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Guest Editors: Ashlee Cunsolo and Sherilee L. Harper

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Editorial

Climate change and health: a grand challenge and grand opportunity for public health in Canada

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Globally, climate change is profoundly impacting human health.[1,2] Directly, climate change impacts human health most often via changes in extreme events (e.g. heat waves, drought, heavy rain), resulting in heat- and cold-related morbidity and mortality, unintentional injury and death, and other adverse health outcomes. Indirectly, the impacts of climate change on health are mediated through climate change impacts on ecosystems and human systems, with health impacts from vector-borne, foodborne, and waterborne diseases, respiratory illnesses, occupational health and safety challenges, undernutrition, and negative impacts on mental health and wellness.[1,2]

The impacts of climate change on human health are not evenly distributed or experienced. A variety of often interlinked political, cultural, economic, institutional, geographical, and demographic factors influence how climate change will or will not impact health, including social exclusion, inequities, and differential access to and control over social, financial, and environmental resources that are required for adaptation and resilience.[2] Given these multifaceted, widespread, and complex impacts on human health, understanding how climate change impacts human health and the ways to best respond are grand and defining challenges of our time. Indeed, this grand challenge has been identified by two *Lancet* Commissions,[1,3] the World Health Organization (WHO),[4] and the Medical Association of Canada,[5] the United States,[6] and Britain.[7]

While the threat of climate change to health is unequivocal and pressing,[2,3] climate change is increasingly being presented as a public health opportunity.[1] For instance, the negative health outcomes resulting from climate change could be reduced with enhanced healthcare provision and public health services, improved disaster management, integrated environment and health surveillance and early warning systems, poverty reduction, and mainstreaming cross-sector collaboration.[2] Furthermore, there are several health co-benefits of climate change mitigation, ranging from improved physical activity resulting from active commuting, to reduced respiratory illnesses from decreased air pollution.[2] While the health sector is already grappling with climate change impacts on public health and healthcare needs, priorities, use, provision, and costs, health adaptation is generally under-represented in policies, planning, and programming. For instance, all initiatives under the United Nations Framework Convention on Climate Change (UNFCC) affect human health; however, only 15% of initiatives had an explicit human health component described.[8]

Canada is no exception to this global trend, with the health sector substantially under-represented in adaptation initiatives compared to other sectors.[8] Of the health sector adaptation actions, many efforts by governments have been groundwork actions, with initiatives focused on building adaptive capacity and preparing conditions to enable adaptation, including increasing awareness about the health impacts of climate change and conducting vulnerability assessments.[8-10]

There have been an increasing number of government adaptation actions which are aimed at reducing vulnerability, including warning and monitoring systems, as well as initiatives aimed at changing practice and behaviour. In Canada, this has included training, information resources, frameworks, general outreach and education, and dissemination of information to decision makers.[9] Importantly, health adaptation is occurring at the local level, ranging from individual, to household, to community scales.

Considering the research gaps, public health practice challenges and opportunities, as well as the urgency of climate change impacts on human health, the six contributions to this Special Issue, published in conjunction with Earth Day, illustrate the many ways in which climate change is already impacting individual and community health. Through a combination of at-a-glance papers and original research articles, this collection demonstrates a diversity of research on climate change and health in Canada and is a clear call to action for the health sector to support both climate change health adaptation measures, and to champion mitigation strategies that have clear associated health co-benefits.

This Special Issue begins with a synthesis of climate-sensitive health concerns in the literature in rural and remote regions in Canada by Kipp et al.[11] Utilizing a scoping review search process, this article identifies the key health vulnerabilities and strengths of rural and remote regions, and discusses challenges associated with food and water security, exacerbation of chronic illness, infectious diseases, morbidity and mortality, and mental health.

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Indigenous Peoples, including First Nations, Inuit, and Metis communities, are often experiencing disproportionate impacts from climate change on their health and wellbeing. Richards et al.[12] describe the Climate Change and Health Adaptation Program within the First Nations and Inuit Health Branch of Indigenous Services Canada, which funds community adaptation research with the objective of developing community-based and culturally-sensitive tools and solutions. Drawing from three case studies, the authors identify the diverse research funded through this program and emphasize the importance not only of funding climate change and health research, but of directly supporting Indigenous communities to do their own work, based on their local contexts and cultures.

Underscoring the important focus on co-benefits, Kingsley[13] examines the ways in which protecting, improving, and increasing green spaces can be not only a climate change mitigation strategy, but also an important health strategy, with positive benefits for chronic diseases and their associated risk factors. Drawing from two examples of multi-sectoral collaborations, including EcoHealth Ontario and Climate Change Parks in Scotland, this contribution puts forward a model that considers green spaces as an important climate change and health intervention.

Demers and Gosselin[14] examine the increase of pollen allergies and seasonal allergic rhinitis in North America from a changing climate, particularly from ragweed. Through an analysis of a strategy implemented by the Quebec government to decrease ragweed and related allergenic pollens, this paper examines the scientific data underpinning the strategy, and demonstrates initial successes from its implementation.

MacIntyre et al.[15] examine the ways in which risk communication related to extreme weather events and climate change occurs in the public health domain. Utilizing a scoping review approach, the authors sought to evaluate public health risk communication strategies, and the implications of these findings for the Ontario Public Health Standards 2018. Their findings indicate that risk communication is more effective when linked to short-term extreme weather events. Such findings are important for informing public health communication strategies and for motivating local actions to mitigate the effects of climate change.

Finally, using a narrative methodology approach, Malena-Chan[16] studies the ways in which young community leaders in Saskatchewan are interpreting and understanding climate change. Findings from this study suggest that narrative dissonance – or the ways in which narratives of climate change cannot be reconciled because of emotional, moral, or conceptual contradictions – can be an explanatory factor in understanding immobilization and inaction, with implications for public health messaging.

In 2015, the *Lancet's* multidisciplinary Commission on Climate Change and Health made ten recommendations to governments, including urging them to: "invest in climate change and public health research"; "finance climate-resilient health systems"; and "collaborate to implement policies that mitigate climate change and promote public health, and monitor progress over the next 15 years."[17] Building on those recommendations and supporting the growing body of scientific literature, this Special Issue exemplifies the diversity of pathways through which climate change is currently impacting the health of Canadians, while underscoring both the grand health challenges and the grand health opportunities from a changing climate.

Conflicts of interest

The authors have no conflicts of interest to declare.

Authors' contributions and statement

AC and SLH contributed equally to the conceptual development, writing, and editing of this manuscript.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

References:

1. Wang H, Horton R. Tackling climate change: the greatest opportunity for global health. Lancet. 2015;386(10006): 7-13.
2. Smith KR, Woodward A, Campbell-Lendrum D, et al. Human health: impacts, adaptation, and co-benefits. In: Field CB, Barros VR, Dokken DJ, et al., editors. Climate Change 2014: Impacts, Adaptation, and Vulnerability Part A: Global and Sectoral Aspects Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. London (UK): Cambridge University Press; 2014. p. 709-54.
3. Costello A, Abbas M, Allen A, et al. Managing the health effects of climate change. Lancet. 2009;373(9676): 1693-733.
4. World Health Organization. COP24 special report: health & climate change. Geneva (Switzerland): World Health Organization; 2018. 38 p.
5. Canadian Medical Association. Climate change and human health. Canadian Medical Assocation policy statement [Internet]. Ottawa (ON): Canadian Medical Association; 2010. Available from: http://policybase.cma.ca/dbtw-wpd/Policypdf/PD10-07.pdf
6. American Medical Association. Confronting health issues of climate change [Internet]. American Medical News. 2011. Available from: https://amednews.com/article/20110404/opinion/304049959/4/#exli
7. British Medical Association. BMA backs action on health effects of climate change [Internet]. British Medical Association; 2015. Available from: https://www.bma.org.uk/news/2015/october/bma-backs-action-on-health-effects-of-climate-change
8. Lesnikowski AC, Ford JD, Berrang-Ford L, Paterson JA, Barrera M, Heymann SJ. Adapting to health impacts of climate change: a study of UNFCCC Annex I parties. Environ Res Lett. 2011;6(4):044009.
9. Austin S, Ford J, Berrang-Ford L, Araos M, Parker S, Fleury M. Public health adaptation to climate change in Canadian jurisdictions. Int J Environ Res Public Health. 2015;12(1):623-51.
10. Panic M, Ford JD. A review of national-level adaptation planning with regards to the risks posed by climate change on infectious diseases in 14 OECD nations. Int J Environ Res Public Health. 2013;10(12):7083-109.

11. Kipp A, Cunsolo A, Vodden K, et al. At-a-glance – Climate change impacts on health and wellbeing in rural and remote regions across Canada: a synthesis of the literature. Health Promot Chronic Dis Prev Can. 2019;39(4): 122-6.

12. Richards G, Frehs J, Myers E, Van Bibber M. Commentary – The Climate Change and Health Adaptation Program: Indigenous climate leaders' championing adaptation efforts. Health Promot Chronic Dis Prev Can. 2019;39(4): 127-30.

13. Kingsley M, EcoHealth Ontario. Commentary – Climate change, health and green space co-benefits. Health Promot Chronic Dis Prev Can. 2019;39(4): 131-5.

14. Demers I, Gosselin P. At-a-glance – Pollens, climate and allergies: Quebec initiatives. Health Promot Chronic Dis Prev Can. 2019;39(4):136-41.

15. MacIntyre E, Khanna S, Darychuk A, Copes R, Schwartz B. Evidence synthesis – Evaluating risk communication during extreme weather and climate change: a scoping review. Health Promot Chronic Dis Prev Can. 2019;39(4):142-56.

16. Malena-Chan R. A narrative model for exploring climate change engagement among young community leaders. Health Promot Chronic Dis Prev Can. 2019;39(4):157-66.

17. Watts N, Amann M, Ayeb-Karlsson S, et al. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. The Lancet. 2018;391(10120):581-630.

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At-a-glance

Climate change impacts on health and wellbeing in rural and remote regions across Canada: a synthesis of the literature

Amy Kipp, MA (1); Ashlee Cunsolo, PhD (2); Kelly Vodden, PhD (3); Nia King, BSc (4); Sean Manners, BA (3); Sherilee L. Harper, PhD (1)

Abstract

This article provides a synthesis of the forthcoming first order draft of the Canadian Government's National Assessment on Climate Change 'Rural and Remote' chapter, highlighting key health concerns from the literature associated with climate change in rural and remote regions, as well as existing and future adaptation strategies. To support the health and wellbeing of those experiencing the negative effects of climate change, and utilizing systematic search processes, this synthesis article highlights the importance of considering the specific socio-cultural, economic, and geographic elements and existing expertise of individuals and communities in rural and remote regions.

Keywords: *climate change, health, wellbeing, rural, remote, adaptation, Canada*

Highlights

- Climate change negatively impacts the health and wellbeing of individuals and communities in rural and remote regions in Canada.
- Key health concerns from the National Assessment on Climate Change 'Rural and Remote' include the exacerbation of issues associated with food and water security, chronic illness, infectious disease, unintentional injury and death, and mental health.
- Although specific characteristics increase climate change vulnerability of rural and remote regions, many strengths within these regions support resilience to climate change.
- Focusing on climate change adaptation, as well as realizing co-benefits from climate change mitigation, presents important opportunities for the health sector.

Introduction

In rural and remote regions (see Box 1) across Canada, human health and wellbeing are often influenced by the close connection individuals and communities have to their social, cultural, and physical environments.[1-5] These communities often rely closely on the environment for their sustenance, livelihoods, and cultural practices, influencing the social determinants of health and wellbeing.[1-3,5,6] As a result, climate change is directly and indirectly impacting the health and wellbeing of individuals and communities.[1,2,5,7,8]

This article synthesizes the health content from the first order draft of the 'Rural and Remote' chapter of the Canadian government's forthcoming National Assessment on Climate Change, *Canada in a Changing Climate: Advancing Our Knowledge for Action.*[9] The Rural and Remote Chapter is one of several national issues chapters of The National Assessment, including chapters focused on Our Natural Capital, International Dimensions, and Resilience of Our People and Society, for example, as well as regional chapters, such as Northern Canada, British Columbia, the Prairies, Ontario, Quebec, and Atlantic Canada.* This assessment will serve as an important resource for communities, policy-makers, and academics to support climate change adaptation decisions and actions and explores how Canada's climate is changing, the impacts of these changes on Canadians, and the adaptation strategies being used to reduce climate related risks.[9] The Rural and Remote Chapter, and by extension this article, is based on a scoping† review of gray and peer-reviewed literature; ongoing engagement with researchers, governments, communities, organizations, and Indigenous knowledge-keepers and leaders; and collaboration with other Chapters in the National Assessment. The scoping review characterized the nature, range, and extent

* For a complete list of Chapters and more information on the National Assessment on Climate Change visit: https://www.nrcan.gc.ca/environment/impacts-adaptation/19926

† The search approach utilized for the Rural and Remote chapter followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR). Full details of the search methods will be available in Natural Resource Canada's National Assessment, Canada in a Changing Climate: Advancing Our Knowledge for Action, Rural and Remote Chapter (forthcoming 2020).

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BOX 1
Definition of rural and remote regions

Building from the PHAC definition,[31] rural and remote regions are defined as areas with less than 10 000 people, in which rural regions have less than 50% of the population that commute to an urban location for work, and remote communities have no residents that commute to an urban location for work or the community is located in one of the Canadian territories.

of literature on climate change impacts and adaptation in rural and remote Canadian communities, and included literature published since the last national assessment (2013). Based on quantitative and qualitative analysis of the scoping review, as well as input from engagement and collaboration, key health concerns associated with climate change and adaptation strategies in rural and remote regions throughout Canada were identified. This article provides a brief overview of these key health concerns.

Climate change, health, and wellbeing in rural and remote regions

Many changing climate conditions and resultant environmental impacts negatively affect individual and community health and wellbeing in rural and remote regions, including: increased prevalence and severity of extreme weather events;[1,2,5,10-12] changes to sea ice, vegetation, fish, wildlife, and water;[1,2,5,12,13] and weather and environmental uncertainties.[1,2,6,14]

Negative health outcomes associated with these changes include an increased prevalence of poor nutrition, obesity, and diabetes;[5,15,16] vector-borne, waterborne, and foodborne disease;[5,12,16,17] cardiovascular disease;[15,16] respiratory issues;[18] injury and mortality;[12-14] and mental health issues.[3,6,18-20] Characteristics of rural and remote regions may increase the sensitivity to these health risks, such as remote geography and limited transportation infrastructure, reliance on natural resources, and under-resourced social and physical infrastructure.[2,5] Additionally, vulnerability to climate change is influenced by the intersection of social, cultural, and political factors in rural and remote regions as well as individual characteristics and circumstances.[2,5,21,22] Based on a synthesis of the literature from this scoping review, key health concerns in rural and remote areas include: 1) challenges with access to and quality of food and water; 2) exacerbation of chronic illness and infectious disease; 3) potential unintentional injury and death; and 4) intensified challenges with mental health and wellbeing. Furthermore, the literature highlights Indigeneity, age, gender, and socioeconomic status as key factors influencing individual and community vulnerability to climate change in rural and remote regions.

Changing access and availability of nourishing, accessible, and preferred food and water

Many rural and remote regions have experienced changing access to, and quality of, food and water systems, linked to environmental changes such as rising temperatures,[7,16,20,23] changing precipitation patterns, and increasing incidents of extreme weather events.[7,18,23] For example, in many Northern remote First Nations and Inuit communities, climate-change-related disruptions to sea ice, wildlife, and vegetation impacts the ability of individuals to hunt, fish, and forage, leading to decreased consumption of healthy and culturally-preferred local food and increased reliance on retail food.[7,16,18,19,23] Water security, including access, availability and quality, may also be challenging in rural and remote regions, where rising temperatures and more frequent extreme weather events can overwhelm fragile water treatment systems, interrupting the provision of safe drinking water.[7,23] Across Northern Canada, where many communities rely on surface water sources, changes to water levels, run-off, flow regimes, and sediment accumulation can drastically affect

TABLE 1
Examples of existing and potential adaptation strategies to the negative health effects of climate change in rural and remote communities in Canada

Examples of existing adaptation strategies	References
Introducing local food production systems	15,16,19
Using experience-based knowledge of local communities to support community resilience	3,6,12
Developing community-based monitoring programs and research to gather data about environment and health to inform decision making	5-7,18,25
Using Indigenous Knowledge and Local Knowledge regarding the physical environment, to support hazard avoidance and emergency preparedness	12-14
Utilizing a social development approach, which involves health professionals, social workers, and those in caring professions supporting those directly impacted by climate change to strengthen community capacity	22
Fostering protective factors for physical and mental health through connection to land-based activities, cultural arts and crafts, and opportunities for bringing community together	27
Examples of potential adaptation strategies	**References**
Using local knowledge, Indigenous Knowledge, and/or western knowledge to respond to specific local sociocultural contexts	7,12,19,22
Eliminating social barriers to adaptation (e.g. poverty, inequality, housing concerns, etc.) and reducing non-climatic factors (e.g. chronic disease)	5,22
Utilizing innovative forms of technology (e.g. telehealth, mobile monitoring applications; satellite imagery)	5,19
Improving public health surveillance and furthering monitoring programs	5,7,8,12,14,15,23,24,29
Supporting sustainable development practices (e.g. clean energy programs)	12,19,22,29
Enhancing communication and awareness of risks and responses (e.g. lists of safe spaces, pamphlets regarding disease outbreaks; developing outreach strategy)	5,12,18,19,29
Expanding knowledge of climate change impacts on health through research and investment, and sharing best practices for public health adaptation	5,19,29
Developing the capacity of health systems and emergency response to withstand and respond to climate risks (e.g. creating technical guidance and training courses; integrating climate change into medical and public health training)	14,19

drinking water availability and quality.[23,24] Both food and water insecurity have been linked to negative health outcomes, including poor nutrition, obesity, diabetes, cardiovascular disease, acute gastrointestinal illness, and mental health concerns.[7,12,16,25]

Exacerbation of chronic illness and infectious disease

Changing precipitation patterns, rising temperatures, and increased frequency and severity of extreme weather conditions can also exacerbate chronic illnesses and infectious diseases in rural and remote regions by increasing exposure to environmental contaminants, and vector-borne, foodborne, and waterborne diseases;[16] putting enhanced stress on underlying chronic conditions (e.g. cardiovascular and respiratory illness);[4,18] and disrupting healthcare provision and chronic disease management.[6] Further, research has documented increased risk of waterborne disease in rural and remote areas, due to weather-related contamination events.[5,25] Additionally, changing winds, ocean currents, and rivers, carrying environmental contaminants North, may lead to increased levels of persistent organic pollutants and toxic heavy metals in local food and water sources in remote polar regions;[7,16,23] the consumption of contaminants can result in many health concerns.[7]

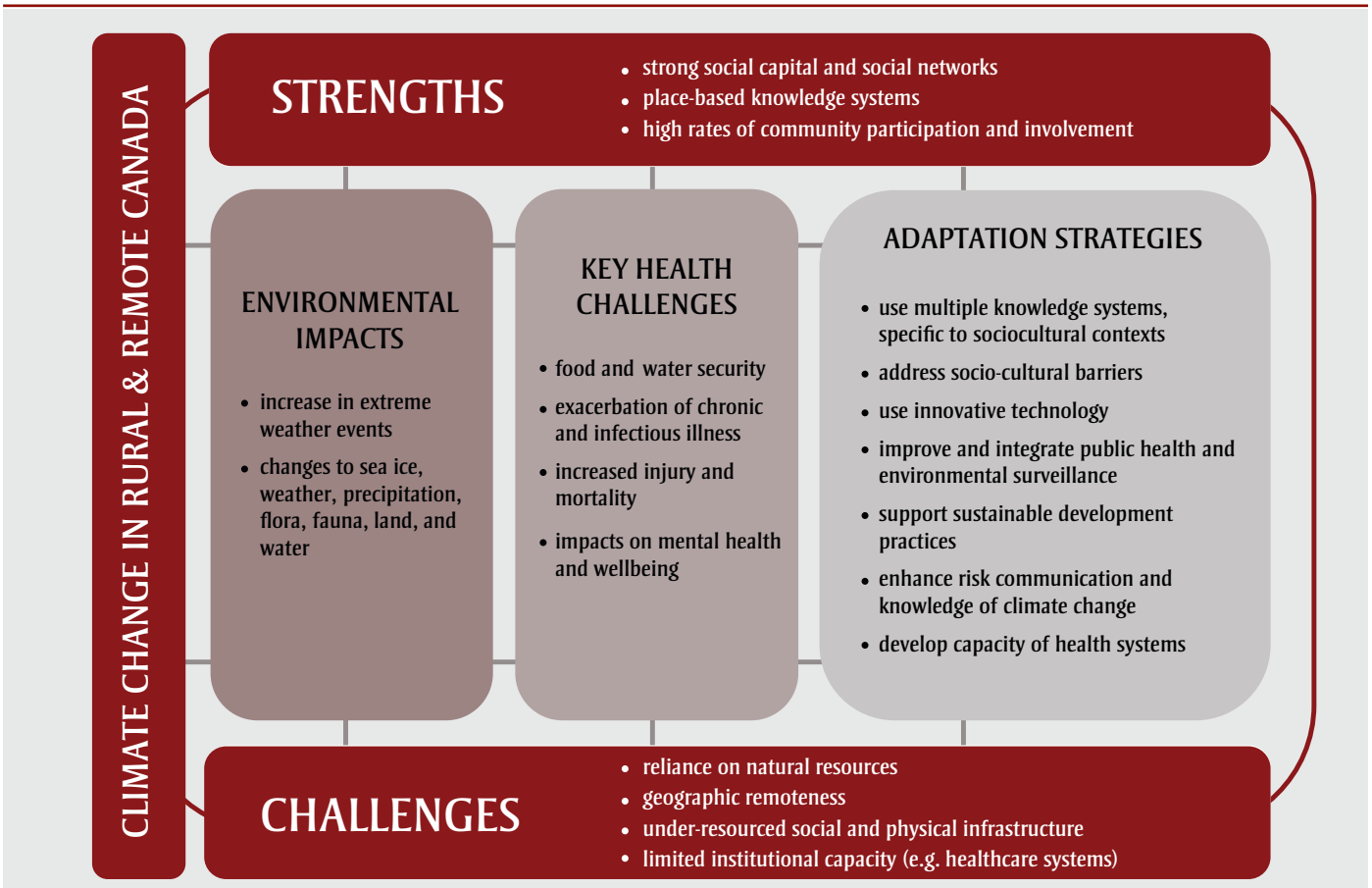
Changing climate conditions resulting in increased injury and mortality

Extreme and rapidly changing weather conditions, including heat waves, storms, droughts, flooding, and changing sea ice conditions, have had significant negative effects on the health of individuals in rural and remote regions. For example, an increase in the number of heat waves experienced in rural regions was associated with increased heat stroke and respiratory related emergency room visits.[26] Additionally, wild fires and associated health challenges, such as respiratory issues, mental health stressors, and damage to critical health infrastructure, have been identified in forest communities across Canada as a threat to safety and wellbeing.[11,18,19]

Changing and uncertain environmental conditions impacting mental health and wellbeing

As environments change and people adapt to new and often fewer desirable conditions, the mental health and wellbeing of individuals in rural and remote regions is also affected. For example, in Indigenous communities in rural and remote regions of Canada, individuals are often deeply connected to the land for their wellbeing; as climatic changes alter the environment, access to places and practices of cultural significance are often disrupted.[3,6,12,27] For Nunatsiavut Inuit, for example, these changes have led to increased anxiety, fear, distress, anger, grief, and depression related to changes to land-based activities, connection to land, and cultural identity.[3,25,27]

FIGURE 1
Visual summary of key health challenges and adaptation strategies in the context of climate change in rural and remote regions in Canada



In regional plans in Manitoba, the potential loss of livelihoods associated with drought was identified as a climate-sensitive mental health concern.[28] In Atlantic Canada, individuals have connected an increase in the prevalence and severity of storms in rural coastal communities and the subsequent damage to important mental health infrastructure,[29] which often differs by gender.[30]

Climate change adaptation responses and opportunities in rural and remote regions

Despite these challenges, focusing on climate change adaptation, as well as realizing co-benefits from climate change mitigation, presents an important opportunity for the health sector. Already many Canadian rural and remote communities have begun to develop and implement health-related adaptation strategies (Table 1). To support adaptation to the health effects of climate change, a number of changes to existing adaptation strategies are needed, including: using multiple knowledge systems, specific to sociocultural contexts; addressing non-climatic factors impacting adaptation; utilizing innovative forms of technology; improving and integrating health surveillance with environmental monitoring; supporting sustainable development practices; enhancing awareness of risks and response; expanding knowledge of climate change impacts; and developing the capacity of the health sector to respond to climate change (Table 1). Ultimately, for rural and remote communities to continue to adapt to the health impacts of climate change, it is important to consider the specific local and regional socio-cultural, economic, and geographic elements; support and draw upon existing expertise of individuals and communities in rural and remote areas in Canada; and continue to view human health within the social-cultural and physical environments of rural and remote regions (Figure 1).

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Conflicts of interest

The authors have no conflicts of interest to declare.

Authors' contributions and statement

AC, SLH, and KV contributed to conceptualizing the literature review and search string to identify peer-reviewed and gray literature. NK and SM conducted the literature review search and extracted quantitative information from articles. AK, AC, and SLH analyzed articles qualitatively and synthesized information, including identifying emergent themes related to health concerns and adaptation strategies, as well as drafted the article. All authors contributed to revising the article.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

References

1. Intergovernmental Panel on Climate Change. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In: Barros VR, Field CB, Dokke JD, et al., editors. Cambridge (UK), New York (USA): Cambridge University Press; 2014. 688 p.

2. Intergovernmental Panel on Climate Change. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In: Field CB, Barros VR, Dokken DJ, et al., editors. Cambridge (UK), New York (USA): Cambridge University Press; 2014. 1132 p.

3. Cunsolo A, Ellis NR. Ecological grief as a mental health response to climate change-related loss. Nat Clim Chang. 2018;8(4):275-81. doi: 10.1038/s41558-018-0092-2.

4. Public Health Agency of Canada. Climate change impacts on the health of Canadians [Internet]. Ottawa (ON): Public Health Agency of Canada; 2017. Available from: http://publications.gc.ca/collections/collection_2017/aspc-phac/HP5-122-2017-eng.pdf

5. Expert Panel on Climate Change Adaptation and Resilience. Measuring progress on adaptation and climate resilience: recommendations to the Government of Canada [Internet]. Gatineau (QC): Environment and Climate Change Canada; 2018. 188 p. Available from: http://publications.gc.ca/collections/collection_2018/eccc/En4-329-2018-eng.pdf

6. Cunsolo Willox A, Stephenson E, Allen J, et al. Examining relationships between climate change and mental health in the Circumpolar North. Reg Environ Chang. 2015;15(1):169-82.

7. Berner J, Brubaker M, Revitch B, Kreummel E, Tcheripanoff M, Bell J. Adaptation in Arctic circumpolar communities: food and water security in a changing climate. 2016;1:1-8.

8. Durkalec A, Furgal C, Skinner MW, Sheldon T. Climate change influences on environment as a determinant of Indigenous health: relationships to place, sea ice, and health in an Inuit community. Soc Sci Med. 2015;136-137:17-26.

9. Natural Resources Canada. Canada in a Changing Climate [Internet]. Ottawa (ON): Natural Resources Canada; 2018 [cited 2018 Nov 26]. Available from: https://www.nrcan.gc.ca/environment/impacts-adaptation/19918

10. Rapaport E, Manuel P, Krawchenko T, Keefe J. How can aging communities adapt to coastal climate change? Planning for both social and place vulnerability. Can Public Policy. 2015;41(2):166-77.

11. Government of Saskatchewan. Prairie resilience: a made-in-Saskatchewan climate change strategy [Internet]. Government of Saskatchewan; 2017. Available from: http://publications.gov.sk.ca/documents/66/104890-2017 Climate Change Strategy.pdf

12. Ford JD, Willox AC, Chatwood S, et al. Adapting to the effects of climate change on Inuit health. Am J Public Health. 2014;104(Suppl. 3):e9-17.

13. Clark DG, Ford JD. Emergency response in a rapidly changing Arctic. Can Med Assoc J. 2017;189:e135–6.

14. Young SK, Tabish TB, Pollock NJ, Kue Young T. Backcountry travel emergencies in arctic Canada: a pilot study in public health surveillance. Int J Environ Res Public Health. 2016;13(3): 276.

15. Barbeau CD, Oelbermann M, Karagatzides JD, Tsuji LJS. Sustainable agriculture and climate change: producing potatoes (Solanum tuberosum L.) and bush beans (phaseolus vulgaris L.) for improved food security and resilience in a Canadian subarctic first nations community. Sustain. 2015; 7(5):5664-81.

16. Loring PA, Gerlach SC. Searching for progress on food security in the North American North: a research synthesis and meta-analysis of the peer-reviewed literature. Arctic. 2015;68(3): 380-92.

17. Harper SL, Edge VL, Schuster-Wallace CJ, Berke O, McEwen SA. Weather, water quality and infectious gastrointestinal illness in two Inuit communities in Nunatsiavut, Canada: potential implications for climate change. Ecohealth. 2011;8(1):93-108.

18. Dodd W, Scott P, Howard C, et al. Lived experience of a record wildfire season in the Northwest Territories, Canada. Can J Public Heal. 2018; 109(3):327-37.

19. Government of Northwest Territories. Northwest Territories Climate Change Strategic Framework 2018-2030 [Internet]. Government of Northwest Territories; 2017. Available from: https://www.enr.gov.nt.ca/sites/enr/files/resources/128-climate_change_strategic_framework_web.pdf

20. Statham S, Ford J, Berrang-Ford L, Lardeau MP, Gough W, Siewierski R. Anomalous climatic conditions during winter 2010-2011 and vulnerability of the traditional Inuit food system in Iqaluit, Nunavut. Polar Rec (Gr Brit). 2015;51(3):301-17.

21. Krawchenko T, Keefe J, Manuel P, Rapaport E. Coastal climate change, vulnerability and age friendly communities: linking planning for climate change to the age-friendly communities' agenda. J Rural Stud. 2016;44:55-62. doi: 10.1016/j.jrurstud.2015.12.013.

22. Drolet JL, Sampson T. Addressing climate change from a social development approach: small cities and rural communities' adaptation and response to climate change in British Columbia, Canada. Int Soc Work. 2017;60(1): 61-73.

23. Medeiros AS, Wood P, Wesche SD, Bakaic M, Peters JF. Water security for northern peoples: review of threats to Arctic freshwater systems in Nunavut, Canada. Reg Environ Chang. 2017; 17(3):635-47.

24. Bakaic M, Medeiros AS. Vulnerability of northern water supply lakes to changing climate and demand [Internet]. Arct Sci. 2017;3(1):1-16. Available from: http://www.nrcresearchpress.com/doi/10.1139/as-2016-0029

25. Harper SL, Edge VL, Ford J, et al. Climate-sensitive health priorities in Nunatsiavut, Canada. BMC Public Health. 2015;15(1):605.

26. Bishop-Williams KE, Berke O, Pearl DL, Kelton DF. A spatial analysis of heat stress related emergency room visits in rural Southern Ontario during heat waves. BMC Emerg Med. 2015; 15(1):1-9. doi: 10.1186/s12873-015-0043-4.

27. Cunsolo A, Shiwak I, Wood M. "You Need to Be a Well-Rounded Cultural Person": youth mentorship programs for cultural preservation, promotion, and sustainability in the Nunatsiavut Region of Labrador. In: Fondahl G, Wilson G, editors. Northern Sustainabilities: Understanding and Addressing Change in the Circumpolar World. Springer Polar Sciences. 2017:285-303.

28. Government of Manitoba. A made-in-Manitoba climate and green plan. Hearing from Manitobans [Internet]. Government of Manitoba; 2017. Available from: http://www.gov.mb.ca/asset_library/en/climatechange/climategreenplandiscussionpaper.pdf

29. Province of New Brunswick. Transitioning to a low-carbon economy: New Brunswick's climate change action plan. Fredericton (NB): Province of New Brunswick; 2016. Available from: https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/TransitioningToALowCarbonEconomy.pdf

30. Vasseur L, Thornbush M, Plante S. Gender-based experiences and perceptions after the 2010 winter storms in Atlantic Canada. Int J Environ Res Public Health. 2015;12(10):12518-29.

31. Public Health Agency of Canada. The Rural Think Tank 2005 - Understanding issues families face living in rural and remote communities [Internet]. Ottawa (ON): Public Health Agency of Canada; 2007. Available at: http://www.phac-aspc.gc.ca/hp-ps/dca-dea/publications/rtt-grr-2005/2-eng.php

https://doi.org/10.24095/hpcdp.39.4.03

Commentary

The Climate Change and Health Adaptation Program: Indigenous climate leaders' championing adaptation efforts

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Abstract

The Climate Change and Health Adaptation Program (CCHAP) is a program within the First Nations Inuit Health Branch of Indigenous Services Canada (which was previously under the responsibility of Health Canada). The CCHAP supports Inuit and First Nation communities in mitigating and adapting to the health impacts of climate change. The impacts of climate change on Indigenous health can be observed in multiple areas including, but not limited to, food security, cultural medicines, mental health and land-based practices. This program seeks to address the needs of climate change and health in First Nation and Inuit communities to support resiliency and adaptation to a changing climate both now and in the future through its emphasis on youth and capacity building. The commentary is based on the Program's eleven years of experience working with and for Indigenous communities and provides an overview of the CCHAP model and the work it has and continues to support. This paper demonstrates three examples of community-based projects to mitigate and adapt to the health impacts of climate change to demonstrate climate change resiliency within Indigenous communities.

Keywords: *climate change, First Nations, Inuit, community-based, adaptation, mitigation*

Highlights

- The Climate Change and Health Adaptation Program (CCHAP) for First Nations South of 60N directly supports First Nations communities to develop and undertake adaptation and mitigation projects to build upon their needs within a changing climate.
- This commentary outlines the CCHAP's work and history, and highlights three cases, in Selkirk First Nation, Arviat and The Mi'kmaw Climate Action, which demonstrate the work these communities have undertaken with support from the Program.

Introduction

Environmental changes are both detrimental to human health, and an opportunity to develop adaptive and creative solutions with those who are threatened the most by these environmental shifts.[1] Amongst those who are critically impacted are First Nation and Inuit communities whose livelihoods and well-being hinges upon the wellness of the land. Cunsolo Willox et al.[2] describes that Indigenous communities' health and well-being are connected to the land, stating: "[Indigenous] identities, well-being, livelihoods, histories, and emotion-spiritual connection are emergent from the land on which they live" (p. 546). Many Indigenous community members continue to live off the land by hunting, fishing, trapping, and gathering. The physical impacts of environmental changes can be observed by First Nation and Inuit communities by disrupting hunting and game migration patterns which impacts food security, the melting of sea ice and permafrost, lower crop yields, and furthermore, the spread of infectious diseases and more intense and longer heat waves.[1,3,4] Communities are also impacted emotionally, as Inuit and First Nation communities express that these environmental changes, and subsequent land changes, have impacted community members' identities and livelihoods.[2,5] These environmental changes are happening at a more accelerated rate than ever before[1] and are compounded by the impacts that colonization has had on Indigenous communities—further affecting their cultures and their livelihoods.[6] Colonization has created multiple impacts including the displacement and relocations of First Nations and Inuit people on their land and territory, the hindrance of rights to self-determination, the suppressing of Indigenous languages and cultural knowledge, and the extraction of land and resources.[7] These impacts of colonization compounded with climate change have subsequently increased communities' vulnerability to experiencing climate change, critically impacting health and well-being.

Indigenous Knowledge is a key component to climate change resiliency which helps mitigate the health impacts of a changing environment, through place and culture specific knowledge that encourages significant adaptive capacity to health concerns that environmental change has caused.[8] Indigenous Knowledge is understood as knowledge that has been accumulating and evolving through adaptive processes and cultural transmission between generations of a community,[9] and "is an understanding of the world and of the human place in the world…a view that explains the mysteries surrounding

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them and, that gives [communities] a sense of place" (*Arctic Climate Impact Assessment*, 2004).[10] One key strength of Indigenous Knowledge lies within local contexts of cultural and kinship systems which enables place and culture specific adaptive capacities to be built within communities.[8] These aspects can lead to stronger mitigation practices amongst First Nation and Inuit communities to adapt to the issues these communities face.

The Climate Change and Health Adaptation Program (CCHAP)

The Climate Change and Health Adaptation Program (CCHAP) was established in 2008 in response to concerns from First Nation and Inuit communities North of 60º including Nunatsiavut (Northern Labrador) and Nunavik (Northern Quebec), who were and are being directly impacted by climate change.[10,11] These communities sought to lead research projects that would positively impact their communities' health and well-being. The CCHAP directly funds Indigenous communities and Indigenous not-for-profit organizations to support communities in conducting their own research in climate change and health, directly building capacity amongst youth and community members. Furthermore, directly funding First Nations and Inuit communities enables communities to use their funds as they see fit to address adaptation and resiliency to climate change. Projects that the CCHAP supports seek to build community capacity and raise awareness around climate change and health while respecting Indigenous sovereignty. Projects thus rely on Indigenous Knowledge and other scientific methods to create tangible change within their communities, and therefore, increase awareness of climate change to reduce risks to health and well-being.

The CCHAP has funded 95 community-based research and adaptation projects from 2008-2016 in areas such as, food security, water quality, land-based activities, mental health, and cultural medicines among others. In 2016 the program expanded to the southern part of Canada, serving First Nation communities South of 60º. Today, there is one program in the South and one in the North to serve First Nation and Inuit communities in adapting to the changing environments and learning how climate change is impacting health and well-being within communities.*

The program embraces First Nation leadership through an Indigenous Selection Committee which reviews projects, offers feedback and makes funding decisions. Transferring the decision-making processes to First Nation and Inuit community representatives ensures that projects undertaken with the CCHAP are truly for communities, by communities. Through the integration of Indigenous leadership, projects undertaken with the CCHAP inherently utilize interdisciplinary approaches that combine Indigenous Knowledge and other scientific approaches to adapt to climate change impacts. The integration of these knowledge streams has enhanced community capacity and encouraged both mitigation and adaptation measures to support communities' well-being.[10]

Three community-based research studies funded through CCHAP

Below are three case studies that exemplify some of the work the CCHAP supports which provide examples of the breadth and scope of the work Indigenous communities have undertaken since 2008. These projects represent some of the successes Indigenous communities have had with initiatives undertaken with support from the CCHAP's funding. Each of these projects represents the adaptive capacity of First Nations and Inuit peoples and how their cultural knowledge has led to adaptation and mitigation within a changing climate, increasing communities' resiliency to climate change. Projects supported in Selkirk First Nation, Arviat, and within Mi'kmaw territory offer an understanding of the ways Indigenous communities are adapting to a changing climate and are addressing the associated health impacts of climate change on community health and well-being. The Northern case studies are adapted from the CCHAP North Synthesis Report which is currently under publication, information from the climatetelling.info website and project reports with permission and input from project leads.[11,12]

The Selkirk First Nation was supported by the CCHAP in 2015/2016 and produced multiple outputs, including a video and publications which can be found at the ClimateTelling website and at the Arctic Institute for Community-Based Research's website.[5,11] Selkirk First Nation rests centrally in the Yukon Territories where the Yukon River salmon are in dramatic decline. The project undertaken by the Selkirk First Nation focused on the relationship between the land, water and the people who rely on the fish camps for food security and to continue cultural practices that support mental, physical, emotional and spiritual well-being of their people. The community relies on salmon as central to their diet and harvesting of the salmon is at the heart of the Northern Tutchone cultural traditions. With the low returns of salmon, due to climactic changes and industrial pressures on the Chinook salmon life cycle, Selkirk people fear not only the loss of a vital food source, but also the loss of age-old traditions of the fish camps. The fish camps are critical to Selkirk food security and at the heart of transferring Indigenous Knowledge to the next generation of Selkirk people. Therefore, the community wanted to continue the traditions of the fish camps to ensure the health and mental well-being of their community members. This project centered around maintaining food security and Tutchone knowledge and culture while adapting to the threat of climate change. To do this, the research was guided by a community advisory committee, Selkirk Elders and the community. A survey of fish camps conducted by the youth with support of the research leads provided an opportunity for the youth to learn first-hand, the value and role of the summer fish camps while being able to understand the impacts that climate change was having on their lands and community. Despite the lack of fish, the youth learned from Elders the importance of keeping Tutchone traditions strong as an important resource for mental well-being and future challenges. The project identified six key strategies for adapting to the changing climate. This project encouraged youth to connect with their Indigenous Knowledge and the role it has in promoting mental wellness, while also learning about the impacts that climate change is having on their land. This was achieved with on-the-land activities at a winter fish camp for youth, as well as their role in the research process, including through conducting interviews and taking photos, culminating in a Photo

* For more information on the CCHAP North please visit: https://www.sac-isc.gc.ca/eng/1536238477403/1536780059794.

Voice story. This project encouraged youth to gain confidence in their communities' knowledge and raised awareness amongst youth and community members on the impacts that climate change is having on their communities' health and culture. Within the community there is a commitment to keep traditions strong through a series of climate change adaptation strategies, including the role of the fish camps.

Arviat, Nunavut was supported by the CCHAP for four years to undertake a project targeting food security beginning in 2010. The community produced multiple reports and outputs including videos and publications which can be found on the ClimateTelling website.[11] In Arviat, Nunavut, the community developed a project targeting food security that was funded. The purpose of this project was to revitalize the practices of local harvesters and hunters which were seemingly displaced through social and cultural dislocation over the last 40–50 years. This dislocation led to greater safety concerns out on the land, and more of the hunted animals wasted as Indigenous Knowledge was discouraged by colonial practices. In addition, many community members developed diabetes due to reliance on store bought food, an expensive and less-healthy alternative to country food.[12] Therefore, the community developed a project by discussing and interviewing Arviat Elders who grounded the project in Inuit values and Indigenous Knowledge, ensuring that the project was culturally appropriate and followed cultural protocols. In these interviews, Elders described the value of 'food sharing' and therefore invested in a community freezer. The next phase explored the options for producing local and healthy foods. To do so, the community developed a composting system and used seaweed at fertilizer. After this, the community worked towards building local capacity to run the greenhouse. Lastly, the project furthered engagement within the community to ensure that a sustainable method of food production could continue. Each of these community-led initiatives built community capacity and supported the revitalization of Indigenous Knowledge. This has resulted in the reintegration of knowledge systems along with new innovations, such as a greenhouse, to ensure community members can be food secure. These initiatives are still strong today, resulting in the Young Hunters' Programming to teach youth hunting skills and several short films and articles which have documented this community's journey. This project is one example of the types of projects which support First Nation and Inuit communities to develop local food systems that are environmentally friendly, produce healthy food options, and are culturally appropriate.

As the program moved to include the southern part of Canada in 2016, Indigenous communities disclosed to the CCHAP that extreme weather events are impacting health and well-being within these communities. Climate change has resulted in increased extreme weather events, including forest fires and floods[13] which disproportionally impact Indigenous communities, particularly rural and coastal communities.[14] The CCHAP supported the Confederacy of Mainland Mi'kmaq's Mi'kmaw Conservation Group (later moved into the Mi'kmaw Climate Action Program) in Nova Scotia in a project that addressed emergency management in six different Mi'kmaw communities. This project conducted research, engaged community members, developed needs assessments and reported on the state of emergency plans. The project supported Mi'kmaw communities in developing emergency management measures that incorporated Indigenous Knowledge of health and safety. The project looked at the physical, mental, emotional and spiritual impacts of climate change, emergency events, and emergency management on the health of community members. Through speaking with community members, including, youth and Elders, the Mi'kmaw Climate Action Program gathered information on their specific concerns and needs in the case of emergency due to extreme weather events. The project also brought together Elders with youth through workshops to share knowledge and to encourage passing along skills that can build capacity and increase resiliency, through future activities such as creating canoe paddles and other crafts and activities to learn emergency skills. These skills can connect the youth to the land and help them learn about climate change and how that will impact extreme weather events.

Conclusion

These three projects that the CCHAP supported represent community led initiatives that support climate change resiliency amongst First Nation and Inuit communities. These projects were chosen to represent the resiliency of First Nation and Inuit communities and community-based initiatives that have positioned these communities at the forefront of both climate change challenges and adaptation. These projects undertaken demonstrate the importance of localizing adaptation and mitigation measures, specifically within food systems and emergency management. These projects developed with the framework of local, Indigenous Knowledge, to build capacity within communities.

Engaging youth and Elders to respectively learn and pass along Indigenous Knowledge from generation to generation strengthens communities' resiliency and helps ensure that the projects and initiatives are sustainable as capacity within the community and amongst youth are built. Through both peer and professional training each project builds capacities in different areas, such as, research and interview skills, technological skills and skills on the land. These skills are built through the passing of knowledge between generations, which is crucial in ensuring sustainability for our future, a future which youth represent. The projects supported by the CCHAP leverage First Nation and Inuit knowledge to build adaptive capacities within a changing climate that address communities' health concerns. It is through these efforts that Indigenous communities can share both their visions and concerns for the seven generations to come.

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Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions and statement

Gabrielle Richards works at the Climate Change and Health Adaptation Program and contributed to the writing of this commentary with Jim Frehs and Erin Myers who approved the manuscript and added their comments to ensure that the program was reflected accurately in the manuscript.

Marilyn Van Bibber critically revised the manuscript and contributed the case study on Selkirk First Nation.

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References

1. Watts N, Amann M, Ayeb-Karlsson S, et al. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. The Lancet. 2018;391(10120):581-630.

2. Cunsolo Willox A, Harper SL, Ford JD, et al. "From this place and of this place:" climate change, sense of place, and health in Nunatsiavut, Canada. Soc Sci Med. 2012;75(3):538-47.

3. Ford JD, Bolton K, Shirley J, Pearce T, Tremblay M, Westlake M. Mapping human dimensions of climate change research in the Canadian Arctic. Ambio. 2012;41(8):808-22.

4. Kwiatkowski RE. Indigenous community based participatory research and health impact assessment: a Canadian example. Environ Impact Assess Rev. 2011;31(4):445-50

5. Arctic Institute of Community-Based Research. Projects [Internet]. Whitehorse (YT): Arctic Institute of Community-Based Research; 2017. Available from: https://www.aicbr.ca/projects/

6. Kress M. Sasipihkeyihtamowin 1: Niso Nehiyaw Iskwewak. Canadian Woman Studies. 2015;31(1):52-64.

7. Tuhiwai Smith L. Decolonizing methodologies: research and Indigenous Peoples. London (UK): Zed Books; 2012.

8. Ford JD. Indigenous health and climate change. Am J Public Health. 2012;102(7):1260-6.

9. Cuerrier A, Brunet ND, Gérin-Lajoie J, Downing A, Lévesque E. The study of Inuit knowledge of climate change in Nunavik, Quebec: a mixed methods approach. Hum Ecol. 2015;43(3):379-94

10. Abele F, Gladstone J. Health Canada - Climate Change Health Adaptation Program: synthesis report and impact analysis [Internet]. ClimateTelling; 2016. Available from: http://www.climatetelling.info/uploads/2/5/6/1/25611440/cchap_final_report.pdf

11. ClimateTelling. ClimateTelling. An Indigenous community portal for climate change and health [Internet]. 2017. Available from: http://www.climatetelling.info

12. Health Canada. Community voices on climate change and health adaptation in northern Canada: summary report of Health Canada's Climate Change and Health Adaptation Program for northern First Nations and Inuit communities [Internet]. Ottawa (ON): Health Canada; 2011. Available from: http://www.climatetelling.info/uploads/2/5/6/1/25611440/final_summaryreport_eng_sm.pdf

13. Intergovernmental Panel on Climate Change (IPCC). Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Summary for policymakers [Internet]. Switzerland: World Meteorological Organization; 2018. Available from: https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_High_Res.pdf

14. Durocher L, Kuiack T. The long road home: a global perspective on evacuees. Communication presented at the Canadian Risk and Hazards Network (CRHNet) Symposium, 2017, Halifax.

https://doi.org/10.24095/hpcdp.39.4.04

Commentary

Climate change, health and green space co-benefits

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Abstract

We examined two of humanity's present-day challenges, climate change and chronic diseases, in relation to the co-benefits that green spaces provide to human health and the environment. The reduction of several chronic diseases and associated symptoms, including anxiety, obesity and cardiovascular disease, has been associated with the presence of and access to green space. Green spaces also contribute to a number of environmental health benefits and have been shown to reduce the likelihood of flooding, improve air quality and provide cooling and shade. These co-benefits address both the symptoms of several chronic diseases and associated risk factors along with the environmental and health impacts of climate change. This article explores how to maximize the co-benefits of green spaces through two examples of multi-sectoral collaborations. With these two examples, we have provided a model of collective collaboration that aims to address complex issues, such as climate change and chronic diseases, through the common intervention of green spaces.

Keywords: *chronic disease, green space, climate change, ecohealth, public health, co-benefits*

Highlights

- Major chronic diseases, such as cancer, heart disease and diabetes, cause 65% of all deaths in Canada each year.
- The impacts of climate change are being felt throughout the country, including increased occurrence of extreme heat, droughts and floods.
- Protecting, improving and increasing green spaces can help address both of these major issues.
- EcoHealth Ontario is an example of a multi-sectoral partnership that works together to achieve multiple public health, planning and conservation objectives.

Introduction

Globally and locally, humanity is facing two very serious issues that are impacting human health: chronic diseases[1] and climate change.[2] Major chronic diseases, such as cancer, heart disease, and diabetes, cause 65% of all deaths in Canada each year.[1] The impacts of climate change are being felt throughout Canada, including an increased occurrence of extreme weather events, such as extreme heat, droughts, wildfires and floods.[2] The indirect impacts of climate change are also becoming evident by compounding public health issues and threatening gains in population health.[3,4] While these impacts affect everyone, vulnerable populations are disproportionately burdened.[5]

Green spaces (Box 1) present a unique intervention that offers co-benefits to climate change mitigation, adaptation, and human health. The presence of and access to urban green spaces has been shown to reduce the rate and impact of chronic diseases.[6,7] At the same time, green spaces can also help mitigate and improve resilience to climate change and its impacts.[8]

As Box 2 shows, green spaces can promote physical activity, contribute to social interaction and cohesion, increase access to healthy food, and contribute to stress reduction and cognitive restoration.[6-8] Green spaces also improve air quality, create shade, reduce outdoor air temperatures, and decrease the likelihood of flooding.[9-11]

This article outlines current health challenges and climate change threats facing Canadians and how the co-benefits of green space provide a unique opportunity to help mitigate them. It also presents two collaborations, EcoHealth Ontario in Canada and Climate Change Parks in Scotland (United Kingdom), for tackling cross-cutting issues such as climate change, public health, and the environment by promoting green space as an effective and efficient climate change intervention.

Chronic disease and green space

There are four major chronic diseases and about twenty percent of Canadians live with at least one of them.[1] Cancer, cardiovascular disease, diabetes and respiratory disease cause approximately 65% of all deaths in Canada.[1] Additionally, mental health disorders, including depression and anxiety, are the primary cause for workplace disability in Canada.[1] Moreover, 33% of direct health-care expenditures in Canada can be attributed to disorders of the circulatory and respiratory systems, musculoskeletal disorders and mental disorders alone.[19] There are several risk factors associated with a person's risk of having a chronic disease, including level of physical activity, exposure to tobacco smoke and eating habits.[1] For example, 9 out of 10 Canadian children do not meet

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BOX 1
The term green space refers to a diverse range of spaces

What is green space?

There are many types of green spaces, all of which can provide health and climate change mitigation and adaptation benefits. Green space describes what may be referred to as green infrastructure, natural spaces, open space, or engineered green spaces. There are diverse sizes, types and functions of green spaces, including:

- Public spaces such as parks, conservation areas, greenways, trails, urban and rural forests, street trees, community gardens, school grounds, shorelines and ravines; and
- Private and institutional spaces and infrastructure such as gardens, green roofs, green walls, cemeteries, golf courses, and other outdoor spaces.

the recommended level of physical activity.[1] However, these risk factors are modifiable and the presence of, and access to, greenspace can potentially reduce some risk factors leading to chronic diseases.[7]

There is a large body of evidence demonstrating the positive impacts of the presence of, and access to, green spaces on health.[7] Studies suggest that the health benefits of green spaces are realized through various pathways (Box 2). Green spaces have a number of positive impacts on the urban environment which helps human health, including reducing noise, providing shade and cooling and reducing both the likelihood of flooding and air pollution.[9-11] In addition, green spaces can support and facilitate health and well-being by enabling stress alleviation and relaxation, physical activity, improved social interaction, and community cohesiveness.[6-8] Health benefits associated with the presence of, and access to, greenspace include improved levels of mental health, physical fitness, cognitive and immune function, as well as lower mortality rates.[12,13]

The health benefits of green space are particularly substantial in populations that experience health inequities.[16] For example, a study conducted in England found that for all-cause and circulatory disease mortality, income-related inequalities between the lowest and highest income deprivation groups were lower among those living in the most green areas compared to the least green areas.[16]

A similar finding was described in a Toronto study, which looked at tree density and self-reported health and cardiometabolic conditions. It was found that the presence of trees could significantly improve health perception, comparable to living in a neighborhood with $10 000 higher median income or being 7 years younger.[20]

Green space can increase resilience to climate change

As Boxes 2 and 3 show, the presence of green spaces helps mitigate climate change and improve human health by reducing chronic disease risk factors. But green space also provides the co-benefits of improving resiliency and recovery from the impacts of climate change (Box 3).[21,22]

An example of how the presence of, and access to, green space provides co-benefits is flooding. Flooding related to climate change is increasing and the presence of green spaces can reduce the likelihood of damage due to and extent of flooding. Green spaces such as parks, bio swales, rain gardens, engineered wetlands, and fields within the flood plain have the potential to temporarily store storm water and reduce run-off.[2] At the same time the presence of, and access to, green spaces has the potential to help reduce mental health symptoms, such as stress and anxiety,[6] which can be exacerbated by experiencing a flood.[23] The Intact Centre on Climate Adaptation estimated that "three years after their home was flooded 48 per cent of respondents from flooded households were worried when it rained, compared to three percent of respondents from non-flooded households."[23]

Putting green space evidence into practice through multi-sectoral collaborations

Protecting, promoting and increasing green spaces can be beneficial to human health through: 1) reducing certain chronic diseases and associated risk factors; 2) helping to mitigate climate change impacts; and 3) contributing to increased resiliency for recovering from climate change impacts.[9-11] These issues are being addressed by many different sectors, from public health officials, to urban planners, to conservationists. Protecting, promoting, and increasing green spaces then provides an intersection for a variety of sectors to come together, collaborate, and achieve greater action as a group. The umbrella of green spaces allows very different sectors to come together under one intervention and to maximize the co-benefits provided by green spaces. Two examples of these types of successful collaborations that promote green space are EcoHealth Ontario in Canada and Climate Change Parks in Scotland.

EcoHealth Ontario is a multi-sectoral, collaborative group that leverages mutually reinforcing activities under the vision that protecting, promoting, and increasing green spaces can be beneficial to human health. The collaboration has hosted several multi-sectoral workshops that allow planners, public health officials, conservationists, among others, to discuss methods, tools, and strategies that can help professionals put green space interventions into action. The collaboration also produces reports, toolkits, and education materials that focuses on promoting the ecological, health, and wellbeing benefits of greenspace, including climate change mitigation and adaptation and chronic disease reduction.

Another example of a multi-sectoral collaboration focusing on the co-benefits of green space is the pioneering 'climate change parks' being developed in Scotland. This initiative works by retrofitting existing urban green spaces to deliver climate change solutions.[24] It identifies how the various elements of a park can be modified to have a low carbon footprint and adapt to the weather impacts of climate change, such as providing flood management and shade, and to make the green spaces enjoyable in a variety of conditions.[24]

Conclusion

Protecting, promoting, increasing, and improving green spaces is one intervention that provides several co-benefits to some of the major issues facing communities today. Focusing on green space provides a unique opportunity for groups to apply a single intervention with multiple benefits for multiple stakeholders. The

BOX 2
Co-benefits and modifiers of green space impacts on climate change and human health

Green space impact on health and environment

The presence of and access to green spaces have positive associations with factors related to the environment and human health[6].

Green space associations with the environment[9-11]	Green space associations with human health and wellbeing[6-8]
• Air quality improvements • Reduction in urban heat island, shade provision • Flooding mitigation through storm water storage • Noise reduction • Provision of food	When people have access to local, neighbourhood green spaces: • Birth outcomes are improved • Mortality from all causes is reduced • Level of obesity is reduced • Number of people with cardiovascular diseases is reduced • Symptoms of mental illness, including depression and anxiety are improved • Self-reported feelings of stress are reduced • Social cohesion is improved

Factors that impact the benefits that green spaces provide

Green space characteristics

- Availability and accessibility, e.g. location, distance from residence, quantity, size[12,13]
- Aesthetic, e.g. landscaping, quality perception[13]
- Amenities/equipment, e.g. infrastructure, services[14]
- Maintenance, e.g. regularity of maintenance, garbage removal[15]

Green spaces that are near residences, accessible, and useable for a diversity of groups, and perceived as well maintained have been found to provide the greatest health impacts.[7]

Populations[7]

Vulnerable groups, including people living on low income, racialized groups, older adults, and children have been found to experience the most benefits from green space.[16] In particular, the health of children has been shown to be positively impacted when well-maintained parks with playgrounds are in close proximity to their residence.[17] The health of vulnerable groups has been shown to experience the benefits of green space even with fairly small increases in nearby green space density.[18]

BOX 3
Climate change impacts on human health and the accompanying green space co-benefit

Health impacts from climate change	Green space co-benefit/mitigation
Illness and premature death from exposure to extreme heat[2,5]	• Provides shade[11] • Reduces heat island effect[11]
Illness, stress and premature death from exposure to flooding[2,10]	• Reduces likelihood of flooding through decreased run-off[21]
Mental stress from the impacts of extreme weather[2]	• Reduces stress, anxiety and depression, common symptoms experienced after a flood[23]
Food insecurity[5]	• Community gardens provide local food source[7]
Cardiovascular and respiratory illness due to degraded air quality[3]	• Improve air quality[9] • Lowers rate of cardiovascular disease[8]

benefits of green space provide an opportunity to both protect and promote these spaces, especially in urban centres.

It is imperative that governments, groups, organizations, and businesses work together towards a common goal, especially when addressing complex issues. Multi-sectoral collaboration is a valuable way to maximize the co-benefits provided by green space.

Working together to make green spaces a priority in communities and surrounding areas will help towards addressing the issues of chronic disease and climate change.

Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions and statement

MK contributed to the study concept and design and writing of the manuscript. EcoHealth Ontario members informed the concept and design and critically revised the manuscript and approved the version submitted for consideration.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

References

1. Public Health Agency of Canada. How healthy are Canadians? [Internet]. Ottawa (ON): Public Health Agency of Canada; 2016. Available from: https://www.canada.ca/en/public-health/services/publications/healthy-living/how-healthy-canadians.html

2. Government of Canada. Canada in a changing climate: sector perspectives on impacts and adaptation [Internet]. Ottawa (ON): Natural Resources Canada; 2014. Available from: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2014/pdf/Full-Report_Eng.pdf

3. Watts N, Amann M, Arnell N, et al. The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come. The Lancet. 2018;392(10163):2479-514.

4. Watts N, Adger W, Agnolucci P, et al. Health and climate change: policy responses to protect public health. The Lancet. 2015;386(10006):1861-914.

5. Intergovernmental Panel on Climate Change (IPCC). Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Internet]. Switzerland: World Meteorological Organization; 2018. Available from: http://www.ipcc.ch/report/sr15/

6. James P, Banay R, Hart J, Laden F. A review of the health benefits of greenness. Current Epidemiology Reports. 2015;2(2):131-42.

7. Toronto Public Health. Green City: why nature matters to health – an evidence review [Internet]. Toronto: Toronto Public Health; 2015. Available from: https://www.toronto.ca/legdocs/mmis/2015/hl/bgrd/backgroundfile-83421.pdf

8. Sandifer P, Sutton-Grier A, Ward B. Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: opportunities to enhance health and biodiversity conservation. Ecosystem Services. 2015;12:1-15.

9. Nowak D, Hirabayashi S, Bodine A, Greenfield E. Tree and forest effects on air quality and human health in the United States. Environ Pollut. 2014;193:119-29.

10. Depietri Y, Renaud F, Kallis G. Heat waves and floods in urban areas: a policy-oriented review of ecosystem services. Sustainability Science. 2011;7(1):95-107.

11. Bowler D, Buyung-Ali L, Knight T, Pullin A. Urban greening to cool towns and cities: a systematic review of the empirical evidence. Landsc Urban Plan. 2010;97(3):147-155.

12. Maas J, Verheij R, de Vries S, Spreeuwenberg P, Schellevis F, Groenewegen P. Morbidity is related to a green living environment. J Epidemiol Community Health. 2009;63(12):967-73.

13. de Vries S, van Dillen S, Groenewegen P, Spreeuwenberg P. Streetscape greenery and health: stress, social cohesion and physical activity as mediators. Soc Sci Med. 2013;94:26-33.

14. Anthamatten P, Brink L, Lampe S, Greenwood E, Kingston B, Nigg C. An assessment of schoolyard renovation strategies to encourage children's physical activity. Int J Behav Nutr Phys Act. 2011;8(1):27.

15. Maas J, Verheij R, Spreeuwenberg P, Groenewegen P. Physical activity as a possible mechanism behind the relationship between green space and health: a multilevel analysis. BMC Public Health. 2008;8(1):206.

16. Mitchell R, Popham F. Effect of exposure to natural environment on health inequalities: an observational population study. The Lancet. 2008;372(9650):1655-60.

17. Potwarka L, Kaczynski A, Flack A. Places to play: association of park space and facilities with healthy weight status among children. J Community Health. 2008;33(5):344-50.

18. Mitchell R, Richardson E, Shortt N, Pearce J. Neighborhood environments and socioeconomic inequalities in mental well-being. Am J Prev Med. 2015;49(1):80-4.

19. Public Health Agency of Canada. Economic Burden of Illness in Canada, 2010 [Internet]. Ottawa (ON): Public Health Agency of Canada; 2017. Available from: https://www.canada.ca/content/dam/phac-aspc/documents/services/publications/science-research/economic-burden-illness-canada-2010/economic-burden-illness-canada-2010.pdf

20. Kardan O, Gozdyra P, Misic B, et al. Neighborhood greenspace and health in a large urban center. Sci Rep. 2015;5(1):11610. doi: 10.1038/srep11610.

21. European Environment Agency. Urban adaptation to climate change in Europe: challenges and opportunities for cities together with supportive national and European policies [Internet]. Copenhagen (Denmark): Office for Official Publications of the European Union; 2012. Available from: https://www.eea.europa.eu/publications/urban-adaptation-to-climate-change

22. World Health Organization (WHO). Urban green spaces and health: a review of evidence [Internet]. Copenhagen (Denmark): WHO Regional Office for Europe; 2016. Available from: http://www.euro.who.int/__data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf?ua = 1

23. Decent D, Feltmate B. After the flood: the impact of climate change on mental health and lost time from work [Internet]. Waterloo (ON): Intact Centre on Climate Adaptation; 2018. Available from: https://www.intactcentreclimateadaptation.ca/wp-content/uploads/2018/06/After-The-Flood.pdf

24. greenspace scotland. Retrofitting urban parks to deliver climate change actions [Internet]. Stirling (Scotland): greenspace scotland; 2012. Available from: https://drive.google.com/file/d/1rWuEtaHSF21rUOxW9hVzAgRVUnq-ZdY7/view

https://doi.org/10.24095/hpcdp.39.4.05

At-a-glance

Pollens, climate and allergies: Quebec initiatives

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Abstract

Pollen allergies are a major source of seasonal allergic rhinitis in North America. This type of rhinitis affects 17% of adults in Quebec, a marked increase in the last 30 years. Ragweed (*Ambrosia artemisiifolia* L.) pollens are responsible for 50% to 90% of rhinitis cases. Climate change has played a significant role in the increased prevalence of seasonal allergic rhinitis over the last few decades. In 2015, the Quebec government put in place a strategy to tackle this problem, the Stratégie québécoise de réduction de l'herbe à poux et des autres pollens allergènes [Quebec strategy to reduce ragweed and other allergenic pollens]. Based on solid evidence, the Strategy advocates for co-operation between stakeholders and the integration of control measures into the maintenance practices of municipalities and other large public and private landowners. This article presents the scientific data underpinning the Strategy and initial successes of the action taken under the Strategy.

Keywords: *rhinitis, allergic, seasonal, allergen, Ambrosia, climate change, ragweed, pollen, public policy, prevention and control*

Highlights

- Climate change increases the quantities and allergenic potential of ragweed pollen.
- Seasonal allergic rhinitis caused by these pollens has increased significantly in North America.
- Simple environmental control methods can clinically decrease the impact of ragweed pollen.
- A coordinated policy that incorporates these control measures in municipalities' groundskeeping practices is being implemented in Quebec.

Introduction

Among the various species of allergenic pollens, ragweed (*Ambrosia artemisiifolia* L.) pollen has been a great source of concern in the Quebec public health care system for more than 30 years. It is a major cause of seasonal allergic rhinitis in North America[1-3] and is believed to be responsible for 50% to 90% of pollen allergies,[4] affecting approximately 1 in 10 Quebecers.[5] In 2005, the health costs attributed to ragweed were evaluated at between $156.5 million and $240 million.[6] In a context where the prevalence of allergic rhinitis has been rising constantly for 20 years in conjunction with the climate change being experienced worldwide, it has recently appeared necessary to enhance environmental control efforts to reduce the effects of allergenic pollens. That is why the Stratégie québécoise de réduction de l'herbe à poux et des autres pollens allergènes (SQRPA), launched in 2015 by the Quebec Department of Health and Social Services (MSSS), was put in place.[7] Below are the scientific bases and main elements of the SQRPA to reduce ragweed and other allergenic pollens.

Methodology and results

The development of the SQRPA was informed by a narrative review of the scientific literature[8] that was carried out in 2011 and resulted in 142 articles. The scientific literature was searched by means of various databases (PubMed, CSA Illumina, EBSCOhost, OvidSP, etc.). Those searches were supplemented with grey literature searches to gather study reports on the topic. The SQRPA has resulted in the funding and completion of several applied field research projects in Quebec, the main aspects of which are presented below.

The impact of climate change

To explain the increased prevalence of seasonal allergic rhinitis, a number of studies have highlighted the impact of climate change.[9-12] The combination of warmer temperatures and higher concentrations of CO_2 is stimulating the growth and pollen production of allergenic plants.[11,13] Specifically, an increase in the length of plants' pollen seasons has been observed,[2] which is leading to increased human exposure to aeroallergens and therefore a higher rate of allergic sensitization.

In addition, studies tend to demonstrate shifts in the distribution of plants. New areas further to the north are becoming conducive to the establishment of certain species, with the result that human populations are being exposed to new allergens.[14] The problem of pollen allergies was included under the health component of Quebec's climate change action plan (Plan d'action contre les changements climatiques du Québec) in 2007.

Data obtained from applied research

In Quebec, knowledge of ragweed management has increased enormously over

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the last 10 years.[15-19] The acquisition of solid evidence demonstrating the positive impact of pollen control has strengthened the relevance of managing the plant at the municipal level.

The *Herbe à poux 2007–2010* research project demonstrated that it is entirely possible to effectively manage ragweed across a municipality at low cost while having a real impact on the health of the allergic population.[16,20] Concretely, the project involved engaging different key players in seven targeted activity sectors in the community (agricultural, business, industrial, institutional, municipal and residential sectors, as well as transportation routes) to synchronize their ragweed control actions.[20] The players showed a strong preference for mowing, with 60% of the players practising it.[21] To determine whether the strategies deployed were effective, two approaches were taken. Pollen concentrations and the density of ragweed were measured using a semi-experimental pre-test/post-test design with a non-equivalent comparison group. In addition, the health impacts on allergic people were assessed using a quasi-experimental chronological series design with a non-equivalent comparison group. At the end of the project, a decrease in ragweed pollen concentrations was observed in the experimental environment compared with the control environment, a statistically and clinically significant reduction in the intensity of certain symptoms was measured in one in two allergic individuals living in the experimental environment, and there was an improvement in their quality of life.[16,20] The preferred intervention method during this project, coordinated management, was deemed very efficient from an economic viewpoint compared with the minimal intervention method generally applied in the province.[20,22] Concretely, coordinated management consists of engaging various key players in the community (e.g. municipality, provincial department of transportation and other large owners and managers of private or public land) to implement joint and simultaneous action for controlling ragweed. In comparison, minimal intervention consisted of regular groundskeeping, without focusing on ragweed in particular and without engaging the community.

In 2008, a study was conducted on the links between the degree of local ragweed infestation and the prevalence of allergic reactions among children 6 months to 12 years old living on the Island of Montreal.[17] The study shows a statistically significant positive relationship between the risk of allergic reactions and the level of local exposure to ragweed (influence zone of 300 to 1000 m). The study therefore demonstrates the relevance of local action to control ragweed to reduce the frequency of allergies in the population, in the context of adaptation to climate change.

Another project carried out in Montreal involved evaluating a ragweed pollen control approach through the distribution of personalized information to the managers of ragweed-infested sites. It explained the health impacts associated with ragweed and asked that the lands be mowed twice during the summer.[19] The results suggest that landowners, particularly owners of vacant lots, are more likely to control ragweed on their land when they receive several notices and reminders. Three times as many owners mowed the ragweed on their land after receiving four notices compared with those who received only one notice.

In response to the need to monitor the presence of ragweed in Quebec and its territorial extension in the future, a method to predict the probability of the presence of ragweed involving remote sensing has been developed.[23] The first phase of the project, carried out between 2011 and 2013, resulted in a prediction rate of 60% to 80% (depending on the region). The second phase of the project is currently under way and is aimed at improving the method's effectiveness so it can be more widely used in the future, providing useful information to municipalities to help them enhance their climate change adaptation strategies.

Work done by Agriculture and Agri-Food Canada has proved the effectiveness of mowing, which is the control method most widely used by Quebec municipalities.[15] In that study, conducted in a greenhouse, plants that reached 25 cm in height were mowed to a height of 10 cm just before flowering, around mid-July; they were mowed a second time when the regrowth reached 25 cm again, around mid-August (see Figure 1).

Lastly, a study conducted by the climate change research consortium Ouranos evaluated the costs arising from the impacts of climate change on health. That study revealed that, for the period from 2015 to 2065, the portion of the costs of ragweed allergies attributable solely to climate change impacts are nearly $360 million for the government and $475 million for society.[24] Those amounts are in addition to the basic costs of ragweed allergies, which do not take into account the impact of climate change and are estimated at $3.4 billion for the same period.[24] Any adaptation efforts will therefore lessen the impacts of the problem of pollen allergies and reduce the costs to the government and society.

Ragweed management and control

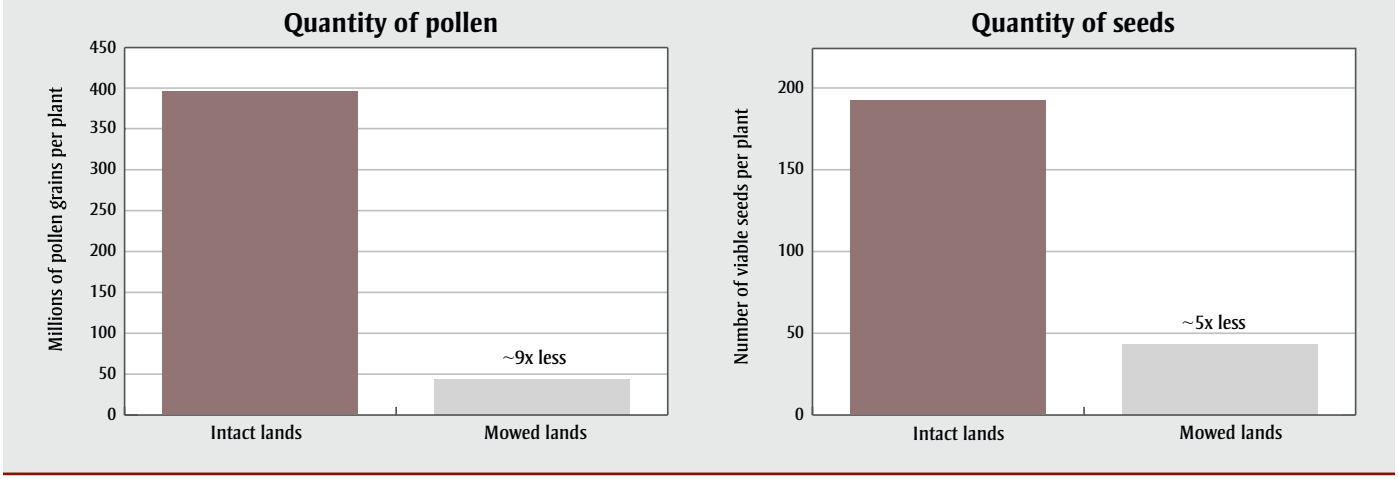
Most ragweed pollen is deposited close to its source, within a radius of 1 km.[17,25] Municipal agencies are in the best position to act because of their roles and responsibilities. Municipalities manage 50% of the Quebec road network (approximately 92,000 km of roads and streets, where ragweed flourishes in their rights-of-way).[26] They also manage several sites that are conducive to the establishment of ragweed (snow dumps, recreational fields, vacant lots, etc.) and can regulate nuisances. These governments also have detailed knowledge of the territory, can influence their local partners and have the necessary equipment to maintain the lands in question, which makes them indispensable. Municipalities therefore play an essential role in ragweed management and control and in its increasing presence in the context of climate change.

Control methods

Various methods can be used to control ragweed. Generally speaking, there are two broad categories:[27,28] methods that prevent the spread of ragweed (hardscaping, planting a competitive plant cover, etc.) and methods that control the ragweed already present (hand pulling, mowing, application of low-impact herbicides, etc.).

Preventive methods are more effective than the other methods in controlling ragweed, as preventive methods impede it from establishing itself in an area. However, they require rigorous maintenance and are expensive.[27,29] Among the methods aimed at completely or partially destroying the plant, hand pulling is an excellent method to use on small plots of

FIGURE 1
Effect of two mowings spaced one month apart on the production of ragweed pollen and seeds, St-Jean-sur-Richelieu, Quebec



Source: Adapted from Simard and Benoît, 2011.[15]

land, but it is inappropriate for large areas.[27,29] Heat methods (boiling water or steam) are somewhat attractive, but their application puts other nearby plants at risk, and they are costly.[27,29] It is an appropriate technique for combatting ragweed growing in the cracks between asphalt and cement along streets.[29] The mechanical method, which involves using the stiff metal brushes on municipal sweepers, is a good alternative to the heat method, because it can be very effective in difficult-to-reach spots (e.g. on sidewalk edges), but uses machinery that is normally used for cleaning.[8] Lastly, applying low-environmental-impact herbicides (saline solution) is an effective option in areas with a high density of plants; however, it is expensive, because it requires specialized equipment, qualified employees and rigorous monitoring.[27,30] Mowing is a simple, effective and low-cost control method,[20,27,30] particularly when it is carried out at a specific stage in the development of ragweed.[15]

Discussion

Quebec's Strategy was put in place in 2015. It is governed by an interdepartmental steering committee chaired by the MSSS. A representative of the Société québécoise des infrastructures, the organization that manages the real estate portfolio of Quebec public departments and agencies, also sits on the steering committee.

Drawing on solid research evidence, the SQRPA relies on coordination between various stakeholders and is aimed at promoting the integration of allergenic pollen control measures into the routine maintenance practices of Quebec government municipalities, departments and agencies. In a changing climate, it is essential to adapt policies and intervention methods to better control allergenic pollens. That is why the SQRPA has been integrated into the adaptation component of Quebec's climate change action plan, the Plan d'action 2013–2020 sur les changements climatiques du Québec (PACC 2013–2020). The ultimate objective of this initiative is to reduce the health effects associated with allergenic pollens and improve the quality of life for people who have a ragweed allergy.

The SQRPA includes several elements:

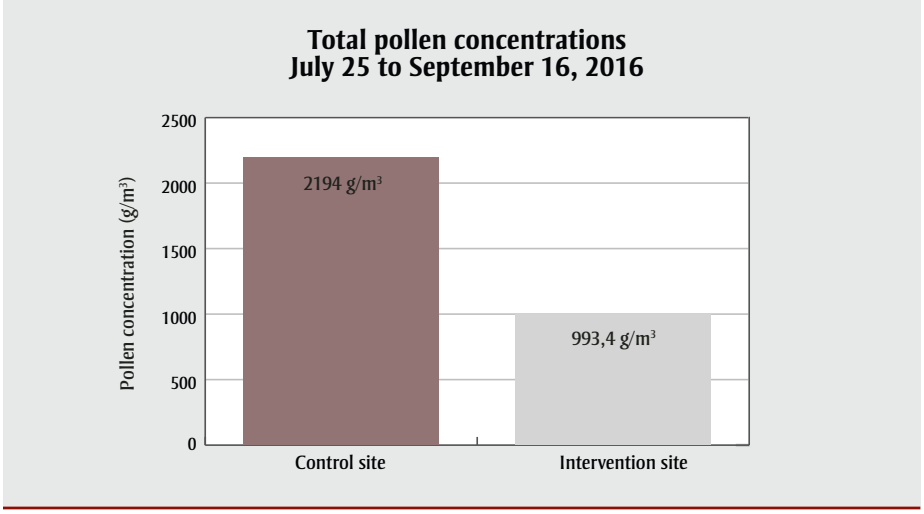
- A financial assistance program to encourage municipalities to implement allergenic pollen control measures in their jurisdictions; 15 municipalities participated over two years;
- The evaluation of the interventions funded by the SQRPA through the measurement of pollen concentrations before and after the interventions;
- A management and control guide for ragweed and other allergenic pollens;[27]
- A maintenance guide for institutional land owned by government departments and agencies; and
- A partnership with the Association pulmonaire du Québec [Quebec lung association] to promote the organization's annual campaign to encourage Quebec municipalities to remove ragweed plants.

Figure 2 presents an example of the initial results obtained from Granby, one of the municipalities that received funding through the SQRPA. Pollen concentrations were measured at two sites: a control site, where no ragweed control was carried out; and a site where ragweed control measures were carried out.

Strengths and weaknesses

To our knowledge, the SQRPA is a very innovative approach around the world, and its hands-on approach and effectiveness make it very affordable for governments. Expectations as to the assessment of the SQRPA's long-term effectiveness must remain modest, since the Strategy is only starting to be implemented and a number of Quebec municipalities do not have the resources required to put concerted actions in place to control allergenic pollens. Recruiting municipalities to join the program could prove more difficult going forward and may not be sustainable over time, given that the budgets allocated to municipalities are not recurrent and there is uncertainty around funding for the SQRPA beyond 2020. Other health priorities may affect municipal decisions. However, the strong growth of these allergies should guarantee citizens' support for this engagement to achieve better environmental control if awareness efforts are maintained. The necessity to maintain these awareness efforts is the

FIGURE 2
Effect of ragweed control measures on pollen concentration in Granby, QC, in 2016



Source: Adapted from Association pulmonaire du Québec, 2016.[31]

same for all climate change adaptation actions, thus this strategy aims to facilitate decision making for managers at the municipal level by providing a favourable context for implementing the SQRPA and encouraging a continued popular demand among elected officials, which often change during elections.[32]

Conclusion

The implementation of the SQRPA is an innovative initiative to control allergenic pollens. In view of the significant increase in respiratory allergies attributable to pollens that has been observed in the last few decades and the growing importance being paid to them, the SQRPA's implementation is important and meets the needs expressed by the health care system and municipalities for a number of years. In addition, with climate change currently occurring, worsening of the problem of pollen allergies is to be expected in the coming decades. The implementation of this climate change adaptation measure will therefore help reduce health impacts and costs for the government and society. If control measures are applied appropriately, the control of allergenic pollens will lead to lower pollen concentrations in the air and, therefore, reduced exposure of people with seasonal allergic rhinitis, which will lead in turn to decreases in the severity of symptoms experienced by those individuals and thus improvements in their quality of life.

However, implementing such a program requires a firm and concrete commitment from provincial and local government decision-makers. Communication is also a crucial factor, particularly with the target clientele: municipalities. The initiative must therefore rely on the existence of direct communication channels with these organizations. Although the SQRPA has led to the implementation of innovative projects that have proved successful, few municipalities are still prioritizing such projects, despite a real willingness to reduce the health effects of allergenic pollens. It is therefore crucial to continue and increase awareness efforts to convince decision-makers to tackle this problem and allocate the necessary resources to it, to strengthen climate change adaptation in Quebec.

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Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions and statement

Both authors contributed to all stages of writing this article and read and approved the final version. ID was the person responsible for setting up the strategy described, and she was responsible for some of the data collected.

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References

1. Ihler F, Canis M. Ragweed-induced allergic rhino-conjunctivitis: Current and emerging treatment options. J Asthma Allergy. 2015;8:15-24.

2. Ziska LH, Knowlton K, Rogers C, et al. Recent warming by latitude associated with increased length of ragweed pollen season in central North America. Proceedings of the National Academy of Sciences. 2011; 108(10):4248-51.

3. Bielory L, Lyons K, Goldberg R. Climate change and allergic disease. Current Allergy and Asthma Reports. 2012;12(6):485-94.

4. Comtois P, Gagnon L. Concentration pollinique et fréquence des symptômes de pollinose: une méthode pour déterminer les seuils cliniques. Revue française d'Allergologie et d'Immunologie Clinique. 1988;28(4): 279-86.

5. Canuel M, Lebel G. Prévalence des symptômes et du diagnostic de la rhinite allergique chez les 15 ans et plus au Québec, 2008. Québec, QC: Institut national de santé publique du Québec; 2012. Available from: https://www.inspq.qc.ca/pdf/publications/1447_PrevalenceSymptDiagnosRhiniteAllerg15AnsEtPlusQc_2008.pdf

6. Tardif I. Portrait des coûts de santé associés à l'allergie au pollen de l'herbe à poux, année 2005. Longueuil, QC: Agence de la santé et des services sociaux de la Montérégie; 2008. Available from: http://extranet.santemonteregie.qc.ca/depot/document/2516/NUISANCE-POUX-Coutssante-2005.pdf

7. Ministère de la Santé et des services sociaux du Québec (MSSS). Herbe à poux et autres pollens allergènes. Stratégie québécoise de réduction de l'herbe à poux et des autres pollens allergènes (SQRPA) [Internet]. Québec, QC: MSSS; 2018 [updated August 20, 2018]. Available at: http://www.msss.gouv.qc.ca/professionnels/sante-environnementale/pollens/strategie-quebecoise-de-reduction-de-l-herbe-a-poux-et-des-autres-pollens-allergenes-sqrpa/

8. Demers I. État des connaissances sur le pollen et les allergies. Les assises pour une gestion efficace. Québec, QC: Institut national de santé publique du Québec; 2013. Available from: https://www.inspq.qc.ca/pdf/publications/1678_EtatConnPollenAllergies_AssisesGestionEfficicace.pdf

9. D'Amato G, Holgate ST, Pawankar R, et al. Meteorological conditions, climate change, new emerging factors, and asthma and related allergic disorders. A statement of the World Allergy Organization. World Allergy Organization Journal. 2015;8(1):1-52.

10. Weber RW. Impact of climate change on aeroallergens. Annals of Allergy, Asthma & Immunology. 2012;108(5):294-9.

11. United States Environmental Protection Agency (US EPA). Review of the impacts of climate variability and change on aeroallergens and their associated effects (Final Report) [Internet]. Washington, DC: US EPA; 2008 Available from: https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=190306

12. Beggs PJ. Impacts of climate change on aeroallergens: Past and future. Clinical and Experimental Allergy: Journal of the British Society for Allergy and Clinical Immunology. 2004;34(10):1507-13.

13. Crimmins A, Balbus J, Gamble JL, et al. The impacts of climate change on human health in the United States: a scientific assessment. Washington, DC: U.S. Global Change Research Program (USGCRP); 2016. 312 p.

14. Beggs PJ. Adaptation to impacts of climate change on aeroallergens and allergic respiratory diseases. International Journal of Environmental Research and Public Health. 2010;7(8):3006-21.

15. Simard M-J, Benoît D-L. Effect of repetitive mowing on common ragweed (Ambrosia artemisiifolia L.) pollen and seed production. Annals of Agricultural and Environmental Medicine. 2011;18(1):55-62.

16. Direction de la Santé publique de la Montérégie. Projet herbe à poux 2007-2010. Résumé scientifique - phase 1 [Internet]. Québec, QC : Ministère de la Santé et des Services sociaux du Québec; 2012. Available from: http://publications.msss.gouv.qc.ca/acrobat/f/documentation/2011/11-244-03W.pdf

17. Jacques L, Goudreau S, Plante C, et al. Prévalence des manifestations allergiques associées à l'herbe à poux chez les enfants de l'île de Montréal 2008. Québec, QC: Institut national de santé publique du Québec; 2010. Available from: https://www.inspq.qc.ca/en/node/1038

18. Joly M, Bertrand P, Gbangou RY, et al. Paving the way for invasive species: road type and the spread of common ragweed (Ambrosia artemisiifolia). Environmental Management. 2011;48(3):514-22.

19. Plante C, Smargiassi A, Hubert F, et al. Implementation and evaluation of a communication strategy to control ragweed pollen. Environment and Pollution. 2016;5(1):87-91.

20. Direction de la Santé publique de la Montérégie. Mobiliser une communauté du sud du Québec pour contrer l'herbe à poux : analyse des coûts de l'intervention et de ses effets sur la distribution spatiale des plants, du pollen et des symptômes d'allergie chez des adultes. Québec, QC: Institut national de santé publique du Québec; 2013.

21. Direction de santé publique de Montérégie. Projet Herbe à poux 2007-2010. Réduire le pollen de l'herbe à poux : mission réaliste. Le succès d'une communauté mobilisée [Internet]. Québec, QC : Ministère de la Santé et des services sociaux du Québec; 2011. Available from: http://publications.msss.gouv.qc.ca/msss/fichiers/2011/11-244-02.pdf

22. Beauchemin C, Drapeau J-B, Groulx J, et al. Évaluation économique d'un mode d'interventions concerté dans la lutte contre l'herbe à poux au Québec. Montreal, QC: Université de Montréal; 2013.

23. Ngom R, Gosselin P. Development of a remote sensing-based method to map likelihood of common ragweed (Ambrosia artemisiifolia) presence in urban areas. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. 2014;7(1):126-39.

24. Larrivée C, Sinclair-Desgagné N, Da Silva L, et al. Évaluation des impacts des changements climatiques et de leurs coûts pour le Québec et l'État québécois. Rapport d'étude 2015-243. Montréal, QC: Ouranos; 2015. Available from: http://www.environnement.gouv.qc.ca/changementsclimatiques/evatuation-impacts-cc-couts-qc-etat.pdf

25. Raynor GS, Ogden EC, Hayes JV. Dispersion and deposition of ragweed pollen from experimental sources. Journal of Applied Meteorology. 1970;9(December 1970):885-95.

26. Transports Québec. Information sur le réseau routier [2017-10-19]. Montréal, QC: Transports Québec; [cited 2019 Jan 8]. Available at: https://www.transports.gouv.qc.ca/fr/projets-infrastructures/info-reseau-routier/Pages/information-sur-le-reseau-routier.aspx

27. Demers I. Guide de gestion et de contrôle de l'herbe à poux et des autres pollens allergènes. Québec, QC: Ministère de la Santé et des Services sociaux du Québec; 2015. Available from: http://publications.msss.gouv.qc.ca/msss/fichiers/2018/18-244-05W.pdf

28. Table québécoise sur l'herbe à poux (TQHP). Dossier herbe à poux : fiches d'aide à la décision. Montréal, QC: Régie régionale de la santé et des services sociaux de la Montérégie, Direction de la santé publique; 2002.

29. Massicotte R, Beaumont J-P, Hamel-Fortin S, et al. Implanter un couvert végétal. Document d'information sur la technique d'implantation d'un couvert végétal compétitif afin de lutter contre l'herbe à poux (Ambrosia artemisiifolia L.). Longueuil, QC: Agence de la santé et des services sociaux de Montérégie, Groupe de travail sur le couvert végétal compétitif (GTCVC) de Table québécoise sur l'herbe à poux; 2006.

30. Genivar. Maîtrise de l'herbe à poux. Comparaison de méthodes d'intervention. Montréal, QC: Hydro Québec; 2011.

31. Association pulmonaire du Québec. Rapport des résultats de l'échantillonnage des pollens dans le cadre du programme de financement de la Stratégie québécoise de réduction de l'herbe à poux et des autres pollens allergènes. Montréal, QC: Association pulmonaire du Québec; 2016.

32. Mehiriz K, Gosselin P. Municipalities' preparedness for weather hazards and response to weather warnings. PLoS ONE. 2016;11(9):e0163390. doi: 10.1371/journal.pone.0163390.

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Evidence synthesis

Evaluating risk communication during extreme weather and climate change: a scoping review

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Abstract

Introduction: Communicating risk to the public continues to be a challenge for public health practitioners working in the area of climate change. We conducted a scoping literature review on the evaluation of risk communication for extreme weather and climate change to inform local public health messaging, consistent with requirements under the Ontario Public Health Standards (OPHS), which were updated in 2018 to include effective communication regarding climate change and extreme weather.

Methods: Search strategies were developed by library information specialists and used to retrieve peer-reviewed academic and grey literature from bibliographic databases (Medline, Embase, Scopus and CINAHL) and Google country specific searches, respectively. The search strategy was validated through a workshop with experts and community stakeholders, with expertise in environment, health, emergency management and risk communication.

Results: A total of 43 articles were included. These articles addressed issues such as: climate change (n = 22), flooding (n = 12), hurricane events (n = 5), extreme heat (n = 2), and wild fires (n = 2). Studies were predominantly from the US (n = 14), Europe (n = 6) and Canada (n = 5).

Conclusion: To meet the OPHS 2018, public health practitioners need to engage in effective risk communication to motivate local actions that mitigate the effects of extreme weather and climate change. Based on the scoping review, risk communication efforts during short-term extreme weather events appear to be more effective than efforts to communicate risk around climate change. This distinction could highlight a unique opportunity for public health to adapt strategies commonly used for extreme weather to climate change.

Keywords: *climate change, extreme weather, risk communication*

Highlights

- We conducted a scoping literature review, validated through a workshop with experts and stakeholders, on risk communication for extreme weather and climate change (EWCC) to inform local public health messaging.
- Risk communication efforts during short-term extreme weather events appear to be more effective than efforts to communicate risk around climate change.
- This distinction could highlight a unique opportunity for public health to adapt strategies commonly used for extreme weather to climate change.
- A conceptual framework is presented to support EWCC risk communication, build adaptive capacity and coordinate recommended actions across short- and long-term timescales.

Introduction

Extreme weather and climate change (EWCC) have well-documented impacts on population health.[1] It is possible that a changing climate will not only exacerbate existing health issues but will also create new health burdens for our population.[2] These impacts will likely have a greater impact on vulnerable populations, such as those living in rural and remote communities.[3] Local public health practitioners have begun planning for health-related climate impacts through activities such as vulnerability assessments,[4] but the complexity of EWCC continues to be a challenge for activities at the local level.[5]

One aspect of EWCC that presents a consistent challenge for public health practitioners is in communicating risk to the public.[6] Risk communication is an evidence-based approach to communicating effectively with the public in times of controversy,[7] and effective risk communication is an important first step toward reducing community vulnerability to EWCC.[8] Unfortunately, risk communication activities aimed at mitigating the human health impacts of EWCC continue to be challenging, despite their critical importance.[9] This was recently described by Pilla et al., in terms of communicating flood risks to the public when households

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pay more attention to past flood events than to scientific assessments of flood risk.[10] During extreme weather, risk communication tends to focus on short-term messaging around the hazards and protective actions that need to be taken by organizations and individuals during these events. In contrast, climate change often requires long-term proactive risk communication strategies that motivate adaptive changes to infrastructure and the built environment to ultimately improve climate resiliency and safeguard the continuity of operations of public health institutions.[11]

Public Health Ontario supports public health unit staff and other health professionals throughout Ontario in the area of EWCC by providing scientific and technical evidence-based advice. In 2018, the Ontario Public Health Standards (OPHS; http://www.health.gov.on.ca/en/pro/programs/publichealth/oph_standards/), which identify the requirements for public health programs and services to be delivered by Ontario's 35* public health units, were updated to include a requirement to *effectively* communicate with the public regarding topics such as climate change and extreme weather, based on an assessment of local needs. This recent update underscores the need for public health practitioners to develop and assess risk communication strategies in the area of EWCC. We conducted a review of previous research on the topic of risk communication during EWCC, particularly the *evaluation* of risk communication strategies, with the ultimate aim of supporting public health practitioners. Given the unique challenges for practitioners and the limited evidence that exists in this area, the review was designed as a scoping review to incorporate a wider range of domains relevant to the topic of risk communication, extreme weather, and climate adaptation. As the scoping review evolved, an expert/stakeholder consultation workshop was held to validate the scoping review and provide additional insights and perspectives on risk communication gaps related to EWCC. This paper describes the results of our scoping review and the expert workshop; with particular focus on the gaps and challenges that were identified and later used to develop a conceptual framework to aid public health professionals working in this area.

Methods

The scoping review was based on an established methodological framework for scoping reviews.[12] Four databases (Medline, Embase, Scopus and CINAHL) were searched for peer-reviewed literature in the English language, published between 1999 and 2013. The search also included grey literature identified from site-specific non-commercial Google searches for Canada, the US, Australia and international organizations. No limitations were placed on the bodies or agencies communicating risk, or the audiences receiving information. There were also no limitations on the type of communication, medium or article. Search strategies (available upon request from the authors) were developed and peer-reviewed by Library Information Specialists. The search strategies were built using keywords and syntax specific to each database to identify literature addressing one or more of the following research questions:

(i) What are the current practices in communicating EWCC risks in the peer-reviewed literature?

(ii) Which of these current practices have been evaluated for effectiveness?

(iii) Which theoretical frameworks from the literature explain current practices? and/or

(iv) What are the research gaps in communicating EWCC risks?

A one-day information-gathering and validation workshop was held in Toronto on February 10, 2014. The workshop: *Communicating about A Different Ontario: Risk Communications, Extreme Weather and Climate Change*, included thirty individuals representing community stakeholders with expertise in environment, health, emergency management and risk communications from local, municipal (rural and urban), provincial and federal jurisdictions. Participants worked in small focus groups that reflected the diversity of attendees. The thematic content areas identified through the scoping review were presented to participants, who were asked to describe experiences with any of the practices identified through the scoping review. Examples from lived experience were sought to confirm or challenge the findings from published literature. The workshop was used to select the practices identified through the scoping review that municipal, provincial and/or federal public health practitioners and allied stakeholders viewed as effective or promising. The workshop also provided additional insights and perspectives on risk communication gaps related to EWCC. Workshop proceedings and evaluations were summarized to enhance and validate the final search strategy.

Following the workshop, the final search strategies were executed on February 26, 2014†. Articles were screened and assessed by two research coordinators. A flow diagram illustrating the screening process is shown in Figure 1. During the screening process, reviewers relied on consensus decision making to resolve any conflicts. A total of 1880 articles were retrieved from database and Google searches. Articles were excluded if they were duplicates (n = 326) or if they addressed psychological responses and recovery of individuals from extreme weather events (as these articles focused on individual-level response instead of organizational-level), or if they reported solely on climate change impacts in the absence of references to extreme weather (n = 1449). The remaining 105 articles were reviewed and those not meeting the screening questions (n = 67) were excluded. Three screening questions were used:

(i) Does the article specifically include risk communication or community adaptation?

(ii) Does the article address some aspect of extreme weather or climate change?

(iii) Does the article include an evaluation of practices, tools, or frameworks using qualitative, quantitative or mixed research methods?

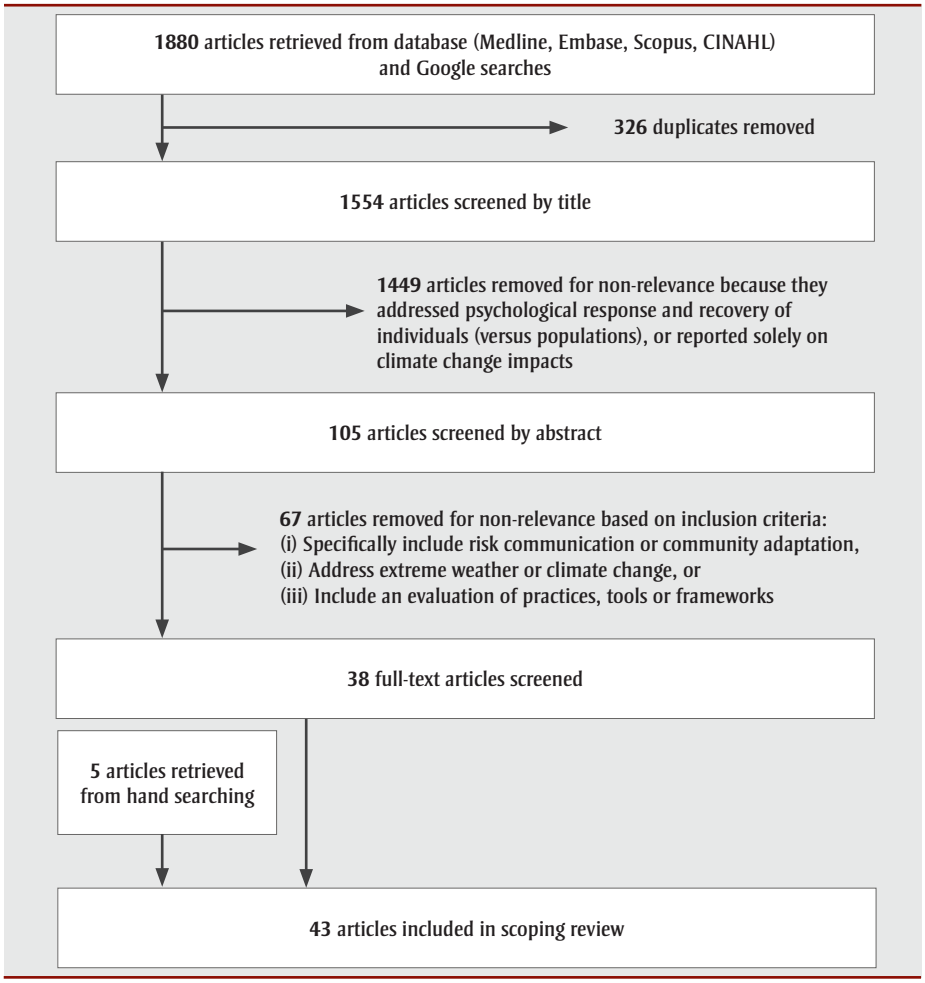
An additional 5 articles were included based on hand searching of key references.

Articles were charted, or mapped, in Excel spreadsheets to enable reporting of results.

* Prior to 2018 there were 36 local public health units in Ontario. There was a merger of two health units in 2018, resulting in a total of 35 local public health units across Ontario.

† The original search was conducted in February 2014. A second search was conducted in March 2016. The updated literature search did not identify literature that departed from the original search.

FIGURE 1
Flow diagram of article selection



These descriptive summaries captured country; main objective and study design; population, type of extreme weather, and key findings (Table 1). Based on an established framework for scoping reviews,[12] the narrative findings were presented in two ways: (i) basic numerical analysis of the nature and distribution of the studies; and (ii) thematic grouping of studies by research design and emerging topic. Using this narrative synthesis approach, the following common themes were identified: risk communication, risk perception, engagement of vulnerable populations, community-based strategies, public health, adaptation and resilience. The theme of risk communication was examined in detail by identifying and grouping practices that were used to communicate risk.

Results

The scoping review focused on the communication media and practices used for EWCC risk communication and did not seek to assess quality or weight of evidence.[12] The 43 articles that were included addressed various types of EWCC risk communication: climate change (n = 22), flooding (n = 12), hurricane events (n = 5), extreme heat (n = 2), and wild fires (n = 2)[‡]. The articles were of disparate and complementary study types: five conceptual models, eight reviews or systematic reviews, five experimental studies, eleven qualitative studies, eight surveys, two case studies, and four commentaries. There were fourteen studies from the United States, six from Europe, and five from Canada. The remaining eighteen studies were from Australia, Asia or international collaborations. Grey literature was used to identify how EWCC messaging was created and delivered rather than for its content. Article summaries are presented in Table 1.

A systematic review of environmental health risk communication suggested risk communications should involve multimodal delivery through many media channels, including radio, television, printed materials, classroom presentations, and Internet-based campaigns.[26] In total, the scoping review identified eight unique risk communication practices (Table 2). The two most common practices were public media campaigns, including radio and Internet-based messages, and organization or expert-led presentations or workshops to communities affected by natural hazards. Public media risk communication campaigns typically originated in government and were focused on uniformity and continuity to effect behavioural intention and change.[50] Within Ontario, communication activities such as promotional messaging, response guidelines, and heat alerts and warning systems were typical risk communication tools used in practice.[2]

The topic of communicating uncertainty around climate change was identified, along with suggestions for improving communication around uncertainty, which included collaboration[25] and carefully targeting messages to each unique audience.[42] Bridging the expert-public divide to improve risk communication was also highlighted as necessary and could include defining standards and increasing knowledge exchange among different domains of learning and practice.[25]

Risk communication themes

Key themes around successful risk communications strategies were: risk perception, targeting vulnerable populations, and engaging with communities (Table 3). The first theme, individual risk perception, was influenced by factors such as age, income, education, credibility, and emotion.[13,43] For example, self-efficacy and feelings of adequate preparedness were positively correlated with risk reduction behaviours in communities at high risk for wildfires.[37]

A second theme involved engaging vulnerable groups, such as low-income communities, the elderly, racial and ethnic minorities, and people with disabilities. This theme highlighted the challenges vulnerable communities face in seeking and processing risk communication information, including complex language, information overload and contradictory

[‡] Some articles addressed more than one type of EWCC risk communication.

TABLE 1
Articles included in the scoping review

First author	Design	Country	EWCC	Main objectives	Key findings
Akompab et al.[13]	Cross-sectional	Australia	Heat wave	To determine the predictors of risk perception using a heat wave scenario and identify the constructs of the health belief model that could predict adaptive behaviours during a heat wave.	The health belief model could be useful to guide the design and implementation of interventions to promote adaptive behaviours during heat waves.
Bajayo et al.[14]	Review	Various	All	To define an approach for building community resilience to climate change and to integrate this approach with a pre-existing framework.	Four principal resource sets contribute to community resilience. They are: economic development, social capital, information and communication, and community competence. These four components comprise the Community Resilience Framework, and can be developed within social, built, natural and economic environments.
Blashki et al.[11]	Commentary	Australia	All	To focus the responses of the Australian health system to health risks from climate change.	N/A
Bubeck et al.[15]	Review	Europe	Flood	To show the relationship between individual flood risk perception and mitigation behaviour, as it is increasingly studied in the literature.	The current focus on risk perception to explain and promote private flood mitigation behaviour is not supported on either theoretical or empirical grounds. Flood risk perception does not impact people adopting precautionary behaviour. Behaviour change rather is affected by efficacy of activities, self-efficacy and response costs.
Buchecker et al.[16]	Experimental	Switzerland	Flood	To elicit the contributions of participatory river revitalization projects on stakeholders' social capacity building through three evaluation methods.	Participatory planning leads to social learning and trust between group members, and it is not always important to have acceptance of the project across the group for work to be effective. Stakeholder involvement should be explicitly designed as tools for long-term social learning.
Burmingham et al.[17]	Focus group survey & interview	United Kingdom	Flood	To develop a better understanding of how local people understand flood risk and account for their flood awareness.	Social class has the most influence on predicting flood risk, followed by flood experience and then length of time in residence. Lack of printed information in different languages and reading levels was cited as major cause for low levels of flood risk awareness, whereas native English speakers cited lack of concern and denial as main reason for inaction.
Buys et al.[18]	Semi-structured interview	Australia	All	To explore perceptions of climate change and trust in information providers.	Risk communication efforts need to improve transparency and consultation with the public when communicating information about climate change.
Cadag et al.[19]	Case study	Philippines	Flood	To demonstrate how participatory mapping can foster integrative disaster risk reduction through a range of stakeholders, both scientists and community members.	Participatory 3D mapping contributes to the empowerment of most marginalized individuals by increasing their access to scientific knowledge and giving them credibility to talk to local officials and decision-makers. It decreases the power imbalance between scientist and local people.
Cairns et al.[20]	Semi-structured interviews and scenario workshop	Australia	All	To assess the value of scenario method as a catalyst for effecting change when multiple agencies, interests and agendas are present.	Scenario method is valuable, but does not itself act as catalyst for effecting change.
Chen et al.[21]	Cross-sectional survey	USA	Hurricane	To measure effect of exposure to natural disaster on future preparedness behaviour.	Found no significant changes in preparedness or evacuation plans in residents of Houston prior to and a year after Hurricane Ike.

Continued on the following page

TABLE 1 (continued)
Articles included in the scoping review

First author	Design	Country	EWCC	Main objectives	Key findings
Coulston et al.[22]	Survey	United Kingdom	Flood	To ascertain whether prior experience with flooding is a strong motivational factor for preparedness for future flooding episodes and assess preparedness in populations at high risk for flooding.	Awareness of being at-risk for flooding is vital for self-protective behaviour. Both awareness of risk and recent exposure are motivational for flood preparedness.
Driscoll et al.[23]	Mixed-methods	Alaska	All	To evaluate the health effects of climate change in rural Alaska.	Community-based sentinel surveillance is an effective method for assessing health impacts of climate change and informing health adaptation planning.
Eisenman et al.[24]	Semi-structured interview	USA	Hurricane	To understand the factors influencing evacuation decisions in impoverished communities which were most severely affected by Hurricane Katrina.	Effective disaster plans and messaging must account for the specific obstacles encountered by vulnerable and minority communities. Social networks and extended families impact individuals' choices and behaviours, and demand better community-based communication strategies.
Faulkner et al.[25]	Conceptual paper	United Kingdom	All	To develop a rationale for pragmatic semiotics of risk communication between the scientific community and decision-makers.	The uncertainties embedded in flood risk communications could be reduced by the development of a formally structured translational discourse between science and professionals, through which process "codes of practice" for uncertainty estimation in different application areas can be developed.
Fitzpatrick-Lewis et al.[26]	Systematic review	Various	All	To identify the effectiveness of communication strategies and factors that impact communication uptake related to environmental health risks.	A multi-media approach is more effective than any single media approach, and printed material that offers a combination of information types (i.e., text and diagrams) is a more effective than just a single type, such as all text. Risk communication strategies that incorporate the needs of the target audience(s) with a multi-faceted delivery method are most effective at reaching the audience.
Heilbrun et al.[27]	Experimental	USA	All	To compare perceptions, decision-making and anticipated action in response to threats of three kinds: natural disasters, violent crime, and terrorism.	Risk of natural disaster was more likely to lead participants to report they would change daily activities and location and was more likely than terrorism to lead to action securing the home. It appears that the mechanisms for perception, decision-making and action in response to threats cannot be generalized in a straightforward way across these domains of threat.
Hess et al.[28]	Review	Various	All	To explore the lack of research on adaptive capacity, outline climate health challenges for public health and consider changes to improve public health's adaptive capacity.	Efforts need to be focused on increasing adaptive capacity, promoting institutional learning, embracing adaptive management and developing tools to increase resilience of public health systems to climate change.
Hilfinger et al.[29]	Semi-structured interview	USA	Hurricane	To explore the role of social networks in gathering and disseminating risk information, and to investigate how social networks effect decision-making in a group setting.	Need to consider social network dynamics of marginalized groups in developing risk communication strategies.
Horney et al.[30]	Survey	USA	All	To assess the resources available for hazard mitigation planning.	There is a disconnect in how well emergency managers perceive they are protecting vulnerable populations, and how well vulnerable groups feel accounted for in mitigation plans. Few counties surveyed included outreach to vulnerable groups as part of their hazard mitigation approach.

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TABLE 1 (continued)
Articles included in the scoping review

First author	Design	Country	EWCC	Main objectives	Key findings
Ireland et al.[31]	Case study	Asia	All	To explore the role of collective action in building adaptive capacity, with particular attention on social networks.	Collective action plays a significant role in enhancing adaptive capacity and should be a central part of climate change adaptation strategies. Social networks are a particularly important component of collective action for building of adaptive capacity.
Kellens et al.[32]	Online survey questionnaire	Belgium	Flood	To test a model (risk information seeking and processing) on factors related to perceived hazard knowledge, response efficacy and information need. This study aimed to look at the mediating role of information need in the model, and the differences in information-seeking behaviour between permanent and temporary residents.	Information need did not mediate risk perception and perceived knowledge. People who were older, had lived in the area longer, and considered the information useful had the highest amount of risk seeking behaviour. Perceiving an information need does not necessarily result in higher rates of seeking the information. Individual perceptions of where the locus of control/responsibility lies are more central to whether or not someone seeks information and acts on it.
Kellens et al.[33]	Systematic review	Various	Flood	To systematically review the literature on risk perception and risk communication in flood-risk research.	There is no methodological standardization in measuring and analyzing people's flood risk perception or behaviour. Most studies are exploratory and have not applied theoretical frameworks. There is almost a complete absence of true risk-communication research.
Kim et al.[34]	Semi-structured interview	USA	Hurricane	To measure pre-hurricane preparedness behaviour on coping behaviour during a hurricane.	The evaluation revealed that an integrated connection to community-level communication resources—comprising local media, community organisations and interpersonal networks—has a direct impact on the likelihood of engaging in pre-hurricane preparedness activities and an indirect effect on during hurricane preparedness activities. Social risk perceptions increase the likelihood of taking preventative steps before a hurricane while personal risk perceptions are positively related to engaging in preventative action during a hurricane.
Kuhlicke et al.[35]	Commentary	Europe	All	To develop a model of social capacity building which considers social vulnerability, risk communication, and risk education.	N/A
Maibach et al.[36]	Conceptual paper	USA	All	To apply the ecological model of public health to examine the potential of communication and marketing interventions to influence population behaviours.	At the social-network level, there is an urgent need to identify and activate popular opinion leaders within all strata of society, including the government and commercial sectors. Personal influence is a powerful source for social change.
Martin et al.[37]	Survey	USA	Wildfires	To analyze the factors that influence risk reduction behaviours among homeowners in wildfire prone areas.	Effects of knowledge and locus of responsibility are mediated by homeowners' risk perceptions, and beliefs in self-efficacy directly influence risk reduction behaviours. Direct experience with wildfire does not directly influence risk mitigation-perception process.

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TABLE 1 (continued)
Articles included in the scoping review

First author	Design	Country	EWCC	Main objectives	Key findings
Mullins et al.[38]	Survey	United Kingdom	Flood	To measure the effect of ethnicity on social responsibility and flood risk preparedness behaviour.	Ethnic differences consistently exist within the perceptions of householder and business groups within communities (in different locations) which have recent experience of flooding, but not in the policy-maker group or in a community without recent flood experience. The finding also suggests three different levels of resilience and their association with different ethnic groups. Future research should conduct further analysis with equal ethnic representation throughout each community group so that more ethnic groups can be investigated and compared.
O'Sullivan et al.[39]	Community based evaluation and interview design	Canada	All	To explore empirically the complexity of disasters, to determine levers for action where interventions can be used to facilitate collaborative action, and to promote health among high-risk populations. The second purpose was to build a framework for critical social infrastructure and develop community-based participatory research design to promote population health and resilience.	Promoting population health in a disaster context requires a shift from risk management to one of resilience, which by its very nature acknowledges changing complexities. 'One size fits all' solutions are not adequate to promote community resilience. Instead, intervention design must emerge from the complexity of the situation and be tailored to the community context at any point in time.
Paterson et al.[2]	Semi-structured interview	Canada	All	To examine climate change adaptation in the public health sector in Ontario.	Health officials are concerned about how climate change could exacerbate existing health issues or create new health burdens. Adaptation is currently taking the form of mainstreaming climate change into existing public health programs, and a lack of resources constrains the sustainability of long-term adaptation programs.
Pidgeon et al.[40]	Commentary	Various	All	To outline the role for social and behavioural science in climate change research.	N/A
Poutiainen et al.[41]	Systematic review	Canada	All	To identify and examine what adaptations are being developed to adapt to the health effects of climate change.	1) Health adaptation actions are predominantly led by environmental organizations; 2) most actions are occurring at national and regional levels; 3) food and/or water contamination and air quality are dominant climate change stimuli for action; 4) responses predominantly reflect awareness and research activities, with limited evidence of substantive intervention; 5) consideration of vulnerable groups is limited; and 6) climate change is usually considered alongside other factors, if at all.
Rabinovich et al.[42]	Experimental	United Kingdom	All	To investigate the effect of beliefs about the nature of purpose of science on responses to uncertainty in climate change risk communication.	Uncertainty can enhance message effects when it fits the audience's understanding of what science is.
Reynolds[43]	Review	USA	All	To explore the psychological underpinnings of risk assessment within emotionally laden events and the risk communication practices that may facilitate subject matter experts to provide the facts assertively and productively.	To influence public action to a threat, communicators need to identify decisions that involve moral and emotional component, as well as logical components. Risk communicators need to include emotions and efforts to leverage them in stressful situations.

Continued on the following page

TABLE 1 (continued)
Articles included in the scoping review

First author	Design	Country	EWCC	Main objectives	Key findings
Roeser[44]	Conceptual paper	Netherlands		To outline the potential role emotions might play in effective risk communication and motivation for behaviour change on extreme weather and climate change adaptation.	Article describes a theoretical framework that supports idea that moral emotions play role in risk communication and public engagement. Emotions are often considered irrational states, but ethics literature shows that dominant technocratic approach to risk fails to touch normative-ethical dimensions that people rely on to assess and make decisions about risk.
Severtson[45]	Survey	USA	All	To identify the influences of risk beliefs and emotions on intention to act.	Participants' beliefs in problem seriousness mediated influence on intention to measure hazard and perceived susceptibility mediated intention to mitigate risk.
Sheppard et al.[46]	Conceptual paper	Canada	All	To describe a framework for community engagement and capacity building for climate change adaptation.	The framework provides a template for a process to integrate emission scenarios with both mitigation and adaptation scenarios and to link these with global strategies. Scenarios can be spatialized at the local level to allow analysis of climate change impacts, vulnerabilities and adaptation, and make them more integrated into planning process. Local knowledge and input into the framing of scenarios are vital for defensibility and public buy-in.
Spence et al.[47]	Semi-structured interview	United Kingdom	All	To categorize how the different psychological dimensions of climate change affect behaviour.	Risk communications techniques designed to reduce psychological distance and to engage the general public with climate change are promising.
Stewart et al.[48]	Semi-structured interviews, floodplain-wide survey	Canada	Flood	To identify risk communications gaps and discuss the range of strategies to enhance information sharing, bottom-up activity and partnership development for EWCC preparedness.	External pressures exerted by regional floodplain policies and procedures can restrict risk communication and affect social vulnerability in the rural floodplain. Policies promote the establishment of community standards to compensate for gaps in risk communication and the development of partnerships between floodplain communities.
Taylor-Clark et al.[49]	Focus group	USA	All	To assess the role of communication on perceptions of environmental health effects, information seeking behaviour and challenges to accessing and utilizing information related to climate change.	Presentation of culturally relevant messages may reduce knowledge gaps and facilitate action. Risk communication efforts need to understand the different sources and channels of information low income minorities trust and use, to be effective.
Tinker[50]	Commentary	USA	All	To examine strategies for communication during extreme weather events that engage stakeholders and encourage individual and organizational behaviour change.	N/A
Wachinger et al.[51]	Review	Europe	All	To review literature on risk perception related to natural hazards.	A risk perception paradox exists in that it is assumed that high-risk perception will lead to personal preparedness, but in fact the opposite can occur if individuals with high-risk perception still choose not to personally prepare themselves in the face of a natural hazard.
Yamada et al.[52]	Community based experimental study	Japan	Flood	To measure the effect of flood risk communication efforts on evacuation behaviour.	Community based flood risk communication was found to be effective for the enhancement of residents' awareness of both self- and mutual help efforts in community-based flood mitigation.
Zia et al.[53]	Survey	USA	All	To measure the effect of ideology on concern for climate change.	Ideology affects citizen understanding and commitment to action on climate change. Ideology trumps higher education and public knowledge must cut across ideological divides if it is to empower people to act on the climate issue.

Abbreviations: EWCC, extreme weather and climate change; N/A, not applicable.

TABLE 2
Risk communication practices identified

Risk communication practice	Articles[a] (%)	Description
Presentations/workshops with experts and/or community [16,33,37,41,42,45,48,50,52]	9 (21)	Public events where community members are invited to learn and give their opinions and experience related to a natural hazard or extreme weather risk.
Public media (television, radio, web-based)[17,24,26,33,36,42,48,50,51]	9 (21)	Any risk communication practice conveyed through radio, the internet or television.
Education and awareness programs[17,20,33,36,41,42,48]	7 (16)	Advocacy work, such as citizen guidebooks and education programs for children.
Informal social network communication[17,24,36,48,52]	5 (12)	Communication within community networks, social networks, families and neighbourhoods. Included 'word-of-mouth' communication.
Print materials (brochures, fact sheets)[17,26,41,42]	4 (9)	Any paper-based resource used to communicate risk, for example printed flood maps, risk sheets or tip sheets.
Community-based scenarios[16,20,46,52]	4 (9)	Hypothetical situations posed to a group of community members in a guided exercise with the objective of creating a mitigation strategy or compiling community perceptions about a risk.
Participatory management strategies[45,52]	2 (5)	A wide range of initiatives, such as community-based sentinel systems or hazard maps. Hazard maps are maps that graphically provide information on inundation, surface temperature, landslide probability or other risk related factors as well as evacuation locations and routes in an easy-to-understand format.[52]
Social media[36,50]	2 (5)	Online applications and platforms, such as Twitter, Facebook, Instagram, and others.

[a] Some articles identified more than one type of EWCC risk communication practice.

information.[45] This was illustrated through interviews with low-income residents fleeing Hurricane Katrina where the low-prevalence of car ownership resulted in heavy reliance on public transportation infrastructure.[24] A disconnect was noted between how well emergency managers perceive they are protecting vulnerable groups, versus how well vulnerable groups feel accounted for in mitigation plans.[30]

The third and final theme addressed the importance of leveraging social networks and creating strategies housed [or based] in communities. For example, people were more aware of extreme weather risks and more likely to initiate protective activities if they were involved in a participatory exercise.[51] Broader involvement of civil society organizations was also highlighted by a review that found that many CSOs, such as the Red Cross and YMCA, play important social roles in health adaptation and community engagement.[32] The reviewed studies suggest that public participation measures with diverse community stakeholders are the most effective means to create awareness of potential disasters, encourage individual responsive action, and increase community trust and cooperation in planning and messaging.[23]

Evaluation of risk communication

Community-based strategies were most-often evaluated for their effectiveness in EWCC risk communication. For example, the production of community-based flood hazard and evacuation maps was identified as an "effective method of raising public awareness while fostering the active participation of the community".[52] Evaluations also identified increased awareness of self- and mutual aid efforts in community-based flood mitigation. These results support community engagement practices around a specific threat, collaboration among key actors[28], and enhancing self-efficacy, as key factors in successful risk communication.

One study described a community-based scenario that involved government, private sector and environmental groups working together to explore the implications of the proposed expansion of a major port facility.[20] A workshop presented 4 potential futures, ranging from an ideal "showcase region" to the most negative "development at all costs." The authors observed that the scenario exercise did not motivate meaningful follow-up actions. They concluded that the scenario approach is valuable for enabling "democratic dialogue" – and bringing together diverse perspectives – but does not act as an effective "catalyst for bringing about consensus-driven collaborative change in support of policy development and planning." The authors attributed weak engagement to poor identification of underlying value systems and a failure to create a shared foundational knowledge from which all participants could work.

A second study involved an iterative and participatory process for community-based sentinel surveillance.[23] The process developed community metrics to measure the health impacts of climate change, and the evaluation examined the effectiveness of using community residents as central communication sources. It also considered how the process of collecting data served to increase residents' awareness of climate change impacts in their community. Community members became more aware and informed of health-related impacts and outcomes and became motivated to contribute to ongoing data collection and to plan for climate adaptation.

Effective risk communication was often defined as a two-way exchange of information between parties (e.g., government, public, community, expert).[35] Involving stakeholders in the risk communication planning and discussion stages may increase their commitment and overall satisfaction with mitigation and preparedness projects.[16] This highlights the importance of bidirectional communication and stakeholder engagement in EWCC risk communications.

Information-gathering and validation workshop

Comments and evaluations from the one-day information-gathering and validation workshop were used to validate our final search strategy [updated in 2016]. Themes from the scoping review were shown to participants who described experiences with relevant practices from the literature. Two key themes arose during the

TABLE 3
Factors that facilitate or impede the success of risk communication strategies

Thematic area	Influencing factors
Risk perception	Self-efficacy[15,37]
	Political ideology[17,38,53]
	Knowledge of and experience with hazards[15,17,22,27,33,35,37,38,40,45,51]
	Population socioeconomic status[51]
	Emotions/psychological impacts[17,35,40,44,45,47]
	Duration of residence in area[17,33,35,37,51]
	Information preferences[15,17,22,33,35,38,40,45,47]
	Trust in information provider[15,17,27,33,35,37,38,40,42,45,47,51]
	Efficacy and cost of mitigation[15]
Vulnerable populations	Include during planning[20,24,30,35,38,39,52]
	Flexible definitions of vulnerability[17,30,35,39,38]
	Involve social networks[17,20,24,39,52]
	Remove barriers to communication[17,35,38,39,52]
	Address economic issues[20,24,52]
	Address transportation issues[20,24,30,38,39,52]
	Establishing trust with authorities[17,24,30,35,39,52]
Community-based strategies	Collaborative hazard maps[19,52]
	Community-based scenarios[14,16,20,39,46]
	Inclusive "awareness-raising" projects[51,23]

workshop: challenges related to (i) communicating uncertainty and (ii) community-based participation.

The stakeholder group identified two EWCC risk communications strategies as priorities: participatory flood/hazard mapping and using case study examples in messaging. Several articles in the scoping review mentioned the power of stories and personal narratives in making EWCC messaging more readily accessible and bidirectional. Unlike official messaging from a government agency, community residents can more easily relate to stories and share their own experiences with other community members.

Key priorities included: engaging community stakeholders in the "broader social fabric" (e.g., Boys and Girls Clubs, community centres) on climate change issues; expanding traditional networks to include inter-institutional expertise among provincial, municipal, and federal actors; and developing differentiated risk-communication strategies for rural and urban areas.

Practitioners agreed that communicating EWCC risks effectively requires individuals and communities to develop self-efficacy and empowerment. This is accomplished by ensuring that community members take an active role in developing preparedness messages for fellow residents. Two participants expressed concern that EWCC risk communications with socioeconomically vulnerable populations must be handled sensitively because such vulnerable audiences do not self-identify as being vulnerable. Participants expressed concern that EWCC risk communication seems to only focus on physical infrastructure and does not address sociodemographic issues. Workshop participants concluded that EWCC risk communicators should use community-based approaches that also connect with and support the specific messaging needs of intergenerational audiences.

Another theme from the workshop was the need to support communities of practice for EWCC risk communication. In part, this workshop guidance reflects the diverse range of audiences and outlets for EWCC messaging and materials. Cross-sectoral communities of practice could help to plan and communicate more broadly and support more effective and integrated communications. Workshop participants agreed that media partnerships should be developed to create credible and well-accepted messages that help build social capacity for climate adaptation.

The scoping review and validation workshop both identified factors that may influence risk communication effectiveness—self-efficacy, prior experience with a hazard, trust in the risk communicator, and duration of residence in risk-prone areas—but these may have limited generalizability to EWCC because they have predominantly come from evaluations of risk communications related to flooding. Challenges to EWCC risk communication include bridging shorter-term hazard preparedness with long-term climate adaptation. One model called "Local Climate Change Visioning" outlined linking mitigation and adaptation measures through community scenario planning, a process that includes facilitation.[46] This model involved informal communication or storytelling networks for flood and climate change scenario planning in Vancouver, British Columbia. It did not address the use of specific risk messages but did highlight participatory processes and inclusive planning examples supported by other retrieved studies.

A framework to address knowledge gaps

Workshop participants reported knowledge gaps similar to those identified in the scoping review (Table 4). One consistent question revolved around whether to disentangle EWCC from messaging, and how to make messages sensitive to community differences and characteristics. Some participants believed referencing climate change reduces the impact and absorption of messages and that implying that extreme weather events are caused by climate change may be counterproductive. The public has learned from various inaccurate sources that the pattern of extreme weather events is cyclical and normal rather than well-correlated with a long-term shift to a more unpredictable and threatening climate reality. This led to a debate about when it is effective to use the term "climate change" in risk communications.

While many studies recommended a multimedia approach to risk communication, there is little consensus on what this should look like for EWCC, and the lack of conceptual frameworks across disciplines

TABLE 4
Research gaps identified in the literature

Research gap identified	Articles
Limited consideration of social units (households and extended families)	8
No standard methodology for measuring risk perception and hazard preparedness intention	9
Little integration of community vulnerability assessments in future planning	8
Lack of empirical studies and application of theoretical frameworks	11
Lack of application of social science or behaviour change models	5
Lack of evaluation and validation of risk communication	5

and jurisdictions in the risk communication field was noted in two systematic reviews.[26,33]

Following the scoping review and validation workshop, a preliminary conceptual framework was developed to address the identified knowledge gaps and support public health practitioners during EWCC risk communication. The framework was also intended to support the adaptive capacity of public health practitioners and decision makers. The preliminary conceptual framework (Figure 2) encompasses both a short-term timescale to address risk communications for extreme weather and a long-term timescale that addresses risk communications for climate change.

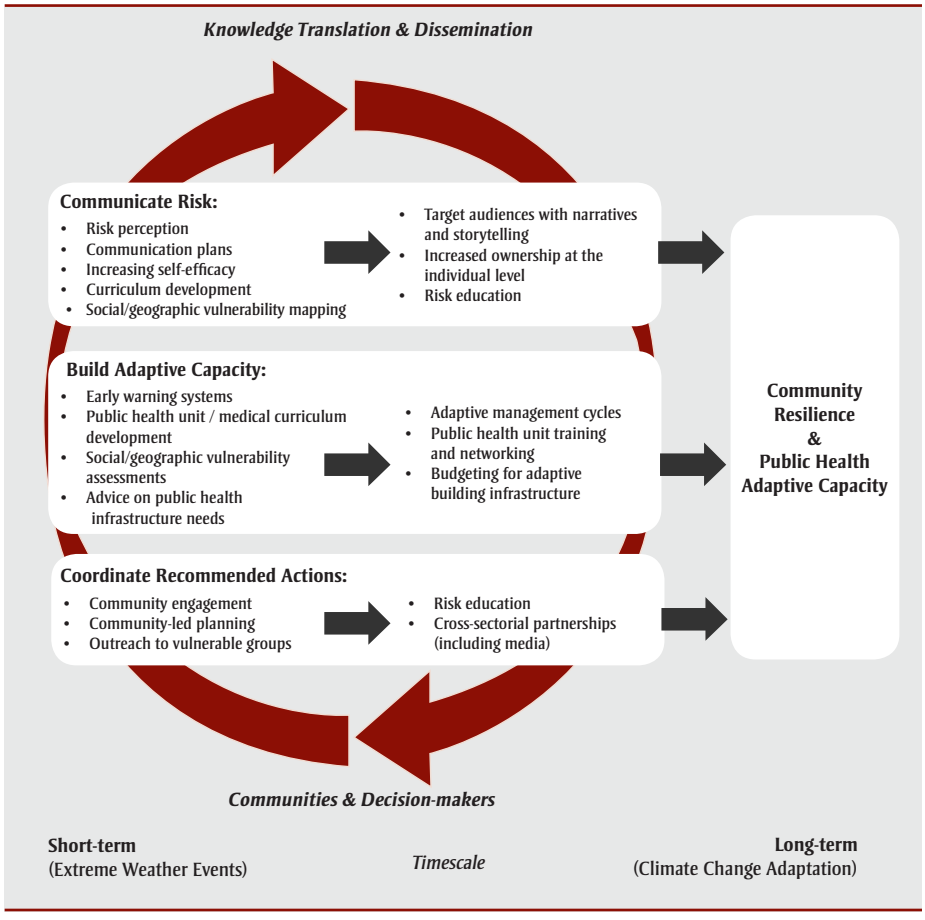
The conceptual framework includes a knowledge translation and dissemination feedback cycle which involves communities and public health policy decision-makers. The feedback cycle intersects with horizontal local and institutional efforts to communicate EWCC risk, build adaptive capacity and coordinate recommended actions across short- and long-term timescales. In the conceptual framework, communities receive risk messages and share feedback in the form of content and lived experience with the public health practitioners and decision-makers who then intelligently adapt EWCC materials in response to grassroots feedback as part of an ongoing process. By applying several of the methods highlighted in the scoping review (e.g., community engagement, targeting audiences, creating adaptive management systems), this model visually represents how public health policy makers, decision makers and educators could become integral to a risk communication framework whose goal is to continually enhance adaptive capacity to climate change and build community resilience.

Discussion

Results from the scoping review and information-gathering and validation workshop highlight important features regarding EWCC risk communication strategies and related practices. The scoping literature review covered diverse issues, jurisdictions and decision-making bodies. It identified methodological approaches and gaps that can affect research outcomes. Public media, community workshops and expert presentations were the most common practices cited for communicating extreme weather risk. Eighteen articles covered how inclusive community-based approaches, such as hazard mapping and scenario planning, allow decision-makers, such as government, to work alongside the general public in a way that encourages mutual respect and increases individual action. This type of communication practice could present a unique opportunity for public health practitioners, who often rely on promotional messaging such as temperature alerts, as EWCC risk communication tools.[2]

Grey literature identified that humanitarian organizations such as the Red Cross are taking the lead in social media, disaster preparedness, health adaptation and community engagement.[41] These include preparedness iPhone apps and combining local radio, SMS and crisis mapping into community-sourced-communication tools for extreme weather events and citizen preparedness.[54] Public participation measures with diverse community stakeholders appear to be the most effective means to raise awareness of disaster preparedness, promote effective individual responses — and increase community trust and cooperation in planning and messaging.

FIGURE 2
Preliminary conceptual framework for extreme weather and climate change risk communication and public health adaptive capacity



A common theme among communication articles was addressing risk perception. Many variables affect how EWCC events are perceived and addressed by individuals and communities. Factors such as self-efficacy, personal experience with hazards, and how long individuals have lived in a potentially affected location all contributed to the perception of the level of threat of an extreme weather event. The state of individual and community risk perception is important to consider in any EWCC risk communication strategy. None of the eighteen articles that addressed risk perception evaluated risk communication strategies, yet it appears some of these factors influence risk perception (e.g., self-efficacy, duration of residence) while others can predict whether individuals will act (e.g., response efficacy).

Despite many authors highlighting that risk communications should be understood as a "two-way exchange between parties," the current literature suggests that most communication is a uni-directional warning from decision-makers to an uninvolved public, rather than a dialogue.[50] Thus, EWCC is largely being discussed at a high level through official media or advocacy campaigns and less so at the household or community level, and is not well integrated across platforms. Tailored, people-centered risk communication practices have been shown to be more effective than top-down approaches.[55]

Research gaps surrounding EWCC risk communications included a shortage of empirical studies and a limited amount of applied theory in study design and execution. Because extreme weather events sometimes occur with little warning, measuring pre-event preparedness and behaviour change is difficult. Even so, the reviewed literature is context specific and difficult to use to generate programs and frameworks because the approaches to measuring variables such as risk perception and a willingness to act are not cohesive or consistent. Another gap in the research was a lack of evaluation of current risk communications strategies. Several authors highlighted poor integration of community-led initiatives in future planning, often because such initiatives were not properly evaluated. The final major gap in the research base relates to a focus on individuals, at the expense of the household and extended family networks. In relation to vulnerable communities (and wider society), authors argued that research should address how decision-making within families affects risk perception and responses during extreme weather events. Future research might therefore include families and various intimate social groupings as a starting point in theoretical frameworks and allow analysis of household dynamics as they pertain to preparedness activity for EWCC risks. Due to the English language restriction used to search published and grey literature, it is possible that relevant research and risk communication efforts were not captured in our scoping review.

The literature shows that a promising risk communications strategy for decision makers and scientists is to acknowledge uncertainty to counter scepticism, improve communication transparency, and enhance trust and credibility.[18,42] Improved communications about uncertain aspects of climate change require collaboration[25] and carefully targeting messages to each unique audience.[42] Bridging the knowledge divide between experts and the public to improve risk communication is necessary and could include developing risk communications standards and improving knowledge exchange among complementary domains of learning and practice.[25]

While the relationship between extreme weather and climate change is increasingly clear, the reviewed literature suggests that researchers have not been able to identify risk communication strategies that span the short- and long-term responses recommended for key audiences. Some studies referred generally to "climate change" but did not provide specific examples of potential threats or climate impacts, making it difficult to identify key approaches that would be effective in communicating a wide variety of risks to a disparate set of audiences. The conceptual framework presented here is intended not only to support EWCC risk communication, but also to build adaptive capacity and coordinate recommended actions across short- and long-term timescales.

Conclusion

To meet the OPHS 2018 requirements, public health unit staff need to engage in effective risk communication that motivate local actions to mitigate the effects of extreme weather and climate change. The issue for public health professionals is that there is little evidence on which to base risk communication strategies,[56] particularly for the long-term impacts of climate change. Best practices include community engagement, initiatives to enhance self-efficacy of individuals and communities, targeting unique audiences and bi-directional communications among leaders and stakeholders. Promising practices such as stakeholder coordination, participatory workshops and addressing vulnerable populations are similar to emerging best practice.

Public health practitioners and decision makers are important intermediaries in EWCC risk communications and provide necessary knowledge to motivate a healthy response to evidence of accumulating EWCC risks.[57] Extreme weather related to climate change is a growing threat to Canadians. Preparedness for and actions taken at individual, family, community, organizational and system levels can mitigate risks associated with these threats. Based on the evidence review, risk communication efforts during short-term extreme weather events appear to be more effective than efforts to communicate risk around climate change. This distinction could highlight a unique opportunity for public health to adapt strategies commonly used for extreme weather to climate change.

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Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions and statement

EM drafted and revised the manuscript. SK designed the project, screened articles, developed the conceptual framework and reviewed the manuscript. AD reviewed and screened articles for relevance, drafted the workshop report and reviewed the manuscript. RC supervised the project and reviewed the manuscript. BS supervised

the project, developed the conceptual framework and reviewed the manuscript.

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References

1. Trenberth K. Framing the way to relate climate extremes to climate change. Climatic Change. 2012;115: 283-90.

2. Paterson JA, Ford JD, Ford LB, et al. Adaptation to climate change in the Ontario public health sector. BMC Public Health. 2012;12:452.

3. Ebi KL, Berry P, Hayes K, et al. Stress testing the capacity of health systems to manage climate change-related shocks and stresses. Int J Environ Res Public Health. 2018;15(11):2370.

4. Levison MM, Butler AJ, Rebellato S, Armstrong B, Whelan M, Gardner C. Development of a climate change vulnerability assessment using a public health lens to determine local health vulnerabilities: an Ontario Health Unit experience. Int J Environ Res Public Health. 2018;15(10):2626.

5. Buse CG. Why should public health agencies across Canada conduct climate change and health vulnerability assessments? Can J Public Health. 2018;109(5-6):782-5.

6. Salman AM, Li Y. Flood risk assessment, future trend modeling, and risk communication: a review of ongoing research. Nat Hazards Rev. 2018; 19(3).

7. Ontario Agency for Health Protection and Promotion (Public Health Ontario), Brecher RW, Copes R. EOH fundamentals: risk communication. Toronto (ON): Queen's Printer for Ontario; 2016.

8. McMartin DW, Sammel AJ, Arbuthnott K. Community response and engagement during extreme water events in Saskatchewan, Canada and Queensland, Australia. Environ Manage. 2018; 61(1):34-45.

9. Dodd W, Scott P, Howard C. Lived experience of a record wildfire season in the Northwest Territories, Canada. Can J Public Health. 2018;109(3): 327-37.

10. Pilla F, Gharbia SS, Lyons R. How do households perceive flood-risk? The impact of flooding on the cost of accommodation in Dublin, Ireland. Sci Total Environ. 2019;650(Pt 1): 144-54.

11. Blashki G, Armstrong G, Berry HL, et al. Preparing health services for climate change in Australia. Asia-Pacific Journal of Public Health. 2011;23(2 suppl):133S-143S.

12. Arksey H and O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol. 2005;8(1):19-32.

13. Akompab DA, Bi P, Williams S, et al. Heat waves and climate change: applying the health belief model to identify predictors of risk perception and adaptive behaviours in Adelaide, Australia. Int J Environ Res Public Health. 2013;10(6):2164-84.

14. Bajayo R. Building community resilience to climate change through public health planning. Health Promotion Journal of Australia. 2012; 23(1):30-6.

15. Bubeck P, Botzen WJ, Aerts JC. A review of risk perceptions and other factors that influence flood mitigation behavior. Risk Analysis. 2012;32(9): 1481-95.

16. Buchecker M, Menzel S, Home R. How much does participatory flood management contribute to stakeholders' social capacity building? Empirical findings based on a triangulation of three evaluation approaches. Natural Hazards and Earth System Science. 2013;13(6):1427-44.

17. Burningham K, Fielding J, Thrush D. 'It'll never happen to me': understanding public awareness of local flood risk. Disasters. 2008;32(2):216-38.

18. Buys L, Aird R, van Megen K, et al. Perceptions of climate change and trust in information providers in rural Australia. Public Understanding of Science. 2014;23(2):170-88.

19. Cadag JRD, Gaillard JC. Integrating knowledge and actions in disaster risk reduction: the contribution of participatory mapping. Area. 2012; 44(1):100-9.

20. Cairns G, Ahmed I, Mullett J, et al. Scenario method and stakeholder engagement: critical reflections on a climate change scenarios case study. Technological Forecasting and Social Change. 2013;80(1):1-10.

21. Chen V, Banerjee D, Liu L. Do people become better prepared in the aftermath of a natural disaster? The hurricane Ike experience in Houston, Texas. Journal of Public Health Management & Practice. 2012;18(3): 241-9.

22. Coulston JE, Deeny P. Prior exposure to major flooding increases individual preparedness in high-risk populations. Prehospital & Disaster Medicine. 2010;25(4):289-95.

23. Driscoll DL, Sunbury T, Johnston J, et al. Initial findings from the implementation of a community-based sentinel surveillance system to assess the health effects of climate change in Alaska. Int J Circumpolar Health. 2013;7.

24. Eisenman DP, Cordasco KM, Asch S, et al. Disaster planning and risk communication with vulnerable communities: lessons from Hurricane Katrina. Am J Public Health. 2007;97(Suppl 1):S109-15.

25. Faulkner H, Parker D, Green C, et al. Developing a translational discourse to communicate uncertainty in flood risk between science and the practitioner. Ambio. 2007;36(8):692-703.

26. Fitzpatrick-Lewis D, Yost J, Ciliska D, et al. Communication about environmental health risks: a systematic review. Environmental Health: A Global Access Science Source. 2010; 9:67.

27. Heilbrun K, Wolbransky M, Shah S, et al. Risk communication of terrorist acts, natural disasters, and criminal violence: comparing the processes of understanding and responding. Behav Sci Law. 2010;28(6):717-29.

28. Hess JJ, McDowell JZ, Luber G. Integrating climate change adaptation into public health practice: using adaptive management to increase adaptive capacity and build resilience. Environ Health Perspect. 2012; 120(2):171-9.

29. Hilfinger Messias DK, Barrington C, Lacy E. Latino social network dynamics and the Hurricane Katrina disaster. Disasters. 2012;36(1):101-21

30. Horney JA, Nguyen M, Cooper J, et al. Accounting for vulnerable populations in rural hazard mitigation plans: results of a survey of emergency managers. Journal of Emergency Management. 2013;11(3):201-11.

31. Ireland P, Thomalla F. The role of collective action in enhancing communities' adaptive capacity to environmental risk: an exploration of two case studies from Asia. PLoS Currents. 2011:1-16.

32. Kellens W, Zaalberg R, De Maeyer P. The informed society: an analysis of the public's information-seeking behavior regarding coastal flood risks. Risk Analysis. 2012;32(8): 1369-81.

33. Kellens W, Terpstra T, De Maeyer P. Perception and communication of flood risks: a systematic review of empirical research. Risk Analysis. 2013;33(1):24-49.

34. Kim YC, Kang J. Communication, neighbourhood belonging and household hurricane preparedness. Disasters. 2010;34(2):470-88.

35. Kuhlicke C, Steinfuhrer C. Social capacity building for natural hazards: a conceptual frame. CapHaz-Net WP1 Report, Helmholtz Centre for Environmental Research – UFZ: Leipzig [Internet]. 2010. Available at: http://caphaz-net.org/outcomes-results/CapHaz-Net_WP1_Social-Capacity-Building.pdf

36. Maibach EW, Roser-Renouf C, Leiserowitz A. Communication and marketing as climate change-intervention assets a public health perspective. Am J Prev Med. 2008;35(5): 488-500.

37. Martin WE, Martin IM, Kent B. The role of risk perceptions in the risk mitigation process: the case of wildfire in high-risk communities. J Environ Manage. 2009;91(2):489-98.

38. Mullins A, Soetanto R. Ethnic differences in perceptions of social responsibility: informing risk communication strategies for enhancing community resilience to flooding. Disaster Prev Manage. 2013;22(2): 119-31.

39. O'Sullivan T, Kuziemsky CE, Toal-Sullivan D, et al. Unravelling the complexities of disaster management: a framework for critical social infrastructure to promote population health and resilience. Soc Sci Med. 2013;93:238-46.

40. Pidgeon N, Fischhoff B. The role of social and decision sciences in communicating uncertain climate risks. Nature Climate Change. 2011;1:35-41.

41. Poutiainen C, Berrang-Ford L, Ford J, et al. Civil society organizations and adaptation to the health effects of climate change in Canada. Public Health. 2013;127(5):403-9.

42. Rabinovich A, Morton TA. Unquestioned answers or unanswered questions: beliefs about science guide responses to uncertainty in climate change risk communication. Risk Analysis. 2012;32(6):992-1002.

43. Reynolds B. When the facts are just not enough: credibly communicating about risk is riskier when emotions run high and time is short. Toxicol Appl Pharmacol. 2011;254:206-214.

44. Roeser S. Risk communication, public engagement, and climate change: a role for emotions. Risk Analysis. 2012;32(6):1033-40.

45. Severtson DJ. The influence of environmental hazard maps on risk beliefs, emotion, and health-related behavioral intentions. Res Nurs Health. 2013;36(4):330-48.

46. Sheppard SRJ, Shaw A, Flanders D, et al. Future visioning of local climate change: a framework for community engagement and planning with scenarios and visualisation. Futures. 2011;43(4):400-12.

47. Spence A, Poortinga W, Pidgeon N. The psychological distance of climate change. Risk Analysis. 2012;32(6): 957-72.

48. Stewart RM, Rashid H. Community strategies to improve flood risk communication in the Red River Basin, Manitoba, Canada. Disasters. 2011; 35(3):554-76.

49. Taylor-Clark K, Koh H, Viswanath K. Perceptions of environmental health risks and communication barriers among low-SEP and racial/ethnic minority communities. J Health Care Poor Underserved. 2007;18(4 Suppl): 165-83.

50. Tinker TL. Communicating and managing change during extreme weather events: promising practices for responding to urgent and emergent climate threats. J Bus Contin Emer Plan. 2013;6(4):304-13.

51. Wachinger G, Renn O, Begg C, et al. The risk perception paradox–implications for governance and communication of natural hazards. Risk Analysis. 2013;33(6):1049-65.

52. Yamada F, Kakimoto R, Yamamoto M, et al. Implementation of community flood risk communication in Kumamoto, Japan. J Adv Transport. 2011;45(2): 117-28.

53. Zia A, Todd AM. Evaluating the effects of ideology on public understanding of climate change science: how to improve communication across ideological divides? Public Understanding of Science. 2010;19(6):743-61.

54. International Federation of Red Cross and Red Crescent Societies. World disasters report: Focus on technology and the future of humanitarian action [Internet]. 2013. Available from: http://www.ifrc.org/PageFiles/134658/WDR%202013%20complete.pdf

55. Haer T, Botzen WJW, Aerts JCJH. The effectiveness of flood risk communication strategies and the influence of social networks–Insights from an agent-based model. Environmental Science and Policy. 2016;60:44-52.

56. Capstick S, Whitmarsh L, Poortinga W, et al. International trends in public perceptions of climate change over the past quarter century. WIREs Clim Change. 2015;6:35-61.

57. Chadwick AE. Climate change, health, and communication: a primer. Health Commun. 2016;31(6):782-5.

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Original qualitative research

A narrative model for exploring climate change engagement among young community leaders

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This article has been peer reviewed.

Abstract

Introduction: Decades of widespread knowledge about climate change have not translated into adequate action to address impacts on population health and health equity in Canada. Research has shown that context-based perceptions and interpretations mediate engagement. Exploring climate change engagement involves inquiry into contextual experience.

Methods: This qualitative study has employed narrative methodology to interpret the meaning of climate change among community leaders in Saskatoon, Saskatchewan, Canada, age 20-40 (n = 10). Climate change narratives were explored both structurally and thematically.

Results: A model was developed to organize results and to describe concepts of fidelity and dissonance within participant narratives. Findings suggested that knowledge of climate change and personal motivation to act did not preclude narrative dissonance, which served as a barrier to a meaningful personal response. Dissonance can result where internal and external barriers mediate mobilization at moments in the plot: (1) moving from knowledge of the challenge to a sense of agency about it; (2) from agency to a sense of responsibility to choose to address it; (3) from responsibility to a sense of capacity to produce desirable outcomes despite contextual challenges; and (4) from capacity to a moral sense of activation in context. Without narrative fidelity, meaningful mobilization can be hindered.

Conclusions: A narrative model is useful for exploring climate change engagement and highlights opportunities for a population health approach to address the conditions that hinder meaningful mobilization. By framing climate change narratives with emotional and moral logic, population health framing could help young leaders overcome internal and external barriers to engagement.

Keywords: *climate change, engagement, narrative methods, public education*

Highlights

- Climate action requires engagement models that capture contextual and cultural barriers experienced by knowledgeable, motivated individuals.
- This qualitative study examined the narrative structure of meaning-making about climate change among community leaders, 20 to 40 years old (n = 10).
- Narrative dissonance could help to explain immobilization, particularly among those with enough knowledge of climate change.
- Modeling narrative dissonance highlights opportunities to frame the challenges, choices, and outcomes related to climate change in a way that mobilizes population health stakeholders.
- By addressing dissonance within public narratives about climate change in Canada, population health professionals can contribute to conditions for meaningful mobilization.

Introduction

Climate change is a serious threat to the health of populations, representing both a challenge and an opportunity for practitioners and researchers.[1-4] Impacts are not experienced uniformly, and existing health inequities will be further exacerbated without urgent action to mitigate greenhouse gas emissions and to enhance community resilience.[1-7] Currently, Canada is not on track to meet its commitments to the Paris Agreement,[8,9] and there is disagreement among stakeholders about the future of Canada's climate policies.[10] Systems-level action is necessary to address the risks of climate change in a meaningful way, but population health professionals may lack frameworks and models for overcoming the barriers to engagement.[3,7]

Professionals who employ an eco-social lens[11,12] to understand health problems have important roles to play in supporting and leading climate action at multiple levels,[3,7] but gaps in knowledge remain about the complex contexts that shape engagement.[13-15] Multi-scalar, multi-dimensional eco-social health problems, such as climate change, are experienced by populations in the structural and social realities of everyday life and, as Golden, McLeroy, Green et al.[16] discuss, it is not immediately clear how an individual might make sense

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of their personal response without models to help navigate that which is outside of individual control.

Bridging the gap between knowledge and action involves engaging with the contextual and cultural barriers to action.[17] The goal of this study was to gain a deeper understanding of the experience of responding to climate change in context, particularly among those motivated by values of social and environmental justice. The objectives were to: (1) employ Ganz's theories[18] about public narrative, power, and collective action to interpret perceptions of climate change amongst knowledgeable, motivated community leaders in Saskatoon, Saskatchewan, Canada (age 20–40 years); and (2) to contribute a model for conceptualizing engagement narratively and for exploring the meaning of eco-social problems like climate change in the context of everyday life.

This article is based on the author's Master's thesis, submitted in partial fulfillment of the requirements for the M.Sc. degree in the Department of Community Health and Epidemiology at the University of Saskatchewan.[19]

Literature

Rather than attributing a lack of climate change action to a lack of public *understanding* about climate science, over the last decade, researchers have increasingly pointed to the importance of public *engagement* for explaining the apparent gap between knowledge and action.[14] In contrast to information-deficit models, which have emphasized increasing understanding, an engagement approach involves mental processes (cognition) as well as emotional and evaluative processes (affect) and processes of embodiment (behaviour).[14] Despite the limitations of the information-deficit model, population health professionals may lack alternative approaches to climate change engagement. For example, the 2017 *Lancet Countdown* argued that "insufficient understanding of climate change [was] one of the largest perceived barriers to individual engagement"[20] when climate change engagement literature has suggested that knowing the facts about climate change can *result* in barriers to engagement.[13-15,21-23] Public health frames may be helpful for relaying information about the risks of climate change in a clear way,[24] but questions have remained about the impact of that understanding in the context of everyday life.

Systematic reviews of literature about climate change engagement[14,15] have found that cultural and contextual factors have mediated interpretations of climate change. Emerging research has indicated a varied landscape of climate attitudes, despite a strong factual and moral basis for climate action.[13,21-23] The literature about climate change engagement has been widely accepting of the limits of the information-deficit model, and has recommended instead a focus on emotions, cultural values, and audience-specific framing.[13-15,21-23] Literature has also demonstrated that climate change can represent an existential threat to self-identity, [15,25-27] which could elicit emotional and social dynamics that hinder meaningful engagement.[18]

Some qualitative researchers have explored the psychological and sociological contexts in which facts about climate change are interpreted, deepening understanding and outlining theories about the preconditions for action. For example, Lertzman,[27] from a psychological perspective, argued that individual meaning-making about climate change is ripe with internal struggle, offering theory about how "environmental melancholia" impacts engagement. Lertzman argued that personal climate change stories are complex and she maintained that an individual might comprehend that what matters in life is being threatened while also distancing that threat to cope with it.[27] From a sociological perspective, Norgaard[25] found evidence of internal dilemma within groups of people who understand climate change and she explored how uncomfortable feelings are shut down to preserve social norms. Norgaard discussed "implicit denial" and concluded that both individuals and collectives look to public narratives to help them manage unwelcome emotions about climate change.[25] Thus, even those who are convinced and concerned about climate change could be hindered from mobilization by a lack of social structures and collective support to process resulting emotional and moral implications.

Questions have remained about the complex relationships between climate change knowledge, values, emotions, and actions, particularly among individuals who are knowledgeable about climate change and who have espoused pro-environmental values.[28,29] As population health professionals aim to mobilize systems-level change, models for engagement are needed which, in addition to improving general understanding about the health impacts of climate change, serve to equip communities to mobilize in a meaningful way. This study was aimed at contributing to research about the barriers to climate change engagement by exploring the lived experience of climate change among young community leaders.

Methods

Narrative approaches have been emerging more prominently in the climate change engagement literature in recent years because of their ability to capture experiences in context.[17,30-34] As Paschen and Ison[30] argued, for example, context-specific perspectives have been gaining momentum in the literature about climate change adaptation, and narrative approaches could play a critical role in closing knowledge gaps about building local capacity. Bushell et al.[17] described how strategic narratives could be used to give meaning to otherwise disconnected events to build buy-in and support. Moezzi et al.[33] argued that storytelling could influence and engage audiences, describing stories "as artefacts to be investigated in terms of content, actors, relationships, power, and structure…used to gather information, provide insight, and reframe evidence in ways that more science-ordered formats miss".[33, p1] In this study, a narrative methodology was employed to gather and analyze data.[35,36]

Humans draw on cultural values when narrating their personal and shared experiences, and the act of constructing self and group narratives is theorized to reveal the goals, motivations, pathways, and plans deemed rational in context.[37,38] Ganz maintained that personal narratives, or "stories of self", are nested in public narratives based in relationships and cultural context, or "stories of us and now".[18] Within "stories of us," the push-and-pull of the context and characters' agency is negotiated discursively as the storyteller draws on shared values, experiences, and frames to convey the meaning of the story.[18] By exploring individual perceptions through Ganz's framework for public narrative,[39] researchers can gain a deeper understanding about how barriers to engagement operate in context.

Study activities

Interpretive studies draw on insights from a homogenous sample to understand the experience of a particular group.[35] Ten individuals were recruited for the study in Saskatoon, Saskatchewan, each between 20 and 40 years old. At the time of their participation in the study, participants were leading diverse lives: some were starting families or businesses, some were students, and some worked in fields such as: health, arts, education, governance, and politics. All participants identified as community leaders embodying a commitment to social and environmental justice values. To broaden the transferability of the findings, recruitment continued until the sample included a mix of men and women (7 out of 10 were women) as well as 3 out of 10 individuals self-identifying as members of a First Nation. By looking at this particular "story of us,"[18] it was possible to gain a deeper understanding of the perspectives of people knowledgeable and motivated to act to address climate change but who live in contexts where many people do not accept the severity or cause of the problem.

This study received ethics approval from the Behavioural Research Ethics Board at the University of Saskatchewan (Beh #17-19). Because this study involved storytelling about themes that may be outside the scope of public attention,[25] as well as themes that may elicit uncomfortable emotions[26] and internal dilemma,[27] participants were provided with the study rationale and the open-ended interview questions beforehand so that they could begin to tune into their perceptions of climate change. Semi-structured interviews were held in a location of the participant's choosing and lasted an average of 60 minutes. At the end of the interview, each participant was given a journal with the five research questions written inside, and they were invited to write about their experience and their story as thoughts emerged in the weeks following the interview. Participants were not asked to share the contents of their journal, but during follow-up contacts, they were invited to add thoughts or reflections to their story. This design allowed for an ongoing dialogue to be established so that as the interpretation of the results developed, participants felt comfortable making additions and changes to better reflect their experience.[35]

Structural interpretation

Structure is intrinsic to the meaning-making function of narrative. As Polkinghorne[38] argued, "[t]he question 'What does that mean?' asks how something is connected to something else…It is the connections and relationships among the events that is their meaning".[38,p6] For example, the beginning of a story has a relationship to the middle of a story, as does the middle of a story to the end of a story.[40] Ganz's plotline (Figure 1) consists of four sequential parts: challenge, choice, outcome, and moral.[18] Ganz argued that by framing information as a narrative, humans "share experiences with each other, counsel each other, comfort each other, and inspire each other to action".[18,p282] Participant narratives were coded according to this four-part structure using NVIVO to allow for comparison and analysis of key themes and patterns. By interpreting how participants framed the challenge, choice, outcome, and moral of their climate change story, the connection points between the parts of the whole could be explored.

After coding each part of the plot, additional codes were applied to themes that facilitate or hinder engagement, indicating structural linkages between knowledge and action. Figure 2 visualizes a narrative model for engagement that was developed inductively throughout the study. The model was used to organize thematic data and to explore the meaning of climate change as perceived by study participants. "Mobilizing moments" in the narrative are identified where themes could contribute to narrative dissonance, shaping the transition points between (1) sufficient knowledge of the challenge of climate change and a sense of agency about it; (2) between a sense of agency and a sense of responsibility to act; (3) between a sense of responsibility and a sense of capacity to achieve a desired future; and (4) between a sense of capacity and a sense of activation in the context of everyday life. By structuring an exploration of connection

FIGURE 1
Interpretive schema

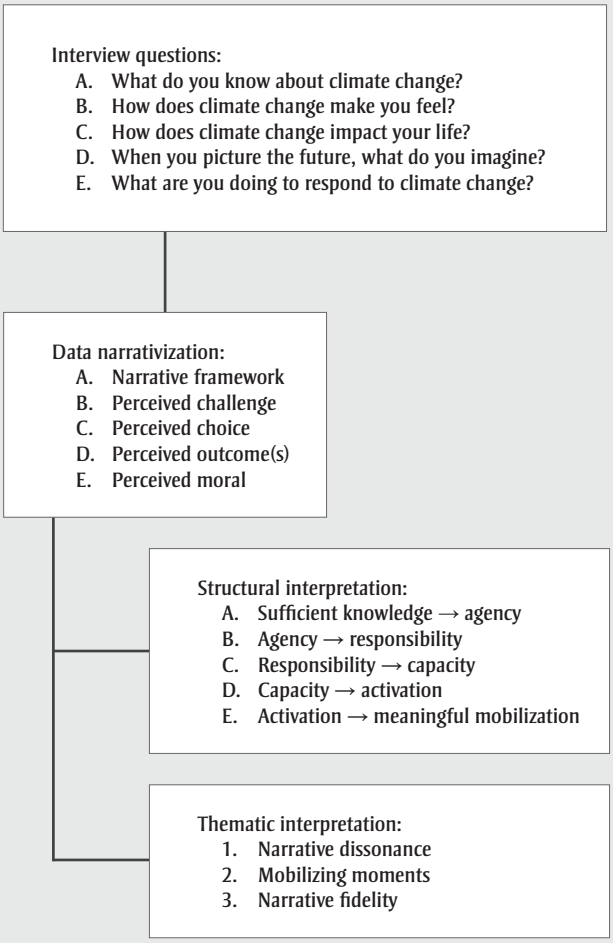

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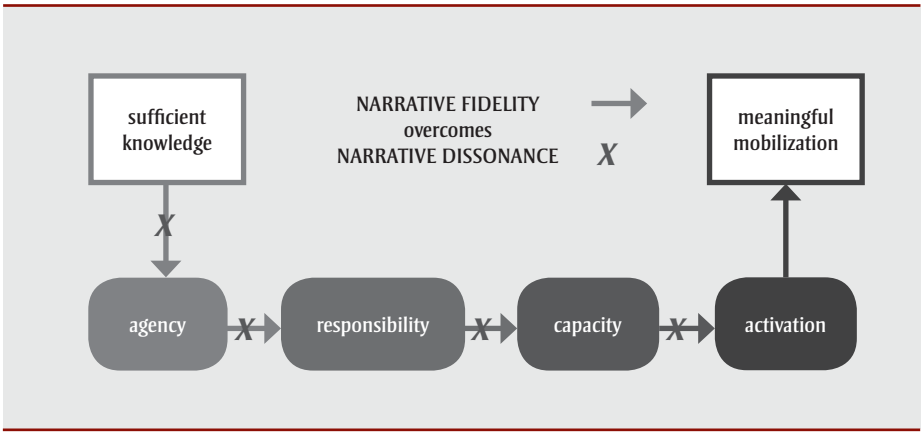
FIGURE 2
A narrative model for engagement



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points within and between participant narratives, the model could contribute to the theory about why knowledgeable, motivated people feel immobilized about climate change.

Thematic interpretation

Narrative patterns and relationships between core themes within participant plots were the subsequent focus of the thematic analysis, with attention to those themes that connected the parts of the whole. Participant narratives were considered together and individually until interpretations about their perceptions emerged clearly. Using the model to explore participant narratives highlighted the concept of *narrative dissonance*, the structural breakdown of a given narrative because of emotional, moral, thematic, or conceptual contradictions within the story itself. According to Ganz, those who lack meaningful public narratives may experience immobilizing emotions such as inertia, apathy, isolation, fear, and self-doubt.[18] The term *narrative fidelity* was useful for conceptualizing an alternative interpretation, whereby dissonance is overcome or reframed. This interpretation could produce a more emotionally meaningful and mobilizing story that could elicit urgency, outrage, solidarity, hope, and a sense of efficacy.[18] Fisher[41] argued that narrative fidelity is experienced when a story "ring[s] true with the stories they know to be true in their lives".[41, p8] In applying the concept of narrative fidelity to climate change narratives, Marshall[42] argued that it is a key element in mobilizing action to address climate change, because only by offering a more compelling story will faulty interpretations of climate change be abandoned. Together, the study's thematic and structural analyses served as a heuristic tool for exploring perspectives in a given context and for understanding how stories facilitate or hinder engagement, and ultimately, action.

Results

Using a narrative model for engagement (Figure 2), *mobilizing moments* were identified at transition points in the interpretive process, representing key themes that bridge or encompass aspects of both dissonance and fidelity. These moments could represent opportunities for transforming knowledge into emotions that mobilize collective action.[18] When public narratives about eco-social problems like climate change lack fidelity, or when they are not apparent at all, the problems themselves may be perceived as meaningless in context, even by those who accept the facts. Manifestations of narrative dissonance and narrative fidelity within participant narratives are described below, organized along the trajectory of a storyline. Thus, a narrative model of engagement (Figure 2) has illuminated a pathway from knowledge to action, outlining stumbling blocks as well as strategies for overcoming them along the way.

Experiences of agency

In locating their personal relationship to climate change, participants demonstrated a sense of *agency*, not just "knowing about" the problem but perceiving it as culturally and personally relevant to their lives:

> … you know, that's not a thing that hits me in the heart, it's more like the impacts of climate change, not the science of climate change. That doesn't have the same kind of impact on me, personally. But as soon as you start talking about the impacts of climate change and how we might have to adapt to climate change, like this is where people can really understand that it's like "Ok, so we might need to change how we transport ourselves, how we feed ourselves"…

Participant experiences of agency helped illustrate why sufficient knowledge of climate change is not directly related to mobilization, as the process of interpreting the risks of climate change was linked by participants to feeling physically drained and emotionally overwhelmed: "I try to do what I can do, and I just sort of emotionally shut down about all that other stuff. But still stay aware, right?"

Table 1 provides further examples of the dissonance that can arise from knowing about climate change, and some participants spoke about minimizing overwhelming emotions by actively reducing the flow of information. They reported limits to the attention that can be directed towards climate change if mental and physical health is to be maintained. Rather than reflecting a lack of access to information, participant narratives suggested information abundance.[43] Participants perceived themselves to be living in a story in which climate change is a reality. However, while participants consistently expressed a sense of being *in* the story about climate change, the *type* of story being told and the type of *role* they play within it were not always clear.

Experiences of responsibility

The next stage of the model explores movement from agency about the challenge of climate change to a sense of *responsibility* about the choices implied. Participant narratives indicated that they understand how human actions and decisions impact climate change. However, if a meaningful role in the story about it was perceived as untenable, or non-existent, the narrative became dissonant. Rather than denying that the problem of climate change is real and important, examples in Table 1 demonstrate how dissonance may result from a lack of perceived power to

TABLE 1
Examples from participant narratives about climate change

Element of engagement	Narrative dissonance	Mobilizing moment	Narrative fidelity
Agency	… it definitely got really draining, and sometimes that led me to feel like "Ugh, I just need to not really think about this right now." I was just trying to not care.	But it's distant in some ways…It's definitely very apparent, but it doesn't, yeah, it's not like something close to home, I guess.	I know that humans are in a lot of trouble if it goes unchecked and if we continue on the path we're on… It's probably the most pressing problem in the world right now. And I don't like it.
	I've noticed that sometimes if I see a headline or a snippet of some depressing news about the climate and I'm having a bad day, I will consciously tell myself 'I can't afford to look at this right now' and I will skip past the news…I think my avoidance is part self-care but also part unhealthy willful ignorance…	Like we'll talk about something and be like, 'Oh yeah, plus, like, climate change on top of that.' …like 'And meanwhile we're all burning.' So that's sort of how I would characterize my climate change lens, I guess; it's constantly in the background of everything else that meanwhile everything is burning.	I feel like I need to challenge those emotions and like try to be more constructive about it instead of being so just about feelings, I don't know. I guess, be more rational – like what do I need to do? How do I get people's attention, how do I engage people back home?
Responsibility	It'd be one thing if people were complaining that they couldn't have an oil job when they had six other jobs…but no one does.	…when I internalize those feelings about climate change, in some ways it motivates me to keep not owning a car, and to keep being mindful of how I travel. I definitely feel guilty…	It's bigger than me, it's about a community…I see us as networks, not really as individuals, so again, it's not about me.
	I think one of the reasons that it can feel so paralyzing is that there's going to need to be so many people working together to work on it and people…we're not really good at coming together unless there's like a crisis where you have to, but by the time we get to that point, maybe, probably, it will be too late.	I know in my head- that people, individuals, can do whatever we want to try to make a difference, but if corporations and governments aren't similarly motivated, it can only go so far, and that feels very frustrating.	For Indigenous People, we always have this way of thinking…we're constantly thinking towards those generations more than our current one. And a lot of the things we make choices and decisions on usually reflect not only our connection to our ancestors, but also to the future.
Capacity	I don't know. I feel like it could go so many different ways, I didn't really – I don't know that I could predict.	But I do think that in my lifetime, and certainly in my children's lifetime, there – it will look radically different.	We're going to have to face things we're not prepared to face, for sure, but I guess when I'm feeling more hopeful, I'm like – but maybe we can do it, together, you know, we can make these changes. But I'm not sure. We'll see.
	It's very hard for me to think about…like "I will have a kid, and he will, he or she will have kids," like to think about generations down the line? I'm just like I just don't – it's going to be so different, who knows? Like maybe, I think maybe it has to be a coping mechanism, like I can't imagine – like you can't imagine apocalypse, really.	[I]t's almost like a looming doom, because even though I can experience certain aspects of climate change myself, it's not something that's affected me in a very intense way or acute way, where the issue is that I know it has for a lot of communities and in the future, will affect way, way more.	What if there is a wakeup call and we actually give power to the people who are the land and water protectors? That could be a really beautiful future. So yeah, there is progress being made in that direction, but it seems so distant from where we are, here.
Activation	Ok yeah, I've saved whatever greenhouse gas emissions myself but, like, it's still this tiny little miniscule drop in the global bucket and when I think about things like Trump, it's just like, ugh nothing I do matters…So there's also this immense feeling of being small, and insignificant, and it's sort of this hopeless cause, but you can't live in that space day to day, or you just totally fall apart right? You can't stay motivated.	…sometimes I feel like I'm not doing things that are very effective just because I'm not in the position to be. Like I'm not just the one, like, signing a paper or making a decision about something, but to an extent, I kind of feel like that's a poor excuse…So I don't know, I could be more effective I'm sure.	I try to do as much as I can in my daily life…but just sort of, you know, choosing a career path where everything I do in my 8-5 life pushes this climate change agenda, and like I'm really interested in - Ok, so let's say the politicians decide to do something, how do you actually get anything done from that?
	Definitely there are little steps, and it's like the small steps that eventually climb mountains, but there's no way that one person can emotionally deal with the backlash that follows with trying to change an unsustainable way of living.	I know that having a more significant impact means I need to be working with other people doing work, and also, that we need to be doing that work together, because, yeah, I don't think there's going to be any movement on climate change without tremendous public pressure, by our elected officials, like that type of movement, so yeah, unless we work together, it's not going to happen.	How do we actually deal with this problem in a way that also doesn't fall into a "lifestyle-ism" but actually tries to change the conditions… essentially, the fundamental point is – how do we engage in these struggles so that we actually can control the production, so that the conditions themselves are controlled?

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intervene meaningfully as through individual roles.

One participant pointed out that responsibility to make personal sacrifices in the face of climate challenges is often moralized, positioned as the "good" or "right" choice:

> …how do we actually deal with this problem in a way that also doesn't fall into a "lifestyle-ism" but actually tries to change the conditions because, we all can't really come from a place of not being totally educated about how to not make greenhouse gases, or being in the conditions we all need to use fossil fuels at different times, and then expect that everyone can just figure it out themselves and we'll be fine?

Personal, political, and economic contexts can limit the availability of pro-environmental choices. If moralizations backfire, individuals may be cut off from personal responsibility altogether, or may revert to a dissonant position and emphasize the limits of personal roles in contributing to climate change. From this perspective, economic conditions and transition timelines may shape how a sense of responsibility is experienced and interpreted.

As Table 1 exemplifies, several participants described choices they already made to address climate change through the reduction of their personal emissions, such as: through transportation, food choices, career paths, and household-level waste management and energy use. However, participants struggled to locate the *meaning* of these actions given the scale and scope of the challenge of climate change. Narrative fidelity about the story's choice-point occurred when an individual identified meaningful choices through a reflection upon their roles, values, self- and cultural identities, and upon the timeline within which their story takes place.

For example, First Nations participants described a sense of responsibility to address climate change intrinsically tied to culturally-based multi-generational thinking, which reflected a connection to ancestors and to a future life, shifting the stakes of the story: "…we're constantly thinking towards those generations more than our current one. And a lot of the things we make choices and decisions on usually reflect not only our connection to our ancestors, but also to the future." They were thinking about their responsibility through a multi-generational lens that is not only political but personal, including choices between life and not-life for participants and their communities. Because of this, participants perceived themselves to be bound to a social change agenda to ensure that their children and their communities can thrive on a livable planet.

Experiences of capacity

In this model, for a participant to experience narrative fidelity, the connection point between a sense of responsibility over the choice-point in the story correlated with a sense of *capacity* to realize a desirable future-state. As Table 1 illuminates, despite adequate knowledge and motivation, participants in this study struggled to make sense of the outcome of the story and their capacity to manifest a positive future. While many participants maintained a mix of pessimism and optimism, participants perceived a decreasing capacity to address climate change with each generation to come, paradoxically inverse to the responsibility to act to address climate change, which can only increase over time:

> I guess, yeah, the best way to put it is, it's like, it's almost like a looming doom, because even though I can experience certain aspects of climate change myself, it's not something that's affected me in a very intense way or acute way, where the issue is that I know it has for a lot of communities and in the future, will affect way, way more. So yeah, my general feeling is just a looming doom.

Thus, dissonance has taken root between responsibility and capacity: because the challenge of climate change is too great in scale and urgency, the role of this generation was perceived to be out of alignment with our capacity to manifest a livable future. The choice-point becomes meaningless, and action seemingly has become unnecessary because visions of a positive future have been blocked.

Accepting the reality of climate change and internalizing its meaning was represented in their stories as an act of courage for young leaders because it involved interpreting the discontinuity guaranteed within one's life course. Table 1 provides further examples of a mobilizing moment related to capacity over outcomes, where participants grappled with divergent visions of the future. Participants discussed coming to terms with the changes ahead, for their families and for families around the world. Feelings of despair and sadness emerged within participant narratives as they described potential outcomes of the story. However, participants also recognized the potential to improve conditions:

> …we need to do a better job of painting the future, of what a low-carbon world would look like. And so, when I think about that, I feel like I could picture that more clearly, I just don't know what will happen. Because it seems like there's, you know, lots of like, really good stuff that could happen.

In such stories, the choice-point has begun to revolve around planning for discontinuity at systems-level and capacity centers upon preparing for large-scale changes that are currently dependent upon collective decision-making. Future outcomes are, thus, dependent on collective resistance to the status quo, bringing into focus the role of power-holders undermining pathways toward crisis-aversion.

Experiences of activation

The final part of the model reflects the moral of the story, conceptualized as a sense of *activation*, defined as an ability to identify and rationalize what "action" looks like in context in a morally and emotionally-logical way. While many participants experienced narrative fidelity regarding the source of their capacity to confront climate change into the future, barriers still hindered their experiences of activation – their sense of being able to turn plans into reality – given the hostile contexts in which they embody their story. Despite ample motivation and willingness to create a more just society, dissonance related to activation was common among participants. They experienced uncertainty about the degree to which their embodied actions (their tactics) were meaningfully contributing to their goals. As one participant articulated, "sometimes, I feel like I'm not doing things that are very effective just because I'm not in the position to be." Across their efforts in government agencies, representing their communities, parenting children, teaching, writing, organizing, and performing, participants made efforts to increase their spheres of influence and yet they still experienced a lack of efficacy about their response to climate change.

Table 1 provides examples of how barriers to activation have hindered a meaningful moral of the story. As Table 1 demonstrates, participants perceived themselves to be but a "tiny little miniscule drop in the global bucket," which hinders the meaning of their personal actions. Instead of finding institutional leaders and organized efforts to join in with, participants who are actively responding to climate change may experience negative consequences from political, economic, and cultural forces or strain in their family and community relationships. As one participant explained,

> …there are little steps, and it's like the small steps that eventually climb mountains, but there's no way that one person can emotionally deal with the backlash that follows with trying to change an unsustainable way of living.

These themes contributed to dissonance about a sense of activation, leaving the story without a clear moral, blocking the path to meaningful mobilization.

Some participants drew connections between hostile conditions for meaningful actions and the colonial and capitalist context in which such actions take place. As one participant argued,

> this narrative of 'low taxes are inherently better, small government is inherently better' is incredibly detrimental to being able to do anything about the environment. To me, that's the biggest barrier.

Another participant explained:

> I just feel like decolonizing will at least help toward making better informed choices, and taking actions, like you know stopping the mining companies, stopping the pipelines. Not being afraid of... the consequences of like chaining ourselves to pipelines and doing road blockades, you know what I mean? We're so fearful and I just feel like it would be a lot different if we were decolonized, I guess.

Participants often defined effectiveness in terms of their ability to contribute to social movements building up capacity to confront structures of power that have perpetuated climate change:

> I feel hopeful when I read about people mobilizing and doing things to change, and working on climate change, because like, when I just read about it by myself, and I do feel very paralyzed, I would say. Because it's such a huge problem with so – there isn't, there will never be, like, one thing you can do to fight it. It's in so many different areas and on so many different levels.

Participants readily admitted that they are stronger in collaboration with others, and they aimed to focus on aspects of the problem over which they could make a difference, with one participant saying,

> there's also this immense feeling of being small, and insignificant, and it's sort of this hopeless cause, but you can't live in that space day-to-day, or you just totally fall apart right? You can't stay motivated.

Despite accepting climate change as a complex eco-social problem, participants who experienced fidelity about the scale and scope of climate change could overcome narrative dissonance and position themselves meaningfully in relationship to climate change.

Discussion

This study has demonstrated how internal and external barriers manifest within the narratives of people who have accepted climate science and who care about making the world a better place. Findings have suggested that simply raising awareness of climate change may not be an adequate strategy for increasing community capacity. Local-level leaders may experience narrative dissonance, and despite their knowledge and motivation, they may confront barriers to meaningful mobilization. Sharing stories could be a means of bringing difficult emotions about climate change to the surface and could elicit feelings of solidarity, which according to Ganz, helps to overcome experiences of isolation.[18]

Narrative dissonance, as it is conceptualized here, relates to similar concepts within climate change engagement literature, such as implicit denial,[25] environmental melancholia,[27] and unspoken loss.[26] As such, the model outlined above could serve as a tool for exploring alignments across engagement research. Participants also confirmed that, through the lens of justice, climate change narratives moralize resistance to the status quo in political, economic, social, and cultural terms. These intersections were inextricable from participant experiences of climate change, and as such, findings have suggested alignments between meaningful mobilization and contextual barriers such as settler futurity,[44] socially organized denial,[25] and predatory delay.[45] Participant narratives helped to contextualize these theories about complex personal and social experiences of climate change.

Modeling a population health response to climate change narratively

In a Canadian context, where inadequate policies to mitigate greenhouse gas emissions[8] have threatened to undermine public health gains made in the last 50 years,[1] population health professionals arguably have a responsibility to address the conditions that contribute to narrative dissonance among knowledgeable, motivated stakeholders like those interviewed for this study. Such individuals may be perceiving public inattention to climate change and could benefit from strategies for coping with dissonance and for working through mobilizing moments. As Table 2 demonstrates, using the model developed during this study, population health responses to climate change can be analyzed for narrative dissonance. By reflecting on the mobilizing moments related to the challenge, choice, outcome, and moral of climate change, a "story" could emerge about the meaning of climate change to the Canadian public and the health system at large. Rather than a formula for mobilization, a narrative model for engagement with climate change can serve as a guide for framing the problem in a mobilizing way, exposing moments in the story where barriers to action could be taking root, even among those who know about climate change and who are motivated to act.

The model could be used as a tool to explore how addressing climate change aligns with existing population health frameworks, such as the Truth and Reconciliation Commission *Calls to Action*.[46] Many participants in this study referenced in their narratives a desire for greater control over lands and decision-making by First Nations, Métis, and Inuit peoples. For example, drawing on environmental justice frameworks like that described by Tuck, McKenzie, and McCoy,[44] participant narratives suggested "a refusal of settler futurity", as sustainable relationships between peoples and lands cannot occur "when those activities are accountable to a futurity in which settlers continue to dominate and occupy stolen Indigenous land".[44,p17] In framing climate change as an environmental justice issue,[7] population health professionals could contextualize

TABLE 2
Reflection questions for population health professionals

Agency	Responsibility	Capacity	Activation
Do population health measures and frameworks reflect the importance of mitigating and adapting to climate change?	Are population health professionals equipped with the competencies and skills needed to play their role in addressing climate change?	Do population health plans and models for the future account for social and ecological discontinuity from the past and the present?	Can population health professionals meaningfully contribute to change through tangible actions in the context of everyday life?
How do population health stakeholders and communities know that climate change matters to population health professionals?	How do population health stakeholders and communities know that addressing climate change meaningfully is part of population health roles and responsibilities?	How do population health stakeholders and communities know population health is strategically mitigating catastrophe and preparing for the future?	How do population health stakeholders and communities know that population health professionals are moving significantly toward shared goals?

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action in terms of reconciliation and the historical context of colonization.[44] Other framework alignments between population health and climate change could include gender and reproductive rights,[47] mental health,[26] or One Health.[48]

Ultimately, this study's findings have suggested that continuing with an information-deficit approach to climate change engagement may not translate into strategic, well-resourced plans for urgent and disruptive systems change. As Steffen[45] implores, "We are about to begin the last decade. The time has come to become the people who can first re-imagine and then remake the world in the time we have left". Despite the importance of this window of time for meaningfully altering the trajectory of planet-wide population health, community leaders may struggle to overcome narrative dissonance about climate change. New models for addressing contextual and cultural barriers to action could be useful even for those who are knowledgeable and who are motivated to act.

Strengths and limitations

This study has demonstrated that narrative methodology can be useful for exploring the barriers to climate change engagement in context. Narrative models for engagement could help in describing, evaluating, and intervening upon the conditions for meaningful mobilization. Tools for engagement and communication about climate change cannot be reduced to a formula for social change, but narrative models could help to illuminate the contextual and cultural dimensions of engagement.

Importantly, this study and its findings must be considered in context. Theoretical findings about engaging with climate change are specific to the study but may be transferrable to other contexts. Notably, the study design included a small sample and recruited only those individuals with adequate time and interest in the study. Conceptual results are exploratory, and the structures and themes outlined here can be built upon by other researchers to deepen understanding about climate change narratives, population health frameworks, and the barriers to engagement.

Conclusion

By employing a narrative framework, this study has provided a visual tool for exploring the interplay of dissonance and fidelity, and the mobilizing moments that could shape interpretations about climate change. Given that most individuals in Canada believe that climate change is happening,[49] it is worth exploring the engagement barriers experienced by knowledgeable, motivated people, and a narrative lens captures the complexities surrounding personal and public realms, the nuance of emotional and moral reasoning, and the contingencies that characterize the context in which mobilization occurs. While the model represented in this article is exploratory, it has affirmed literature about the contextual dimensions of interpretation[13-15,21-34]. Without strategic efforts to foster narrative fidelity, population health professionals may fail to translate knowledge about climate change into meaningful action.

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Conflicts of interest

None to declare.

Statement

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

References

1. Watts N, Amann M, Ayeb-Karlsson S, et al. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. Lancet. 2018;391(10120):581-630.

2. Intergovernmental Panel on Climate Change (IPCC). Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Internet]. Geneva (Switzerland): World Meteorological Organization; 2018 [cited 2018 Dec 16]. Available from: http://www.ipcc.ch/report/sr15/

3. Patrick R, Capetola T, Townsend M, Nuttman S. Health promotion and climate change: exploring the core competencies required for action. Health Promot Int. 2012;27(4):475-85.

4. Howard C, Rose C, Rivers N. The Lancet Countdown report: briefing for Canadian Policymakers [Internet]. Ottawa (ON): Canadian Public Health Association; 2018 [cited 2018 Dec 16]. Available from: https://www.cpha.ca/sites/default/files/uploads/advocacy/2017_lancet_canada_brief.pdf

5. Levy BS, Patz JA. Climate change, human rights, and social justice. Annals of Global Health. 2015;81(3):310-22.

6. Schor J. Climate, inequality, and the need for reframing climate policy. Rev Radic Polit Econ. 2015;47(4):525-36.

7. Masuda JR, Poland B, Baxter J. Reaching for environmental health justice: Canadian experiences for a comprehensive research, policy and advocacy agenda in health promotion. Health Promot Int. 2010;25(4):453-63.

8. Office of the Auditor General of Canada. Perspectives on climate change action in Canada—a collaborative report from Auditors General [Internet]. Ottawa (ON): Office of the Auditor General of Canada; 2018 [cited 2018 Dec 16]. Available from: http://www.oag-bvg.gc.ca/internet/English/parl_otp_201803_e_42883.html

9. Climate Action Tracker. Canada: country summary [Internet]. 2018 [cited 2018 Dec 16]. Available from: https://climateactiontracker.org/countries/canada/

10. Henstra D. Climate adaptation in Canada: governing a complex policy regime. Rev Policy Res. 2017;34(3):378-99.

11. Krieger N. Theories for social epidemiology in the 21st century: an eco-social perspective. Int J Epidemiol. 2001;30:668-77.

12. Hancock T. Population health promotion 2.0: an eco-social approach to public health in the Anthropocene. Can J Public Heal. 2015;106(4):e252-5.

13. Luís S, Lima ML, Roseta-Palma C, et al. Psychosocial drivers for change: understanding and promoting stakeholder engagement in local adaptation to climate change in three European Mediterranean case studies. J Environ Manage. 2018;223(2017):165-74.

14. Wibeck V. Enhancing learning, communication and public engagement about climate change - some lessons from recent literature. Environ Educ Res. 2014;20(3):387-411.

15. Moser SC. Communicating adaptation to climate change: the art and science of public engagement when climate change comes home. Wiley Interdisciplinary Reviews: Climate Change. 2014;5:337-58.

16. Golden SD, McLeroy KR, Green LW, Earp JAL, Lieberman LD. Upending the social ecological model to guide health promotion efforts toward policy and environmental change. Heal Educ Behav. 2015;42(1_suppl):8S–14S. doi: 10.1177/1090198115575098.

17. Bushell S, Colley T, Workman M. A unified narrative for climate change. Nat Clim Chang. 2015;5(11):971-3.

18. Ganz M. Public narrative, collective action, and power. In: Odugbemi S, Lee T, editors. Accountability through public opinion: from inertia to public action [Internet]. The World Bank; 2011 [cited 2018 Dec 16]. p. 273–90. Available from: https://dash.harvard.edu/bitstream/handle/1/29314925/Public_Narrative_Collective_Action_and_Power.pdf?sequence = 1

19. Malena-Chan R. Making climate change meaningful: narrative dissonance and the gap between knowledge and action [Master's thesis]. Saskatoon (SK): University of Saskatchewan; 2019. Available from: http://hdl.handle.net/10388/11948

20. Watts N, Adger WN, Ayeb-Karlsson S, et al. The Lancet Countdown: tracking progress on health and climate change. Lancet. 2017;389(10074):1151-64.

21. Leiserowitz A, Maibach E, Roser-Renouf C, Rosenthal S, Cutler M, Kotcher J. Climate Change in the American Mind. 2017:1-60.

22. Vulturius G, David M, Bharwani S. Building bridges and changing minds: insights from climate communication research and practice. Discussion brief. Stockholm: Stockholm Environment Institute; 2016.

23. Hine DW, Phillips WJ, Cooksey R, et al. Preaching to different choirs: how to motivate dismissive, uncommitted, and alarmed audiences to adapt to climate change? Glob Environ Chang. 2016;36:1-11. doi: 10.1016/j.gloenvcha.2015.11.002.

24. Maibach EW, Nisbet M, Baldwin P, Akerlof K, Diao G. Reframing climate change as a public health issue: an exploratory study of public reactions. BMC Public Health. 2010;10:299.

25. Norgaard KM. Living in denial. Cambridge, Massachusetts and London, England: The MIT Press; 2011.

26. Randall R. Loss and climate change: the cost of parallel narratives. Ecopsychology. 2009;1(3):118-29.

27. Lertzman R. The myth of apathy: Psychoanalytic exploration. In: Weintrobe S, editor. Engaging with climate change: psychoanalytic and interdisciplinary perspectives. New York: Routledge; 2013. p. 117-33.

28. Roser-Renouf C, Maibach EW, Leiserowitz A, Zhao X. The genesis of climate change activism: from key beliefs to political action. Clim Change. 2014;125:163-78.

29. Doherty KL, Webler TN. Social norms and efficacy beliefs drive the Alarmed segment's public-sphere climate actions. Nat Clim Chang. 2016;6(9):879-84.

30. Paschen JA, Ison R. Narrative research in climate change adaptation - exploring a complementary paradigm for research and governance. Res Policy. 2014;43:1083-92.

31. Fløttum K, Gjerstad Ø. Narratives in climate change discourse. Wiley Interdisciplinary Reviews: Climate Change. 2017;8:e429. doi: 10.1002/wcc.429.

32. Gjerstad Ø, Fløttum K. Stories about climate change in political and survey discourse 1. Remain Relev – Mod Lang Stud Today. 2017;7:21-38.

33. Moezzi M, Janda KB, Rotmann S. Using stories, narratives, and storytelling in energy and climate change research. Energy Res Soc Sci. 2017; 31(Aug):1-10.

34. Jones MD, Song G. Making sense of climate change: how story frames shape cognition. Polit Psychol. 2014; 35(4):447-76.

35. Crist JD, Tanner CA. Interpretation/analysis methods in hermeneutic interpretive phenomenology. Nurs Res. 2003;52(3):202-5.

36. Riessman CK. Narrative methods for the human sciences. Thousand Oaks (CA): SAGE Publications; 2008.

37. Connelly FM, Clandinin DJ. Stories of experience and narrative inquiry. Educ Res. 1990;19(5):2-14.

38. Polkinghorne D. Narrative knowing and the human sciences. Albany (NY): State University of New York Press; 1988.

39. Kouri L, Guertin T, Shingoose A. Engaging student mothers creatively: animated stories of navigating university, inner city, and home worlds. Engaged Scholar Journal: Community-Engaged Research, Teaching, and Learning. 2016;2(2):103-14. doi: 10.15402/esj.v2i2.172.

40. Mishler E. Models of narrative analysis: a typology. J Narrat Life Hist. 1995;5(2):87-123.

41. Fisher WR. Narration as a human communication paradigm: the case of public moral argument. Commun Monogr. 1984;51:1-22.

42. Marshall G. Don't even think about it: why our brains are wired to ignore climate change. New York and London: Bloomsbury USA; 2014.

43. Bernauer T, McGrath LF. Simple reframing unlikely to boost public support for climate policy. Nat Clim Chang. 2016;6(7):680-3.

44. Tuck E, McKenzie M, McCoy K. Land education: Indigenous, post-colonial, and decolonizing perspectives on place and environmental education research. Environ Educ Res. 2014; 20(1):1-23. doi: 10.1080/13504622.2013.877708.

45. Steffen A. The last decade and you [Internet]. 2017 [cited 2018 Dec 16]. Available from: https://thenearlynow.com/the-last-decade-and-you-489a5375fbe8

46. Truth and Reconciliation Commission of Canada. Truth and Reconciliation Commission of Canada: Calls to Action [Internet]. 2015 [cited 2018 Dec 16]. Available from: https://nctr.ca/assets/reports/Calls_to_Action_English2.pdf

47. Gaard G. Ecofeminism and climate change. Womens Stud Int Forum. 2015;49:20-33.

48. Zinsstag J, Crump L, Schelling E, et al. Climate change and One Health. FEMS Microbiol Lett. 2018;365(11): 1-9.

49. Mildenberger M, Howe P, Lachapelle E, Stokes L, Marlon J, Gravelle T. The distribution of climate change public opinion in Canada. PLOS One. 2016; 11(8):e0159774. doi: 10.1371/journal.pone.0159774.

Other PHAC publications

Researchers from the Public Health Agency of Canada also contribute to work published in other journals. Look for the following articles published in 2018 and 2019:

Ahmed R, **Diener A**, Bahri S. Retailer compliance as a predictor of youth smoking participant and consumption. J Sch Health. 2019;89(2):115-23. doi: 10.1111/josh.12719.

Badawi A, Giuseppe GD, **Arora P**. Cardiovascular disease risk in patients with hepatitis C infection: results from two general population health surveys in Canada and the United States (2007-2017). PLOS ONE. 2018;13(12). doi: 10.1371/journal.pone.0208839.

Chaput JP, **Yau J, Rao DP**, Morin CM. Prevalence of insomnia for Canadians aged 6 to 79. Health Rep. 2018;29(12):16-20.

Colley RC, **Butler G**, Garriguet D, **Prince SA, Roberts KC**. Comparison of self-reported and accelerometer-measured physical activity in Canadian adults. Health Rep. 2018;29(12):3-15.

Klarenbach S, **Sims-Jones N**, Lewin G, […] **Doull M, Courage S, Garcia AJ**, et al. Recommendations on screening for breast cancer in women aged 40-74 years who are not at increased risk for breast cancer. CMAJ. 2018;190(49):E1441-E1451. doi: 10.1503/cmaj.180463.

Prince SA. The Christmas e-list (an ode to big data). Med J Aust. 2018;209(11):510. Doi: 10.5694/mja18.00838.