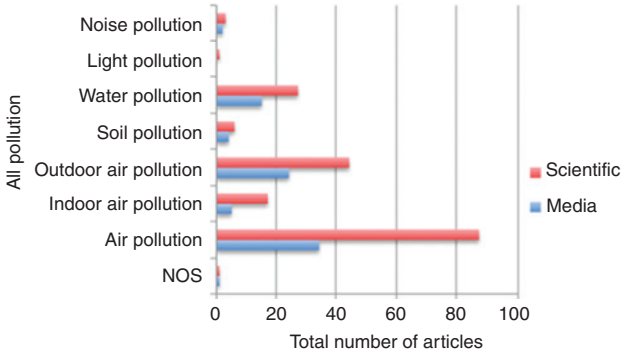

Figure 2: Pollution overview.

the last decade, the media has been less interested in the effects of cigarette smoking. Both science and the media are very interested in the safety of dioxins and dioxin-like substances such as polychlorinated biphenyls (PCB), polybrominated diphenyl ethers (PBDE), and other substances found in flame-retardants. Other air pollutants discussed in the scientific and/or gray literature include benzene, benzo[a]pyrene, hexavalent chromium, organochlorine and lindane, perchlorate and perchloroethylene, and perfluoro molecules. A small number of articles explore the effectiveness of high-efficiency particulate absorption (HEPA) filters in improving health effects (Figure 3).

Of the articles that did distinguish between outdoor and indoor air pollution, outdoor air pollution is the most represented in both the scientific and gray literature. Within this topic, the scientific literature focuses mainly on nitrogen, sulfur, and ozone in the air. The media, however, is more focused on the possibility that outdoor air pollution in Sarnia, Ontario, and the surrounding area is disproportionately high due to industrial waste. One scientific article explores this possibility. Other substances of study in the outdoor air include 1,3-butadiene, substances created by oil harvesting and refining, ammonia and

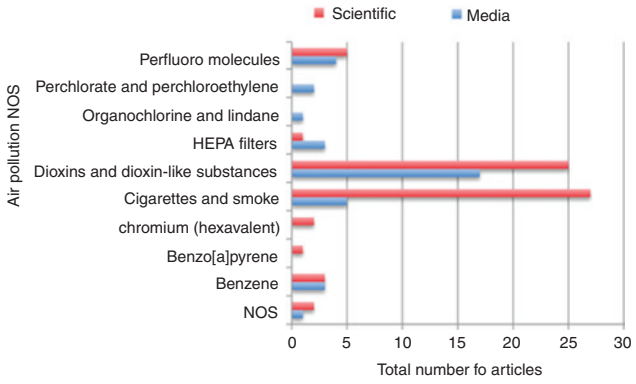

Figure 3: Air pollution NOS.

ammonium nitrate, benzene, carbon monoxide, chlordane and oxychlordane, formaldehyde, fuel (including biomass fuels, coal, gas, diesel, and exhaust), methanol, o/m/p-xylene, phenanthrene, phosphorous, polycyclic aromatic hydrocarbons (PAH), toluene, toxaphene, trans-nonachlor, and tritium (Figure 4).

The scientific literature has a stronger focus on indoor air pollution than the gray literature. Most articles explore the topic in general, but a small number focus on mould exclusively, and one media article describes higher ozone concentration in indoor air filtered by ionizing air cleaners (Figure 5).

Water pollution is represented by a small number of articles, mostly in the scientific literature. The most represented topic in this category for both scientists and the media is rising mercury levels in fish living in polluted water. One scientific article also explores PCB in fish. Other topics that are represented in the scientific literature include 1,3-butadiene, arsenic, benzene, benzo[a] pyrene, hexavalent chromium, halobenzoquinones, and chlorination by-products (Figure 6).

Within the topic of pollution, there is interest in its disproportionate effect on the Canadian Aboriginal population. The scientific and gray literature includes different aspects of this issue. The scientific literature focuses on health effects from pollution in those who eat a traditional diet that includes wild game and fish. The media is most interested in pollution affecting inhabitants of the Ammjiwnaang reserve in the region of Sarnia, Ontario. We also found two media articles that discuss pollution in Inuit and First Nations habitats. A small number of articles in both types of literature discuss water pollution on First Nations reserves. One scientific article explores lead levels in Nunavik (Figure 7).

The next most represented topic is metals. Science and the media are coherent with their highest interest in lead, then mercury. There is a notable scientific

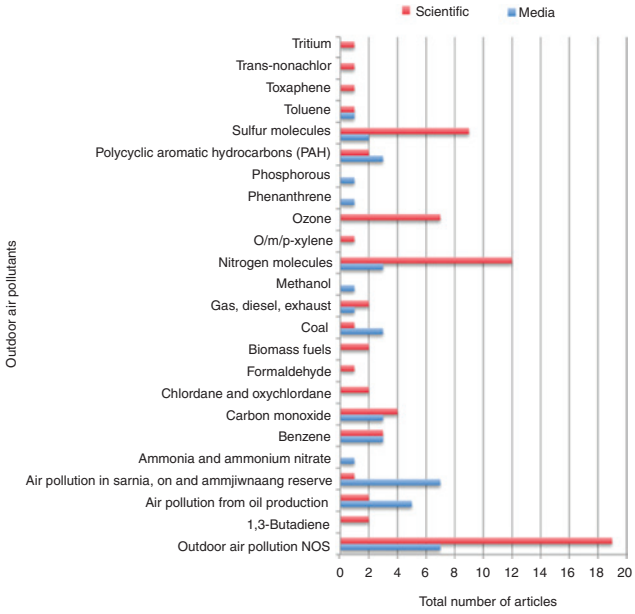

Figure 4: Outdoor air pollution.

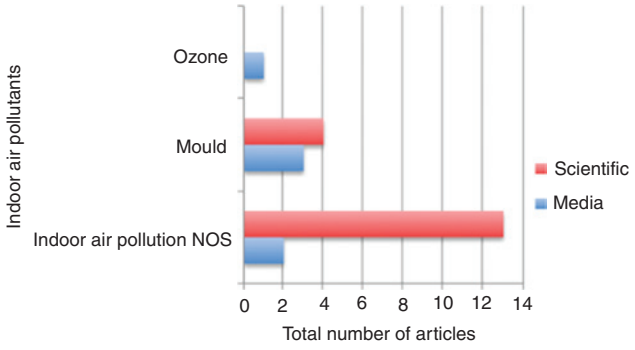

Figure 5: Indoor air pollution.

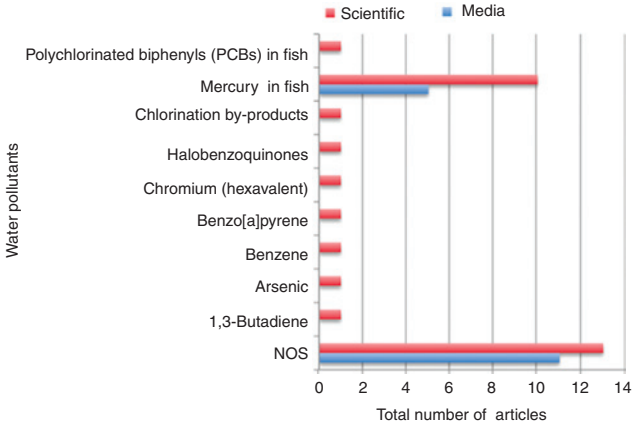

Figure 6: Water pollution.

interest in cadmium. Aluminum, copper, manganese, nickel, uranium, and zinc are represented in a smaller number of articles (Figure 8).

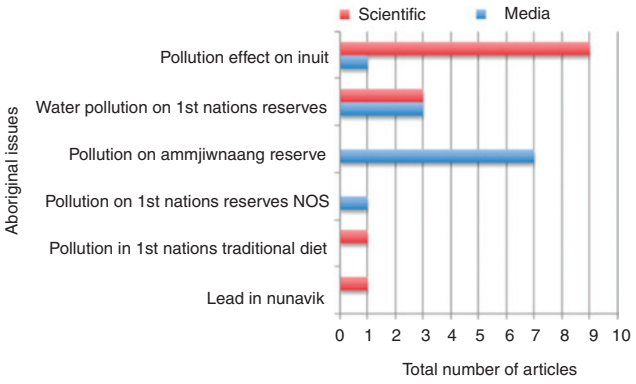

Figure 7: Aboriginal issues.

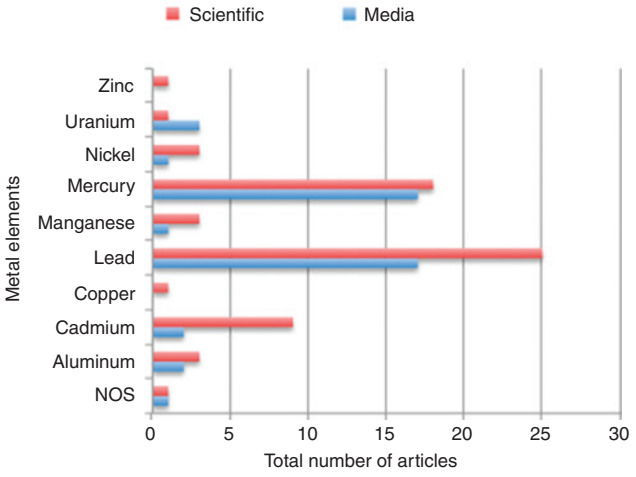

Figure 8: Metals.

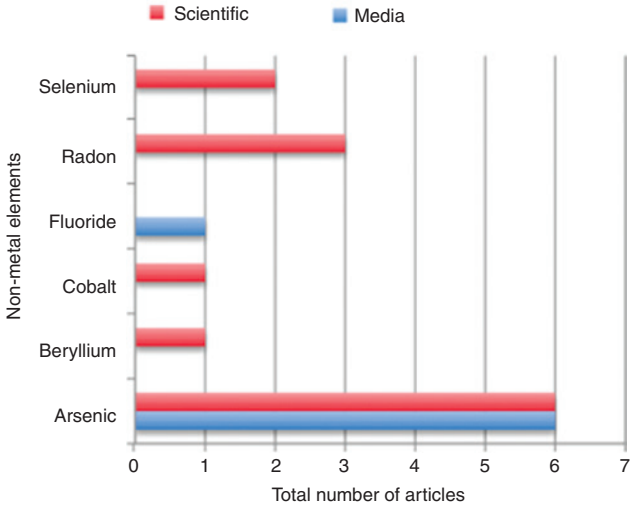

Figure 9: Elements.

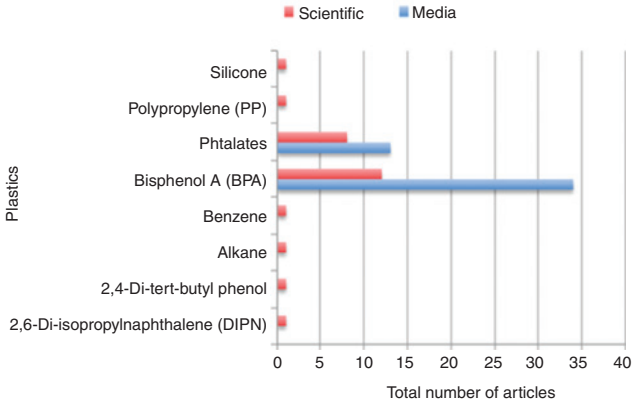

Figure 10: Plastics.

Although less represented than metals, the general safety of some non-metallic elements is also discussed in the literature. Arsenic is most represented element in both the scientific and gray literature. There are a small number of articles in the scientific literature on beryllium, cobalt, radon, and selenium. We did not find media articles discussing any of these elements. We found only one media article and no scientific articles on the subject of fluoride (Figure 9).

After pollution, the highest number of media articles are related to safety of plastics, most notably BPA. This topic is represented in the scientific literature to a lesser extent. Both types of literature are also interested in phtalates. Within the scientific literature, substances including 2,6-di-isopropylnaphthalene (DIPN), 2,4-di-tert-butyl phenol, alkane, benzene, propylene (PP), and silicone are also discussed (Figure 10).

Pesticides are another topic of notable representation in the literature and include the following substances: acetylcholinesterase inhibitors, β-hexachlorohexane, hexachlorobenzene, dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), diethyldithiophosphate (DEDTP), diethylphosphate (DEP), diethylthiophosphate (DETP), dimethyldithiophosphate (DMDTP), dimethylthiophosphate (DMTP), organochlorides, organophosphates, and tributyltin. There are more media than scientific articles and they discuss the topic in general, rather than questioning the safety of individual pesticides. Pesticide contamination of food is also a concern for human health.

Food safety is another topic that stands out in the literature review, particularly amongst the scientific literature. Both science and the media report rising mercury levels in fish and related health concerns. There is one scientific article that also explores PCB in fish. There are a small number of media and scientific articles that discuss genetically modified organisms. The scientific literature discusses other substances that may be of concern in food, including 1,3-butadiene, acrylamide, alternia and

alternariol, ammeline and ammelide, arsenic, artificial food coloring, benzene, benzo[a]pyrene, benzoate, hexavalent chromium, cyanuric acid, and melamine (Figure 11).

The safety of personal hygiene products and cosmetics is discussed, mostly in media articles. Particular ingredients of interest include formaldehyde, parabens, toluene, and triclosan. There is one scientific article on halobenzoquinones, which are not discussed in the media (Figure 12).

Of the small number of articles on cleaning products, there is only one in the scientific literature, which discusses the safety of cleaning products in general. Within the few media articles, there is discussion about the safety of 2-butoxyethanol, ethoxylated nonyl phenols, and triclosan (Figure 13).

Within the scoping review, there is one scientific article that explores the safety of modern technology, focused on nanoparticles. There is one media article on this subject that discusses cellular telephones and power lines (Figure 14).

There are a few miscellaneous articles that did not fit into the above categories. The greatest number of articles, mostly from the media, focus on asbestos. There are a small number of articles on radiation and ultraviolet (UV) light. There is one scientific article on the safety of azo dyes, and we did not find this topic in the media articles (Figure 15).

Overall, a large number of diverse topics in the field of environmental pediatrics are captured by the literature review.

The associated references can be found in Tables 4 and 5 in the online supplement.

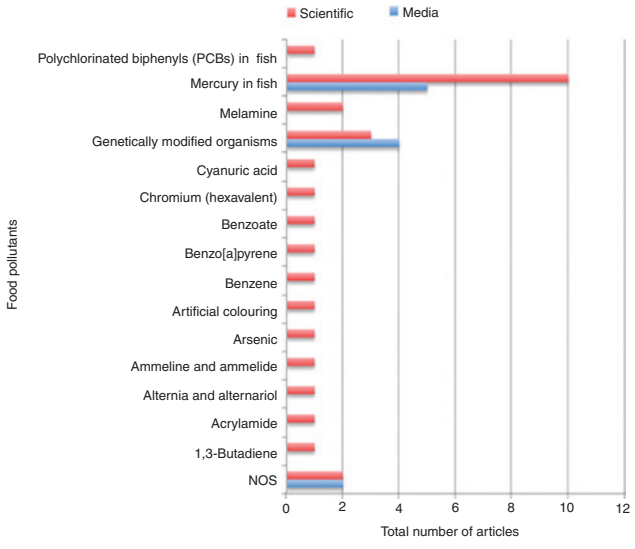

Figure 11: Food.

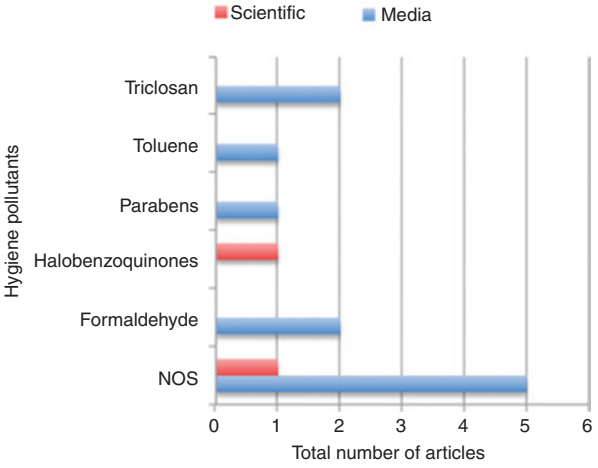

Figure 12: Personal hygiene products and cosmetics.

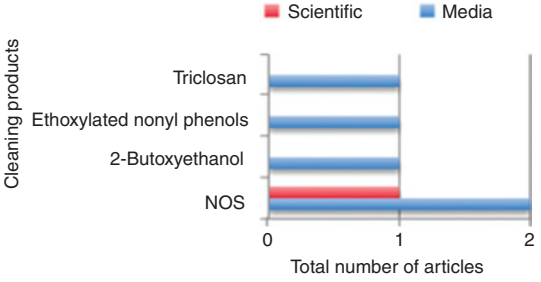

Figure 13: Cleaning products.

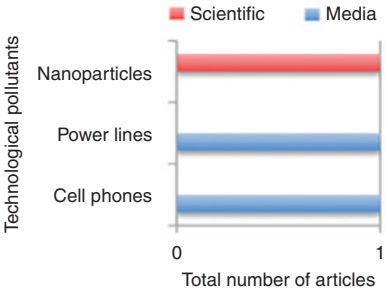

Figure 14: Technology.

Part 3: Identification of gaps on the ChEHC website and in the literature

The environmental health topics featured on the ChEHC website (16) are curated by experts in the field for the purpose of anticipatory guidance. Most topics that emerge from the scoping review are represented on the ChEHC website or easily found via links on the website. There are a few exceptions. In regards to pollution, gaps on the

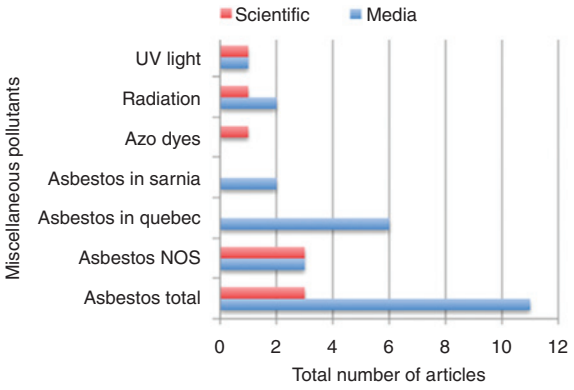

Figure 15: Miscellaneous.

website include air pollution in Sarnia, Ontario, phenanthrene in outdoor air pollution, soil pollution, light pollution, halobenzoquinones in water, and the disproportionate effect of environmental exposure on Aboriginal populations. In regards to plastics, the only identified gap is information on DIPN. In regards to food, there is no information on the website about alternia and alternariol. The ingredient halobenzoquinone is again found to be missing in the information about personal hygiene products. Finally, while there is information about asbestos in general, there is no specific information about asbestos in Quebec or Sarnia, Ontario. Almost all topics on the ChEHC website are represented in the literature review, with a few exceptions.

There are a small number of topics that are on the ChEHC website or easily found via links on the website that did not emerge from our literature review. In regards to pollution, we did not come across articles about acid rain or the safety of fertilizers in soil. While many metals are represented in the literature, this did not include iron or steel. Similarly, many non-metallic elements are represented in the literature review, but this does not include lime. The literature review demonstrates a notable interest in plastics, but not in polystyrene. Finally, there are no articles about the safety of cement, pulp and paper, wood, potash, or the risks that come with their production.

Part 4: Assessment of the quality of the ChEHC website

The ChEHC website (16) contains information compiled by experts in the field. This includes a list of links to online resources for further reading on major topics related to environmental health. The links lead to 1) a newsletter written by ChEHC staff, 2) Health Canada's website (17), or 3) the WHO website (18). We sought to objectively assess the quality of the content on the website and on the linked websites.

Part 4: Assessment of the quality of the ChEHC website: Methods

Although there is no validated tool for evaluating health websites, there is a checklist (19) created by the National Network of Libraries of Medicine, a group that specializes in health literacy. We used this checklist to objectively evaluate the content on the ChEHC website.

A point was assigned for each criterion that was satisfied. The scores were then tallied for each of the three sources of information on the website.

Part 4: Assessment of the quality of the ChEHC website: Results

The information on the website and accessed via its links proves to be of high quality. Of the three sources of information, the WHO website (18) scores the highest (86%) on the checklist. It is the most current (it had been updated a month prior to accessing it) and clearly cites references to valid and reliable research. It also has a very complete, easily searchable database of information on environmental toxins and toxicants. The Quarterly Newsletter (16) is of good quality (76%), particularly as it is written by researchers and clinicians with expertise in the field, but has not been updated since 2011 and more recent research has since been made available. The Health Canada website (17) also fares well (76%) but loses points for not listing its sources. It does, however, offer a uniquely Canadian perspective (Figure 16).

Part 5: Update of the website

Environmental pediatrics is a dynamic, evolving field. There is a need for an accessible, high-quality resource that can be easily updated. The ChEHC website (16) is ideal for this purpose. The culmination of this research is to update the ChEHC website, with the goal of creating a resource for information in the field of environmental pediatrics that is as complete, reliable, and valid as possible. The website update is currently in progress. It will include

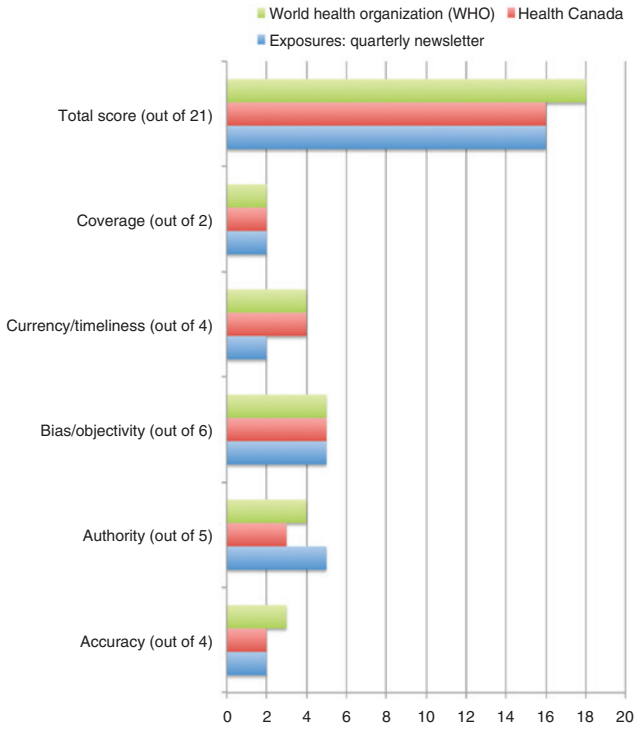

Figure 16: Results of website evaluation.

topics identified as missing via the literature review. The links will lead to the WHO website whenever possible, as this website was found to contain the most scientifically reliable, valid, and current information. When this is not possible, the information will come directly from the experts at the ChEHC, using primary scientific research in the field, or from Health Canada, which also fared well in our quality analysis.

Discussion

Health professionals and the public will benefit from an accessible introduction to the field of environmental pediatrics and a relevant, evidence-based, and accessible environmental health resource. To this end, Part 1 of this paper introduced the field of environmental pediatrics. Part 2 identified topics in the field of environmental pediatrics that have gained attention in Canada in the last decade. In order to do so, we performed a scoping review of the scientific and gray literature. A scoping review consists of "mapping" a field – in this case, environmental pediatrics. "Mapping" is defined as "the process of summarizing a range of evidence in order to convey the breadth and depth of a field." (8). This type of review is advantageous for researchers who want to "examine the extent, range, and nature of research activity, determine the value of undertaking a full systematic review, summarize and disseminate research findings, or identify gaps in the existing literature", (8) as we intended in this study. While we achieved our goal of creating a snapshot of the Canadian literature in the last decade, it is important to recognize that a scoping review is not intended to be an exhaustive review of the literature. This was illustrated by the fact that our review did not find eight articles that were later added by Dr. Irena Buka, an expert in the field. It also did not yield any articles on the emerging topic of electronic waste (also known as "e-waste") (20). As awareness grows of pediatric environmental health, emerging environmental hazards in the international literature will likely receive more attention in Canada. Our hope is that this summary leads to future systematic reviews of more specific topics within the field of environmental pediatrics, so that they can be understood in greater depth.

The dynamic nature of research, particularly in a developing field such as environmental pediatrics, means that the supply of and demand for information in the field will also be dynamic. The results of our scoping review are only representative of Canadian environmental pediatrics literature in the last decade. For the purposes of this study, the results adequately satisfy the goal of Part 3 of the paper: to identifying gaps in information on the website. As time goes on, the website will require further updates, informed by more current literature reviews. It will also require recurrent assessments of the quality of information available on the site and via its links.

Part 4 of this study was an assessment of the quality of information on the ChEHC website (16). The checklist (19) used for this purpose was created by experts in the field of health literacy (the National Network of Libraries of Medicine) and helped us to objectively analyze and compare the information on the website and accessible via its links. The results must be taken with the caveat that the checklist has not yet been validated in peer-reviewed literature. As the internet reaches more users and more people turn to it for health-related information, there is a growing need for a validated checklist that will allow researchers and the public to objectively analyze scientific information available online. We hope the next time the ChEHC website is analyzed for quality of content, it can be done with a validated checklist. For the purposes of this study, the checklist is sufficient for guiding our update of the website in Part 5 of the study.

We must consider the question of how to best update the website when it comes to topics that are notably represented in the media but where scientific evidence is lacking or conflicting. We will endeavor to close the gaps

and update the website with information that scored the highest on the checklist (i.e. the WHO website, followed by articles written directly by the experts at the ChEHC or by Health Canada). The resulting resource will be easily accessible online, relevant to Canadian environmental health in the last decade, as complete as possible, and of the highest possible scientific quality, as assessed by this study, within its limitations.

The general public is becoming increasingly aware of the potentially adverse effects of environmental toxins and toxicants (4) and this may be influenced by what they read in the media. The results of this research paper illustrate the large number of topics within the field of environmental pediatrics that are of concern. As described in Part 1, our understanding of how environmental toxins and toxicants affect our health is still in its infancy. Research suggests that the relationship between environment, host, and agent is complex and unique to each agent, each host, and each environment in each moment in time (1). Interpreting the research in order to offer practical advice for balancing the risk of environmental exposures is a daunting task, even for experts in the field. Journalists who create the gray literature are taking on this task, often without a sufficient foundation in science to understand environmental health in depth. Their work is sometimes influenced by scientific research but, as shown in the results of our literature review, this is often not the case. The gray literature influences public opinion and policy. This was nicely illustrated by the Canadian government's ban of BPA in 2012. Scientists are still divided on the safety of BPA, as research on this topic has yielded conflicting results. The public and the media proved more influential than the science in this case, and were largely responsible for influencing the government to ban the ingredient. A discussion of the importance of science literacy is beyond the scope of this paper, but if physicians feel inadequately prepared to address concerns in the realm of environmental pediatrics (3), how can journalists or the general public be expected to interpret ever-changing research and balance risks in their own lives and the lives of their children? Health care professionals, particularly those who practice primary care and prevention, are responsible for translating scientific research into anticipatory guidance for the public. It is thus important for health care professionals to be able to confidently provide accurate anticipatory guidance in regards to environmental exposures.

As PEHSUs evolve and expand internationally, health professionals will have greater access to education about environmental health. In the meantime, we call on experts in the field to continue to translate science to practice. Our hope is that this paper contributes to addressing that need and points to future directions in research and practice. Assessing what is actually toxic in the environment, for whom, and at what dose is a complex task, and those types of conclusions are beyond the scope of this paper. As research advances, so will our understanding of toxic exposures and their effect on health. It may not be possible to avoid toxic exposures, but our hope is that this paper and the ChEHC website may help clinicians and the public become more informed and better able to balance risk.

Supplementary material

See Table 2 in the online supplement – Complete results of literature review.

See Table 3 in the online supplement – Results of website evaluation.

See Table 4 in the online supplement – Literature review references: gray literature/Media.

See Table 5 in the online supplement – Literature review references: scientific literature.

See Figure 17 in the online supplement – Checklist for evaluating consumer health information on the internet (Benedetti and Vargas, 2016).

*See "Online supplement" for more tables and figures.

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