McMaster University | HEALTH FORUM

Rapid Evidence Profile #30

(8 June 2022)

Question

What are the biggest gaps in evidence – both overall and for equity-deserving groups – about:
1) the impacts of climate change on population health in Canada; and
2) adaptation and mitigation strategies that are applicable to Canada (evidence syntheses)?

What we found

To identify gaps in evidence about the impacts of climate change on population health in Canada and on adaptation and mitigation strategies applicable to Canada, we used data from a living evidence synthesis that identified 17,105 documents as of the end of 2021. See Box 1 for additional details about our approach. We organized documents that mentioned Canada or one or more Canadian provinces using the components of the framework from the living evidence synthesis related to health risks and impact (for part 1 of the question above) and options and responses to address climate change (for part 2 of the question above). The framework is provided below. If there is an opportunity to extend this work in future, we would move beyond relying on the machine-learning based assignment of documents to public-health related topics and manually assign documents to a mutually exclusive and collectively exhaustive list of public health functions. In addition, we would also use the opportunity to categorize the single studies by the type of evidence they provide (data analytics, modeling, evaluation, behavioural/ implementation, and qualitative insights).

Box 1: Our approach

We identified evidence related to the question from the 17,105 documents included in a living evidence synthesis that used machine learning to map the global research on climate change and health. The dataset was last updated in December 2021. We added to the dataset – drawing from Social Systems Evidence and excluding duplicates– systematic reviews, rapid reviews or protocols for systematic reviews that mention Canada or a province in the title or abstract and/or include at least one study conducted in Canada. Each of the 402 documents that mentioned Canada and/or one or more provinces and territories was assessed by one reviewer to ensure relevance to Canada, climate change, and public health. The 6,433 documents that included one or more authors with a Canadian affiliation were used to derive a list of Canadian institutions and authors who had published one or more documents related to climate change and health and the number of publications from each.

We appraised the methodological quality of full systematic reviews and rapid reviews using AMSTAR. Note that quality appraisal scores for rapid reviews are often lower because of the methodological shortcuts that need to be taken to accommodate compressed timeframes. AMSTAR rates overall quality on a scale of 0 to 11, where 11/11 represents a review of the highest quality. It is important to note that the AMSTAR tool was developed to assess reviews focused on clinical interventions, so not all criteria apply to systematic reviews pertaining to delivery, financial or governance arrangements within health systems or to broader domains like climate change.

This rapid evidence profile was prepared in the equivalent of three days of a 'full-court press' by all involved staff.

Organizing framework

- Health risks and impacts
  - All-cause mortality
  - Chronic
    - Heat stress
    - Thermal stress and comfort
    - Stroke

    - Food and nutrition
        - Farmers and agriculture
        - Food insecurity
    - Patients and health systems
        - Public health
        - Hospital admissions (note that this sub-element and the next two are not relevant to public health per se)
        - Patients
        - Visits to healthcare facilities
    - Infectious diseases
        - Infectious diseases general
        - Viral diseases
        - Mosquito vector dynamics
        - Malaria
        - Dengue
        - Influenza
        - Hand, foot, and mouth disease (HFMD)
        - Leptospirosis
        - Cholera
    - Maternal and child health
        - Child health
        - Birth and pregnancy
    - Mental health
        - Mental health and post-traumatic stress disorder (PTSD)
        - Suicide
    - Occupational health and injury
    - Respiratory
        - Air pollution
        - Respiratory viruses
        - Pollen and allergies
        - Asthma
        - Fungal spores
    - Water, sanitation and hygiene (WASH)
        - Drinking water quality
- Options and responses
    - Developing community resilience
    - Disaster risk reduction
    - Mitigation
        - Energy policy and co-benefits
        - Greenhouse pathways
    - Policies and practices that support adaptation

The living evidence synthesis included 395 documents that mentioned Canada and/or one or more provinces and territories and we identified another seven potentially relevant evidence syntheses from Social Systems Evidence. From these, we included 267 documents that included 258 single studies addressing health risks and impacts (question 1) and 13 evidence syntheses (one overview of systematic reviews, 10 systematic reviews and two scoping reviews) addressing options and responses to climate change (question 2). We provide a profile of the health risks and impacts addressed by Canadian studies in Table 1, which we use to describe the main gaps in evidence both overall and for equity-

deserving groups below. In addition, Table 2 and the summary below provides key findings and gaps in available evidence syntheses about adaptation and mitigation strategies that are applicable to Canada and within the sphere of control and/or influence of public health leaders. We then provide a profile of Canadian producers of evidence about climate change and health by institution (Table 3) and authors (Table 4). Note that the profile of producers includes Canadian institutions and authors with a Canadian affiliation in any of the 17,105 documents included in the data from the living evidence synthesis. A detailed summary of our methods is provided in Appendix 1, key findings from all of the included evidence syntheses (including those deemed of medium and low relevance) in Appendix 2 and the documents identified as addressing equity-deserving populations are provided in Appendix 3a (for health risks and impacts) and 3b (for evidence syntheses focused on adaptation and mitigation strategies). We also provide a list of reviews excluded at the final stages of reviewing in Appendix 4.

Areas of focus and gaps in Canadian studies about health risks and impacts from climate change

We identified 258 single studies relevant to Canada (defined as mentioning either Canada and/or one or more provinces or territories in Canada). As can be seen in Table 1, in relation to the health risks and impacts in the organizing framework, the Canadian literature is focused on all-cause mortality, chronic conditions (with almost all focused on heat stress), patient and health systems (with most focused on public health) and respiratory issues (with most focused on the role of air pollution). Few studies focus on infectious diseases, maternal and child health, mental health, occupational health and injury and water sanitation and hygiene.

From the 258 included studies, we identified 42 that focus on the health risks and impacts from climate change on equity-deserving populations. We adopt the acronym PROGRESS-Plus to describe characteristics across which health equity may exist. Findings from the documents included in the rapid evidence response focused on the following equity-deserving populations: those living in the arctic (or sub-arctic) (n=10), those living in rural and remote regions (n=7), those living in urban communities (n=7), Indigenous populations (n=14), immigrant populations (n=1), gender/sex differences (n=5), education levels (n=2), low-socioeconomic and materially deprived neighborhoods (n=11), infants and children (n=2), older adults (n=10), unhoused or homeless populations (n=1), and people who use substances (n=1) . It should be noted that these groupings are not mutually exclusive as documents could have relevance to several equity-deserving groups. The greatest concentration of equity-focused literature on health risks and impacts related to public health (n=22), followed by hospital admissions (n=7) and food insecurity (n=5).

Key findings and gaps in available evidence syntheses about adaptation and mitigation strategies that are applicable to Canada and within the sphere of control and/or influence of public health leaders

Key findings

We identified 13 evidence syntheses (one overview of systematic reviews, 10 systematic reviews and two scoping reviews) addressing options and responses to climate change, which are summarized in Table 2 according to key findings, gaps in evidence identified and insights about equity-deserving groups. Syntheses are grouped into the four areas related to options and responses from the organizing framework: developing community resilience (n=2), mitigation (n=3), and policies and practices that support adaptation (n=9). We did not identify evidence syntheses addressing options for disaster-risk reduction.

Key findings from a low and medium-quality evince syntheses addressing developing community resilience mentioned that changing climate conditions is negatively affecting the health and wellbeing of individuals in rural and remote regions. As a result, it highlights that strategies that promote community resilience are needed. Examples of strategies highlighted include using multiple knowledge systems specific to sociocultural contexts, supporting sustainable-development practices, enhancing risk communication and knowledge of climate change, and increasing community-based monitoring to address the disproportionate food security and climate-change impacts experienced by Indigenous communities. One review mentioned that measuring resilience is challenging because concepts like food-system resilience has not been well well-defined for climate change and the relationships between resilience of food systems and climate change are not exhaustive.

Regarding mitigation responses, two systematic reviews (one medium- and one low-quality) showed a potential risk of a trade-off between accountability and efficiency principally when decision-makers are using policies that target the private sector and need to carefully balance practical and feasible policies. One low-quality systematic review also mentioned the necessity of mitigation responses to face the public-health effects of long-term evacuees (LTEs) in Canada. Another low-quality systematic review focused on understanding the direct effects of policy instruments that target environmental problems and how these policies interact. It reported that: 1) policy instruments designed to control expenditure perform better than regulatory instruments; 2) policy instruments with voluntary reporting procedures are much less likely to be positively evaluated than those with mandatory reporting procedures; and 3) as the defined time frame of policies increases, the likelihood these policies will be positively evaluated for efficiency and process also increases.

We identified a greater number of systematic reviews addressing policies and practices that support adaptation (seven low-quality and two medium-quality). One medium-quality systematic review reported the most frequent adaptation activities identified in the studies included community-based programs, ecological restoration, knowledge sharing and learning platforms, changing crop types, planting and harvesting practices. Those activities demonstrated improvement in at least one category of effectiveness (that is, they reduced risk and vulnerability, developed resilient social systems, improved the environment, increased economic resources, or enhanced governance and institutions). Other systematic reviews focused on other adaptation activities such as enhancing risk communication and knowledge of climate change; regular population-health risk assessments and risk-management activities by local public-health units; development of community adaptation plans; and awareness, research and networking activities implemented by civil society organizations (CSOs) that aim to build adaptive capacity principally on water contamination and air quality.

One low-quality systematic review focused on the impacts of climate change on occupational health and safety suggested some adaptation strategies such as developing training tools to prepare workers for the health effects of climate change, developing protective clothing and other equipment for extreme climates, and developing methods to heighten workplace awareness of potential risks.

A low-quality systematic review focused on adaptations being employed by Inuit population in the artic to manage the risks of current climate change found that financial resources are an important component of the means to adapt and are identified as one of the main barriers preventing adaptation from taking place. Many adaptations are costly and exceed the financial ability of households, communities, businesses, regional governments, and regional institutions. Other adaptation barriers are social–cultural in nature including the erosion of traditional land skills among younger generations, weakening of sharing networks, and the cultural value of hunting and consuming certain traditional foods at certain times of the year.

Gaps in evidence identified by included evidence syntheses

Ten systematic reviews (six low-quality and four medium-quality) identified several research gaps, which can be grouped into three areas related to options and responses to address climate change. First, there is limited focus of studies on reporting evaluation findings. This includes a lack of specificity of context, which makes it difficult 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. Second, the need for research focused on the rationale, design, implementation and performance measurement of private policy initiatives was identified as another key gap in the literature. Lastly, the necessity of considering vulnerable populations was noted as a gap and priority for future research. Specifically, there is a noted need for studies providing gender-disaggregated data that facilitate the understanding of how women, men, and gender-diverse people may have different experiences with community resilience options, mitigation, and adaptation responses. As well as studies that contribute to a better understanding of the full spectrum of community-based monitoring practice occurring within Indigenous communities, the representation of diverse types of knowledge and expertise on designing adaptation strategies, and the health impacts of long-term evacuees in Canada.

Insights about equity-deserving groups

We identified insights about equity-deserving groups from four of the 13 included evidence syntheses, which focus on those living in the arctic (or sub-arctic) (n=2), those living in rural and remote regions (n=1), Indigenous populations (n=3), gender/sex differences (n=2), low-socioeconomic and materially deprived neighborhoods (n=1), older adults (n=1).

One medium-quality systematic review reported that only one third of the reviewed articles provided gender-disaggregated data. The authors highlighted the necessity of studies establishing the relationship between climate, food, and gender, for planning and designing a community-based monitoring systems that reflect gender equity.

A medium-quality systematic review found that vulnerable communities such as low-income communities, the elderly, racial and ethnic minorities, and people with disabilities, face challenges in seeking and processing risk-communication information, including complex language, information overload and contradictory information.

Lastly, two low-quality systematic reviews reported several challenges faced by Inuit populations in the artic. For instance, key challenges identified included: the substitution of traditional foods for store foods when hunting areas are not accessible; altered timing, mode, and methods of subsistence activities; the erosion of traditional land skills among younger generations; weakening of sharing networks; the cultural value of hunting and consuming certain traditional foods at certain times of the year, and that households often do not have access to the capital resources to purchase new hunting equipment to take advantage of new conditions or replace equipment lost or damaged in climate-related hunting accidents.

Producers of Canadian evidence about climate change and health

Table 3 provides a list of 30 Canadian institutions that have been listed at least five times in any of the 17,105 publications identified in the living evidence synthesis (a full list of institutions was too long to include here, but is available upon request). The list includes groups located in 18 universities with rest being federal or provincial government agencies (n=7), other arms-length government-funded agencies (n=3) and groups within hospital research centres (n=2). This is accompanied by a list of 195 authors who appear in at least five publications and who listed at least one Canadian affiliation (a full list of authors was too long to include here, but is available upon request).

Table 1: Canadian studies addressing health risks and impacts from climate change, and options and responses to climate change by type of evidence document

Focus		All Canadian single studies (n=268)	Single studies with a pan-Canadian focus* (n=68)	Single studies with a provincial focus* (n=200)	Single studies with an equity focus (based on PROGRESS Plus)
All-cause mortality		43	13	30	3
Chronic	Heat stress	30	4	26	1
	Thermal stress and comfort	6	-	6	-
	Stroke	9	1	8	-
Food and nutrition	Farmers and agriculture	4	2	2	-
	Food insecurity	5	1	4	5
Patients and health systems	Public health	83	29	54	22
	Hospital admissions (note that this sub-element and the next two are not relevant to public health per se)	24	4	20	7
	Patients	5	1	4	-
	Visits to health care facilities	29	3	26	1
Infectious	Infectious diseases general	23	4	19	1
	Viral diseases	3	2	1	-
	Mosquito vector dynamics	-	-	-	-
	Malaria	-	-	-	-
	Dengue	-	-	-	-
	Influenza	2	1	1	-
	Hand foot and mouth disease (HFMD)	-	-	-	-
	Leptospirosis	-	-	-	-
	Cholera	-	-	-	-
	Child health	13	6	8	1

Maternal and child health	Birth and pregnancy	8	2	8	-
Mental health	Mental health and post-traumatic stress disorder (PTSD)	17	7	1	7
	Suicide	2	1	1	1
Occupational health and injury		11	3	8	1
Respiratory	Air pollution	55	15	40	5
	Respiratory viruses	3	-	2	-
	Pollen and allergies	1	-	1	-
	Asthma	12	1	11	-
	Fungal spores	-	-	-	-
Water, sanitation and hygiene (WASH)	Drinking water quality	8	1	7	2

*Includes documents that mention Canada at the national level as at least part of the focus of the document

**Includes documents that mention one or more Canadian provinces and territories as at least part of the focus of the document

Table 2: Summary of key findings and gaps identified from included evidence syntheses about adaptation and mitigation strategies that are applicable to Canada and within the sphere of control and/or influence of public health leaders

Area of focus		Key findings from included evidence syntheses	Gaps identified from included evidence syntheses	Insights about equity-deserving groups
Options and responses to address climate change	Developing community resilience (n=2)	• One low-quality scoping review mentioned that changing climate conditions is negatively affecting the health and wellbeing of individuals in rural and remote regions, including: increased prevalence and severity of extreme weather events, changes to sea ice, vegetation, fish, wildlife, weather and environmental uncertainties • Adaptation strategies were identified as being needed to address these challenges, including: ○ Using multiple knowledge systems, specific to sociocultural context ○ Addressing socio-cultural barriers ○ Using innovative technology ○ Improving and integrating public health and environmental surveillance ○ Supporting sustainable-development practices ○ Enhancing risk communication and knowledge of climate change ○ Developing capacity of health systems to respond to the health impacts of climate change • One medium-quality systematic review reported an increasing interest in community-based monitoring (CBM), which is a strategy to address the disproportionate food security and climate change impacts often experienced by Indigenous communities globally ○ Considering the history of unethical research conducted on and not with Indigenous communities, there is increasing demand for the recognition of Indigenous peoples' contributions and knowledge ○ Community engagement is important for generating local ownership and understandings of environmental change, and to facilitate the development of local adaptation responses	• One medium-quality systematic review identified the following gaps: ○ Lack of studies providing gender-disaggregated data, resulting in an incomplete understanding of how Indigenous women, men, and gender-diverse people may differentially participate in, and experience community-based monitoring ○ The limited focus of studies on reporting evaluation findings ○ The need of analyzing the grey literature to better understand the full spectrum of community-based monitoring practice occurring within Indigenous communities, especially of autonomous monitoring systems which may be investigated or evaluated outside of research and the published literature	• One medium-quality systematic review reported that only one third of the reviewed articles provided gender-disaggregated data; authors highlighted the necessity of studies establishing the relationship between climate, food, and gender, for planning and designing a community-based monitoring systems that reflect gender equity

		○ Measuring resilience is challenging because the concept of food system resilience has not been well defined for climate change and the links between resilience of food systems and climate change are not straight forward		
	Disaster risk reduction (n=0)	• No evidence syntheses identified		
	Mitigation (n=3)	• One low-quality systematic review reported the difficulty to determine if and to what extent the public-health effects of prolonged evacuation and the public health needs of long-term evacuees (LTEs) in Canada are being assessed, monitored, and addressed • One medium-quality systematic review that focused on the use of alternative fuels in cement manufacturing found that energy recovery in cement manufacturing is one of the best end-of-life options, even though the performance in resource consumption and conservation, and metal and hazardous air pollutant emissions can be worse than for other end-of-life options, such as recycling • One low-quality systematic review focused on understanding the direct effects of policy instruments that target environmental problems and how these policies interact, reported the following key findings: ○ A potential risk of a trade-off between accountability and efficiency depending on a policy instrument's source of authority; this indicates that decision-makers using policies that target the private sector must carefully balance a need for practical and feasible policies against the threat of becoming captured by these interests ○ Expenditure instruments perform better than regulatory instruments in overall and impact evaluations ○ Policies with built-in flexibility are more likely to have positive overall, process and efficiency evaluation results	• Trends in the incidence of disasters and emergencies underscore the urgency of conducting more research to improve our understanding of prolonged displacement within Canada and in other high-income countries • Academic papers focused on the use of alternative fuels in cement manufacturing did not discuss health or social impacts, and economic impacts were investigated for few end-of-life options • More research is needed to examine the leaders in the water management field to understand what works and does not work for adapting to climate change in different coastal and freshwater systems • It is also important to study the emerging nexus between water and energy, for instance, countries that experienced water's significance first-hand during droughts, can bring acute electricity blackouts and energy rationing to the populous, this risk also exists in other power generation sources, such as nuclear energy • The need for primary research with business on the rationale, design, implementation and performance measurement of private policy initiatives; similarly, primary research	• None identified

		○ Policy instruments with voluntary reporting procedures are much less likely to be positively evaluated than those with mandatory reporting procedures ○ There is a possible trade-off between environmental effectiveness and cost-effectiveness depending on the stage of activity that a policy target ○ As the defined time frame of policies increases, the likelihood these policies will be positively evaluated for efficiency and process also increases	examining a wider swath of policies would help verify that expenditure policies fare better than regulation in overall evaluations	
	Policies and practices that support adaptation (n=9)	• One medium-quality systematic review reported which adaptation activities are most frequently represented, which include: community-based programs, ecological restoration, knowledge sharing and learning platforms, and changing crop types and planting and harvesting practices ○ While these activities demonstrated improvement in at least one category of effectiveness (that is, they reduced risk and vulnerability, developed resilient social systems, improved the environment, increased economic resources, or enhanced governance and institutions), several activities indicated effectiveness across multiple categories • One low-quality systematic review suggests the following adaptation strategies: identify and evaluate adaptation methods, develop training tools to prepare workers for the health effects of climate change, develop protective clothing and other equipment for extreme climates, explore adaptation methods using organization of work and work schedule management, and develop methods to heighten workplace awareness of potential risks • A low-quality systematic review identified the following adaptation strategies needed to address climate change challenges, including: ○ Using multiple knowledge systems, specific to sociocultural context ○ Addressing socio-cultural barriers ○ Using innovative technology	• It is necessary more research addressing issues of justice, including representation of diverse types of knowledge and expertise, fair distribution of adaptation benefits, and imbalanced power relationships within the adaptation process • Research and evaluation offer techniques to reveal issues in leadership, decision-making, access, and profit and to monitor progress towards developing more equitable adaptation practices • Assessments of heat-health vulnerabilities require projections of the future frequency and severity of extreme heat events, information related to the geographical variation in exposure to extreme heat, identification of vulnerable populations and identification of actual temperature and morbidity/mortality thresholds • Public health interventions that may be implemented to reduce climate change impacts on health within relevant time scales (5–10 years) need to be identified through assessments	• Vulnerable communities such as low-income communities, the elderly, racial and ethnic minorities, and people with disabilities, face challenges in seeking and processing risk communication information, including complex language, information overload and contradictory information • A low-quality systematic review reported several adaptations documented as being employed by Inuit population in the artic to manage the risks of current climate change, among those: ○ The substitution of traditional foods for store foods when hunting areas are not accessible, ○ Altered timing, mode, and methods of subsistence activities, ○ The establishment of community evacuation

		○ Improving and integrate public health and environmental surveillance ○ Supporting sustainable development practices ○ Enhancing risk communication and knowledge of climate change ○ Developing capacity of health systems to respond to the health impacts of climate change • One low-quality systematic review found that regular population-health risk assessments and risk-management activities by local public-health units can help to address risks related to climate hazards • One low-quality systematic review found that adaptations being implemented by civil society organizations (CSOs) in Canada consist predominantly of groundwork interventions including awareness, research and networking activities that aim to build adaptive capacity ○ Adaptations most frequently address water contamination and air quality, and occur most often as awareness raising and research activities ○ Adaptations infrequently recognize vulnerable groups or climate change as a motivator ○ While water contamination and air quality are commonly addressed, extreme heat, which is widely acknowledged as a key vulnerability facing Canadians in a changing climate, is reported in fewer than 2% of initiatives ○ Similarly, flooding is another key vulnerability yet is addressed in fewer than 7% of actions • One medium-quality systematic review focused on practices for risk communication, found that the 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 ○ Within Ontario, communication activities such as promotional messaging, response guidelines, and heat alerts and warning systems were typical risk communication tools used in practice	• It is necessary more research in adaptations to flooding and extreme heat • It is necessary more research that consider adaptations for vulnerable groups • The 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 • Lack of evaluation of current risk communications strategies, specially, poor integration of community-led initiatives in future planning, often because such initiatives were not properly evaluated • Future research might 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 climate change risks • Studies lack detailed policy analysis and often presenting adaption responses as part of 'wish lists' • No published studies have undertaken cost benefit • Few publications report on adaptations in health, cultural and education, or economy and business sectors • There needs to be more research to understand the policy implications of either allowing municipalities, the provinces and territories, or the federal government to take the lead	and preparedness plans in case of extreme events, ○ The development of new ice-based transportation routes to avoid dangerous areas, ○ The strengthening of municipal infrastructure to cope with altered climatic extremes, ○ The development of youth–elder mentoring programs to transmit traditional knowledge on environmental risks • Some adaptation barriers are social–cultural in nature including the erosion of traditional land skills among younger generations, weakening of sharing networks, and the cultural value of hunting and consuming certain traditional foods at certain times of the year

		○ Self-efficacy and feelings of adequate preparedness were positively correlated with risk reduction behaviours in communities at high risk for wildfires ○ People were more aware of extreme weather risks and more likely to initiate protective activities if they were involved in a participatory exercise • One low-quality systematic review found that less than half of the articles included covered climate change solutions in a health context ○ Examples of mitigation strategies included decreasing greenhouse gas emissions by installing solar panels, improving household insulation, and increasing active transport use ○ Suggested adaptation strategies included creating community adaptation plans, cutting back on strenuous outdoor activity on hot or smoggy days, and building coastal protection • A low-quality systematic review focused on adaptations being employed by Inuit population in the artic to manage the risks of current climate change found that financial resources are an important component of the means to adapt, and are identified as one of the main barriers preventing adaptation from taking place ○ Many adaptations are costly and exceed the financial ability of households, communities, businesses, regional governments, and regional institutions ○ Households often do not have access to the capital resources to purchase new hunting equipment to take advantage of new conditions or replace equipment lost or damaged in climate-related hunting accidents ○ Municipalities often struggle to afford existing maintenance projects and are not able to invest in climate proofing infrastructure • Other adaptation barriers are social–cultural in nature including the erosion of traditional land skills among younger generations, weakening of sharing networks, and the cultural value of hunting and	on direct potable re-use policies and implementation	

		consuming certain traditional foods at certain times of the year • One low-quality systematic review focused on municipalities considering a shift to direct potable re-use (DPR), suggested that while conducting the public engagement, planners, engineering and policy makers should ensure information does not overburden citizens with technical information, but at the same time, should not withhold information because experts feel the public may lack the knowledge or understanding to provide accurate feedback • This review also suggested that post secondary education should do more to focus on curricula that includes alternative energy models and policy solutions		

Table 3: Canadian institutions with publications relevant to climate change and health

Institutions	Number of affiliation mentions in articles*	Percent
McGill University	194	3.02
University of Toronto	148	2.30
University of British Columbia	128	1.99
University of Guelph	119	1.85
University of Alberta	98	1.52
Health Canada	97	1.51
Dalhousie University	86	1.34
McMaster University	80	1.24
Institut National de Santé Publique du Québec	64	0.99
British Columbia Centre for Disease Control	62	0.96
University of Laval	59	0.87
Hamilton Health Sciences, Population Health Research Institute	57	0.89
Public Health Agency Canada	56	0.87
Public Health Ontario	49	0.76
University of Ottawa	43	0.67
Western University	37	0.58
Institute of Clinical and Evaluative Sciences	49	0.76
University of Montreal	30	0.47
Simon Fraser University	29	0.45
Institute National Reserche Scientifique, Eau Terre Environnement Research Centre	23	0.36
Carleton University	22	0.34
Montreal Heart Institute	18	0.28
Concordia University	15	0.23
University of Waterloo	15	0.23
University Regina	14	0.22
Environment and Climate Change Canada	13	0.20
Environment Canada, Atmospheric Science and Application Unit	12	0.19
Ontario Agency of Health Protection and Promotion	11	0.17
Ryerson University	11	0.17
University of Calgary	10	0.16

*Note that this column provides the total number of mentions of an institution in the articles identified, and includes articles that have two or more mentions of the same affiliation

Table 4: Canadian authors of publications relevant to climate change and health

Author	Affiliation	Number of publications	Percent of contribution to all Canadian publications
Gosselin, Pierre	Ouranos & Univ Laval, Inst Natl Sante Publ Quebec, Quebec City, PQ G1V 5B3, Canada.	97	1.51
Henderson, Sarah B.	Univ British Columbia, Sch Populat & Publ Hlth, Vancouver, BC V5Z 1M9, Canada.	65	1.01
Smargiassi, Audrey	Univ Montreal, Sch Publ Hlth, Dept Environm & Occupat Hlth, Montreal, PQ, Canada.	59	0.92
Lavigne, Eric	Univ Ottawa, Interdisciplinary Sch Hlth Sci, Ottawa, ON, Canada.	54	0.84
Harper, Sherilee L.	Univ Guelph, Dept Populat Med, Guelph, ON N1G 2W1, Canada.	50	0.80
Auger, Nathalie	Univ Montreal, Dept Social & Prevent Med, Montreal, PQ H3C 3J7, Canada.	45	0.70
Ford, James D.	McGill Univ, Dept Geog, Montreal, PQ, Canada.	44	0.70
Brauer, Michael	Univ British Columbia, Sch Environm Hlth, Vancouver, BC V5Z 1M9, Canada.	42	0.65
Goldberg, Mark S.	McGill Univ, Div Clin Epidemiol, Ctr Hlth, Montreal, PQ H3A 1A1, Canada.	32	0.50
Belanger, Diane	CHUQ, Ctr Rech, Quebec City, PQ G1V 2M2, Canada.	30	0.47
Chen, Hong	Inst Clin Evaluat Sci, Toronto, ON, Canada.	30	0.47
Kosatsky, Tom	Direct Sante Publ Montreal, Inst Natl Sante Publ Quebec, Montreal, PQ H2L 1M3, Canada.	29	0.45
Berrang-Ford, Lea	McGill Univ, Dept Geog, Montreal, PQ, Canada.	28	0.50
Gilliland, Jason A.	Western Univ, Sch Hlth Studies, London, ON, Canada.	26	0.40
Fisman, David N.	Univ Toronto, Dalla Lana Sch Publ Hlth, Div Epidemiol, Toronto, ON M5T 3M7, Canada.	25	0.39
Baumgartner, Jill	McGill Univ, Inst Hlth & Social Policy, Montreal, PQ H3A 0G4, Canada.	24	0.37
Martin, Randall V.	Dalhousie Univ, Dept Phys & Atmospher Sci, Halifax, NS B3H 4R2, Canada.	24	0.30
Kwong, Jeffrey C.	Inst Clin Evaluat Sci, Toronto, ON, Canada.	21	0.33
To, Teresa	Univ Toronto, Dalla Lana Sch Publ Hlth, Toronto, ON, Canada.	21	0.33
Berry, Peter	Hlth Canada, Climate Change & Hlth Off, Ottawa, ON K1A 0K9, Canada.	20	0.31
Bilodeau-Bertrand, Marianne	Inst Natl Sante Publ Quebec, Montreal, PQ, Canada.	19	0.30
van Donkelaar, Aaron	Dalhousie Univ, Dept Phys & Atmospher Sci, Halifax, NS B3H 4R2, Canada.	19	0.30

Author	Affiliation	Number of publications	Percent of contribution to all Canadian publications
Villeneuve, Paul J.	Carleton Univ, Dept Hlth Sci, Ottawa, ON K1S 5B6, Canada.	19	0.30
Cakmak, Sabit	Hlth Canada, Populat Studies Div, Ottawa, ON K1A 0L2, Canada.	18	0.28
Copes, Ray	Univ Toronto, Toronto, ON, Canada.	17	0.26
Rowe, Brian H.	Univ Alberta, Emergency Operat Clin Network, Univ Alberta Hosp, Dept Emergency Med,Alberta Hlth Serv, Edmonton, AB T6G 2B7, Canada.	17	0.26
Cunsolo, Ashlee	Mem Univ, Labrador Inst, Happy Valley Goose Bay, NF A0P 1E0, Canada.	16	0.25
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Vélez CM, Waddell K, Berrang-Ford L, Callaghan M, Minx J, Harper S, Lavis JN, Wilson MG. Rapid evidence profile #30: What are the biggest gaps in evidence about the impacts of climate change on population health in Canada, and adaptation and mitigation strategies that are applicable to Canada? Hamilton: McMaster Health Forum, 8 June 2022.

To help health- and social-system leaders as they respond to pressing challenges related, the McMaster Health Forum prepares rapid evidence profiles like this one. This rapid evidence profile was commissioned by the Office of the Chief Science Officer, Public Health Agency of Canada. The opinions, results, and conclusions are those of the McMaster Health Forum and are independent of the funder. No endorsement by the Public Health Agency of Canada is intended or should be inferred.

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Appendices for COVID-19 Rapid Evidence Profile #30

(8 June 2022)

Appendix 1: Methodological details

Identifying research evidence

To identify gaps in evidence about the impacts of climate change on population health in Canada and on adaptation and mitigation strategies applicable to Canada, we used data from a living evidence synthesis that identified 17,105 documents as of the end of 2021. Of these documents, 402 mentioned Canada and/or one or more province in the title or abstract and/or include at least one study conducted in Canada. Each of the 402 documents were assessed by a single reviewer to ensure relevance to Canada, climate change, and public health.

We supplemented this dataset by drawing on Social Systems Evidence and excluding duplicates that had already been included from the living evidence synthesis. In Social Systems Evidence, we used filters under programs and services for "climate action," "environmental conservation," "food safety and security," and "natural resources." We combined these with key words searches for "climate change" AND (health OR public health) and required that the documents mentioned Canada and/or one or more studies was conducted in Canada. A single reviewer assessed these documents for inclusion to ensure they related to climate change and public health.

Searching and triaging process to identify and include equity-relevant evidence

We draw on WHO's definition of equity and health equity, defining equity as the absence of avoidable, unfair, or remediable differences among groups of people, whether those groups are defined socially, economically, demographically or geographically or by other means of stratification. Health equity implies that everyone should have a fair opportunity to attain their full health potential and that no one should be disadvantaged from achieving this potential.

To identify documents that include an equity focus, we compiled key words across 10 equity-related search strings or filters identified in the literature or through recognized library and information science organizations. In addition to terms describing PROGRESS-Plus (acronym used to describe the many dimensions across which health equity may exist), we also included an ethics-specific filter, developed by the Health Technology Assessment division of the Institut national de l'excellence en santé et services sociaux (INESSS). Our final list included 243 unique keywords addressing various equity-related terms.

We individually searched for each keyword in the titles and abstracts of all included documents. Documents were screened by a single reviewer.

Assessing relevance and quality of evidence

We assess the relevance of each included evidence document as being of high, moderate or low relevance to the question. We then use a colour gradient to reflect high (darkest blue) to low (lightest blue) relevance.

Two reviewers independently appraised the methodological quality of systematic reviews and rapid reviews that are deemed to be highly relevant. Disagreements are resolved by consensus with a third reviewer if needed. AMSTAR rates overall methodological quality on a scale of 0 to 11, where 11/11 represents a review of the highest quality. High-quality reviews are those with scores of eight or higher out of a possible 11, medium-quality reviews are those with scores between four and seven, and low-quality reviews are those with scores less than four. It is important to note that the AMSTAR tool was developed to assess reviews focused on clinical interventions, so not all criteria apply to systematic reviews pertaining to health-system arrangements or to economic and social responses to COVID-19. Where the denominator is not 11, an aspect of the tool was considered not relevant by the raters. In comparing ratings, it is therefore important to keep both parts of the score (i.e., the numerator and denominator) in mind. For example, a review that scores 8/8 is generally of comparable quality to a review scoring 11/11; both ratings are considered 'high scores.' A high score signals that readers of the review can have a high level of confidence in its findings. A low score, on the other hand, does not mean that the review should be discarded, merely that less confidence can be placed in its findings and that the review needs to be examined closely to identify its limitations. (Lewin S, Oxman AD, Lavis JN, Fretheim A. SUPPORT Tools for evidence-informed health Policymaking (STP): 8. Deciding how much confidence to place in a systematic review. *Health Research Policy and Systems* 2009; 7 (Suppl1):S8.

Preparing the profile

Each included document is hyperlinked to its original source to facilitate easy retrieval. For all included guidelines, systematic reviews, rapid reviews and single studies (when included), we prepare declarative headings that provide a brief summary of the key findings and act as the text in the hyperlink. Protocols and titles/questions have their titles hyperlinked given that findings are not yet available. We then draft a brief summary that highlights the total number of different types of highly relevant documents identified (organized by document), as well as their key findings, date of last search (or date last updated or published), and methodological quality.

Appendix 2: Key findings from evidence syntheses that address the question, organized by document type and sorted by relevance to the question

Type of document	Relevance to question	Key findings	Recency or status

Systematic review	• Climate risks
	  ○ General climate change
	• Health risks and impacts
	  ○ Food and nutrition
	  ▪ Food insecurity
	• Options and responses
	  ○ Developing community resilience
	• Equity-deserving groups
	Indigenous
	• Women and gender-diverse people
		• Authors reported an increasing interest in community-based monitoring (CBM) and explained this increase in interest as part of a broader trend around the need to address the disproportionate food security and climate change impacts often experienced by Indigenous communities globally
		• One third of the reviewed articles provided gender-disaggregated data; authors recommend a better understanding of the gendered nature of CBM, as well as the relationship between climate, food, and gender, for planning and designing a CBM system that reflect gender equity
		• Considering the history of unethical research conducted on and not with Indigenous communities, there is increasing demand for the recognition of Indigenous peoples' contributions and knowledge in the context of research, including climate change research
		• Successful CBM generally occurs when Indigenous communities monitor things they personally connect with and care about, rather than for externally driven needs
		• Community engagement is also important for generating local ownership and understandings of environmental change, and to facilitate the development of local climate change adaptation responses
		• It is likely that monitoring is carried out without documentation in the published literature, as many Indigenous communities often monitor environmental changes and the health of their land
			Literature last searched 2018

		• Studies where the food security pillar was specified, CBM typically focused on food availability and access • Measuring resilience is challenging because the concept of food system resilience has not been well defined for climate change and the links between resilience of food systems and climate change are not straight forward; moreover, limited conceptual tools and frameworks are available to guide such assessments Research gaps • Lack of studies providing gender-disaggregated data, resulting in an incomplete understanding of how Indigenous women, men, and gender-diverse people may differentially participate in, and experience CBM • The limited focus on reporting evaluation findings • Analyzing the grey literature is recommended for future research to better understand the full spectrum of CBM practice occurring within Indigenous communities, especially of autonomous monitoring systems which may be investigated or evaluated outside of research and the published literature • Source (AMSTAR rating 4/9)	

Systematic review	• Climate risks
	  ○ General climate change
	• Options and responses
	  ○ Mitigation co-benefits
	• Energy policy & co-benefits
		• There is the potential risk of a trade-off between accountability and efficiency depending on a policy instrument's source of authority; this indicates that decision-makers using policies that target the private sector must carefully balance a need for practical and feasible policies against the threat of becoming captured by these interests
		• Expenditure instruments perform better than regulatory instruments in overall and impact evaluations
		• Policies with built-in flexibility are more likely to have positive overall, process and efficiency evaluation results
		• Policy instruments with voluntary reporting procedures are much less likely to be positively evaluated than those with mandatory reporting procedures
			Literature last searched 2011

		• There is a possible trade-off between environmental effectiveness and cost-effectiveness depending on the stage of activity that a policy target
		• As the defined time frame of policies increases, the likelihood these policies will be positively evaluated for efficiency and process also increases
		Research gaps
		• More research is needed to examine the leaders in the water management field to understand what works and does not work for adapting to climate change in different coastal and freshwater systems
		  ○ It is also important to study the emerging nexus between water and energy, for instance, countries that experienced water's significance first-hand during droughts, can bring acute electricity blackouts and energy rationing to the populous, this risk also exists in other power generation sources, such as nuclear energy
		  ○ Thermal power production across Canada in 2005 consumed 64 percent of national gross water use, underscoring its high reliance on water and the close connection of water and energy
		• The need for primary research with business on the rationale, design, implementation and performance measurement of private policy initiatives; similarly, primary research examining a wider swath of policies would help verify that expenditure policies fare better than regulation in overall evaluations
		• Source (AMSTAR rating 2/9)	

Systematic review	• Climate risks
	  ○ General climate change
	• Options and responses
	  ○ Policy and practice
	  ▪ Adaptation
		• Adaptation activities most frequently represented in this review were community-based programs, ecological restoration, knowledge sharing and learning platforms, and changing crop types and planting and harvesting practices
		• While these activities demonstrated improvement in at least one category of effectiveness (that is, they reduced
			Literature last searched 2018

		risk and vulnerability, developed resilient social systems, improved the environment, increased economic resources, or enhanced governance and institutions), several activities indicated effectiveness across multiple categories • The development of local cooperative associations improved individual and community access to resources, improved livelihoods through offering financial assistance and increasing income levels, and facilitated learning and knowledge sharing within and across communities • Community-based and institutionalized techniques for sharing physical, financial, and informational resources; and techniques that aim to improve human wellbeing, institutional relations, and environmental security Research gaps • It is necessary more research addressing issues of justice, including representation of diverse types of knowledge and expertise, fair distribution of adaptation benefits, and imbalanced power relationships within the adaptation process • Research and evaluation offer techniques to reveal issues in leadership, decision-making, access, and profit and to monitor progress towards developing more equitable adaptation practices. Currently, however, these techniques are not often implemented in practice Source (AMSTAR rating 4/9)	

Scoping review	• Climate risks
	  ○ Extreme weather events
	• Health risks and impacts
	  ○ Patients and health systems
	  ▪ Public health
	• Options and responses
	  ○ Policy and practice
	  ▪ Adaptation
	• Equity-deserving groups
		• This scoping review was led by Public Health Ontario, and highlighted three big themes:
		• First, the most common practices for risk communication were public media campaigns, including radio and Internet-based messages, and organization or expert-led presentations or workshops to communities affected by natural hazards
		  ○ Within Ontario, communication activities such as promotional messaging, response guidelines, and heat
			Literature last searched 2014

	○ Low-income communities ○ The elderly ○ Racial and ethnic minorities ○ People with disabilities	alerts and warning systems were typical risk communication tools used in practice ○ Self-efficacy and feelings of adequate preparedness were positively correlated with risk reduction behaviours in communities at high risk for wildfires • Second, the challenges vulnerable communities, such as low-income communities, the elderly, racial and ethnic minorities, and people with disabilities, face in seeking and processing risk communication information, including complex language, information overload and contradictory information • Third, the importance of leveraging social networks and creating strategies housed [or based] in communities, for instance, people were more aware of extreme weather risks and more likely to initiate protective activities if they were involved in a participatory exercise ○ Broader involvement of civil society organizations such as the Red Cross and YMCA, play important social roles in health adaptation and community engagement Research gaps • Authors highlighted three major research gaps surrounding EWCC (extreme weather climate change) risk communications • First, a shortage of empirical studies and a limited amount of applied theory in study design and execution, 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 • Second, a lack of evaluation of current risk communications strategies, specially, poor integration of community-led initiatives in future planning, often because such initiatives were not properly evaluated	

		• Third, the research base relates to a focus on individuals, at the expense of the household and extended family networks, 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 Source (AMSTAR rating 4/9)	

Systematic review	• Climate risks
	  ○ Extreme weather events
	• Options and responses
	  ○ Policy and practice
	  ▪ Adaptation
	• Equity-deserving groups
	  ○ Indigenous
		• Several adaptations are documented as being employed by Inuit population in the artic today to manage the risks of current climate change:
		  ○ The substitution of traditional foods for store foods when hunting areas are not accessible
		  ○ Altered timing, mode, and methods of subsistence activities
		  ○ The establishment of community evacuation and preparedness plans in case of extreme events
		  ○ The development of new ice-based transportation routes to avoid dangerous areas
		  ○ The strengthening of municipal infrastructure to cope with altered climatic extremes
		  ○ The development of youth–elder mentoring programs to transmit traditional knowledge on environmental risks
		  ○ Increasing use of community freezers to store and make accessible traditional foods
		• Financial resources are an important component of the means to adapt, and are identified as one of the main barriers preventing adaptation from taking place
		  ○ Many adaptations are costly and exceed the financial ability of households, communities, businesses, regional governments, and regional institutions
		  ○ households often do not have access to the capital resources to purchase new hunting equipment to take advantage of new conditions or replace equipment lost or damaged in climate-related hunting accidents
			Literature last searched 2009

		○ municipalities often struggle to afford existing maintenance projects and are not able to invest in climate proofing infrastructure • Other adaptation barriers are social–cultural in nature including the erosion of traditional land skills among younger generations, weakening of sharing networks, and the cultural value of hunting and consuming certain traditional foods at certain times of the year • Some adaptations have the potential to reduce future exposure-sensitivities and increase adaptive capacity, including integrated regional planning to anticipate future conflicts and stresses, enhanced harvester support assistance, improved skills training, improved search and rescue capacity, better weather and ice hazard forecasting, protection of cultural sites, infrastructure strengthening, and support for new technology Research gaps • There is need to identify a suite a potential adaptation and examine their effectiveness in reducing climate change vulnerability, specify their costs and benefits, and assess broader non climatic benefits • Studies lack detailed policy analysis and often presenting adaption responses as part of 'wish lists' • No published studies have undertaken cost benefit • analysis of adaptation options, examined how adaptations would be developed and implemented, assessed support for various options among stakeholders and community members, • or examined the performance of adaptation options under different climate change scenarios • Few publications report on adaptations in health, cultural and education, or economy and business sectors Source (AMSTAR rating 3/9)	
Scoping review	• Climate risks ○ General climate change • Health risks and impacts	• Changing climate conditions is negatively affecting the health and wellbeing of individuals in rural and remote regions, including: increased prevalence and severity of	Literature last searched 2019

	○ Patients and health systems ▪ Public health • Options and responses ○ Developing community resilience ○ Policy and practice ▪ Adaptation • Mediating pathways ○ Geographic exposure ▪ Rural households • Equity-deserving groups ○ Indigenous	extreme weather events, changes to sea ice, vegetation, fish, wildlife, weather and environmental uncertainties • Health impacts of these include poor nutrition, obesity, vector-borne/waterborne/foodborne disease, cardiovascular disease, respiratory issues, and mental health issues, among others • Adaptation strategies are needed to address these challenges, including: ○ using multiple knowledge systems, specific to sociocultural context ○ address socio-cultural barriers ○ use innovative technology ○ improve and integrate public health and environmental surveillance ○ support sustainable development practices ○ enhance risk communication and knowledge of climate change ○ develop capacity of health systems to respond to the health impacts of climate change • Additional details for the implementation or evaluation of these adaption strategies were not provided Source (AMSTAR rating 2/9)	
Systematic review	• Climate risks ○ General climate change • Options and responses ○ Policy and practice ▪ Adaptation	• Health impacts of climate change on populations include greater morbidity and mortality from poor air quality, food shortages, water- and food-borne contamination, extreme weather events and changing patterns of disease spread by animals • Literature review examines the similarities and difference between the climate change adaptation frameworks that have been developed and the Ontario Public Health Standards • The review found that regular population health risk assessments and risk management activities by local public health units can help to address risks related to climate hazards	Literature last searched 2008

		• The comparison between frameworks and Ontario Public Health Standards show many similarities in the steps to address health impacts – steps featured in both include:
		  ○ Engagement of stakeholders
		  ○ Identification and burden of climate-related illness and injury
		  ○ Identification of vulnerable populations
		  ○ assessment of the effectiveness of programs and activities to reduce climate-related health risks
		  ○ Identification and prioritization of policy and program options to meet health needs
		Research gaps
		• Assessments of heat-health vulnerabilities require projections of the future frequency and severity of extreme heat events, information related to the geographical variation in exposure to extreme heat, identification of vulnerable populations and identification of actual temperature and morbidity/mortality thresholds
		• Public health interventions that may be implemented to reduce climate change impacts on health within relevant time scales (5–10 years) need to be identified through assessments
		• It is necessary case studies and community examples that aid public health officials in their efforts to obtain, analyze and integrate findings from climate scenarios and models to gauge future impacts on health
		• Additional efforts should be made to understand the most effective and efficient ways to provide this information to authorities charged with protecting the public from climate-related health risks
		Source (AMSTAR rating 2/9)	

Systematic review	• Climate risks ○ General climate change • Health risks and impacts	• Adaptations being implemented by civil society organizations (CSOs) in Canada consist predominantly of groundwork interventions including awareness,	Literature last searched 2013

	○ Patients and health systems ▪ Public health ○ WASH ▪ Drinking water quality • Options and responses ○ Policy and practice ▪ Adaptation	research and networking activities that aim to build adaptive capacity • Adaptations most frequently address water contamination and air quality, and occur most often as awareness raising and research activities • Adaptations infrequently recognize vulnerable groups or climate change as a motivator • A deficit in terms of what needs to be done to address adaptation and what is being done; part of a broader problem identified in Canada and beyond and that is reflected in limited CSO action on key vulnerabilities, for instance: ○ While water contamination and air quality are commonly addressed, extreme heat, which is widely acknowledged as a key vulnerability facing Canadians in a changing climate, is reported in fewer than 2% of initiatives ○ Similarly, flooding is another key vulnerability yet is addressed in fewer than 7% of actions ○ Such impacts will affect the activities of multiple CSOs that deal with the elderly, low-income households, marginalized communities and the homeless • The diversity of organizations engaged in adaptation indicates potential for collaboration between public health bodies and CSOs Research gaps • It is necessary more research in adaptations to flooding and extreme heat • Consideration of vulnerable groups is limited Source (AMSTAR rating 2/9)	
Systematic review	• Climate risks ○ Drought • Health risks and impacts ○ WASH ▪ Drinking water quality	• When municipalities are considering a shift to direct potable re-use (DPR), while conducting the public engagement, planners, engineering and policy makers should ensure information does not overburden citizens with technical information, but at the same time, should	Literature last searched not provided

	• Options and responses
	  ○ Policy and practice
	  ▪ Adaptation
		not withhold information because experts feel the public may lack the knowledge or understanding to provide accurate feedback
		○ In the United States, Australia and Canada, citizens would report negative feedback when asked about drinking recycled wastewater
		• Post secondary education should do more to focus on curricula that includes alternative energy models and policy solutions
		• Research points to decentralized direct potable re-use (DPR) either being already competitive, or shortly becoming competitive against traditional waster water treatment plant (WWTPs)
		• Some of the major reasons that DPR has not been implemented in Canada are:
		○ A lack of understanding on public opinion around drinking and using recycled wastewater for potable reuse
		○ Policies and regulations are varied across provinces, territories, and municipalities
		○ Canada has not had to experience as many extreme weather events as a result of global warming
		○ A lack of research and interest by industry, academia, and the federal government
		• Due to the diversity of climate, urbanization, and landscape across Canada, it can be difficult to standardize a triple bottom line (TBL) that could serve as the backbone for many municipalities
		Research gaps
		• There needs to be more research to understand the policy implications of either allowing municipalities, the provinces and territories, or the federal government to take the lead on DPR policies and implementation
		Source (AMSTAR rating 2/9)	

Systematic review	• Climate risks ○ General climate change	• Less than half of the articles included in this review covered climate change solutions in a health context	Literature last searched 2016

	• Health risks and impacts
	  ○ Patients and health systems
	  ▪ Public health
	• Options and responses
	  ○ Policy and practice
	  ▪ Adaptation
		• Examples of mitigation strategies included decreasing greenhouse gas emissions by installing solar panels, improving household insulation, and increasing active transport use
		• Suggested adaptation strategies included creating community adaptation plans, cutting back on strenuous outdoor activity on hot or smoggy days, and building coastal protection
		• Adaptation was discussed more frequently than mitigation in Quebec, the Prairies, and British Columbia, and adaptation was also more frequently mentioned than mitigation between 2007 and 2008 compared to other years
		• The limited coverage on climate change solutions may contribute to the feelings of hopelessness commonly associated with climate change, thereby undermining the public's feelings of self-efficacy and impetus to engage in climate-mitigating or adaptive actions
		Source (AMSTAR rating 2/9)	

Systematic review	• Climate risks
	  ○ Hurricanes
	• Health risks and impacts
	  ○ Patients and health systems
	  ▪ Public health
	• Options and responses
	  ○ Mitigation co-benefits
	  ▪ Greenhouse pathways
	• Equity-deserving groups
	Long-term evacuees
		• It is difficult to determine if and to what extent the public health effects of prolonged evacuation and the public health needs of long-term evacuees (LTEs) in Canada are being assessed, monitored, and addressed
		• Trends in the incidence of disasters and emergencies underscore the urgency of conducting more research to improve our understanding of prolonged displacement within Canada and in other high-income countries
		Research gaps
		• Some studies broadly consider the long-term
		• repercussions of emergencies and disasters in high-income countries, but they pay little or no attention to the effects of evacuation, and potential effects of prolonged vs. short-term displacement
		Source (AMSTAR rating 2/9)
			Literature last searched 2018

Overview	• Health risks and impacts ○ Occupational health and injury	• The review identifies five categories of climate hazards that are likely to effect occupational health and safety in	Literature last searched

	• Options and responses
	  ○ Policies and practices that support adaptation
		Canada including heat waves/increased temperatures, air pollutants, UV radiation, extreme weather events, vector-borne/zoonotic diseases
		• The review notes that they will have a significant effect on occupations related to natural resources such as agriculture and fishing as well as changing the built environment and emerging green industries which in turn will change the occupational hazard landscape
		• In addition to acquiring new knowledge on hazards and ongoing surveillance, the review suggests the following adaptation strategies:
		  ○ identify and evaluate adaptation methods
		  ○ develop training tools to prepare workers for the health effects of climate change
		  ○ develop protective clothing and other equipment for extreme climates
		  ○ explore adaptation methods using organization of work and work schedule management
		  ○ develop methods to heighten workplace awareness of potential risks
		Source (AMSTAR rating 2/9)
			December 2010

Systematic review	• Climate risks
	  ○ Emissions
	• Options and responses
	  ○ Mitigation co-benefits
	  ▪ Greenhouse pathways
		• This review focused on the use of alternative fuels in cement manufacturing
		• Overall, energy recovery in cement manufacturing is one of the best end-of-life options, even though the performance in resource consumption and conservation, and metal and hazardous air pollutant emissions can be worse than for other end-of-life options, such as recycling
		• Landfilling should be avoided, and incineration discouraged in favour of better end-of-life options
		• An environmentally sound end-of life solution is the use of sludge as fertilizer, although the practice is illegal in some countries if the sludge is not treated
		• Landfilling or reusing tires in asphalt road pavement appeared to be the worst options
			Literature last searched 2010

		Research gaps • The social impact of the use of alternative energy sources in cement manufacturing were not identified • Academic papers did not address comparisons between the use of animal and bone meal, IC&I residues, and waste wood in cement kilns with other end-of-life options • Academic papers did not discuss health or social impacts, and economic impacts were investigated for few end-of-life options • Source (AMSTAR rating 4/9)	

Appendix 3a: Identified documents on health risks and impacts of climate change that include an equity focus, organized by PROGRESS-Plus

Progress-Plus characteristics	Progress-plus characteristics identified in included documents	Identified documents
Place of residence	Arctic (or sub-arctic)	• Identifying and achieving consensus on health-related indicators of climate change in Nunavut • Food insecurity among Inuit women exacerbated by socioeconomic stresses and climate change • "From this place and of this place:" climate change, sense of place, and health in Nunatsiavut, Canada • Climate change influences on environment as a determinant of Indigenous health: Relationships to place, sea ice, and health in an Inuit community • What we know, do not know, and need to know about climate change vulnerability in the western Canadian Arctic • SOS! Summer of smoke: A retrospective cohort study examining the cardiorespiratory impacts of a severe and prolonged wildfire season in Canada's high subarctic • "We're people of the snow" Weather, climate change, and Inuit mental wellness • Inuit vulnerability and adaptive capacity to climate change in Ulukhaktok, Northwest Territories, Canada • Protective factors for mental health and well-being in a changing climate: Perspectives from Inuit youth in Nunatsiavut Labrador • Community vulnerability to climate change in the context of other exposure-sensitivities in Kugluktuk, Nunavut • Using qualitative scenarios to understand regional environmental change in the Canadian North
	Rural and remote	• The association between farming activities, precipitation, and the risk of acute gastrointestinal illness in rural municipalities of Quebec, Canada: A cross-sectional study • Household access to capital and its effects on drought adaptation and migration: A case study of rural Alberta in the 1930s • Use of traditional environmental knowledge to assess the impact of climate change on subsistence fishing in the James Bay Region of Northern Ontario, Canada • Climate change impacts on health and wellbeing in rural and remote regions across Canada

		• Exploration of the spatial patterns and determinants of asthma prevalence and health services use in Ontario using a Bayesian approach • Energy poverty in Canada: Prevalence, social and spatial distribution, and implications for research and policy • Waterborne outbreaks: A public health concern for rural municipalities with unchlorinated drinking water distribution systems
	Urban	• Air quality in Canadian port cities after regulation of low-sulphur marine fuel in the North American Emissions Control Area • Nature-based equity: An assessment of the public health impacts of green infrastructure in Ontario Canada • A multilevel analysis to explain self-reported adverse health effects and adaptation to urban heat: A cross-sectional survey in the deprived areas of 9 Canadian cities • Neighbourhood and dwelling characteristics associated with the self-reported adverse health effects of heat in most deprived urban areas: A cross-sectional study in 9 cities • Healthy neighbourhoods: Walkability and air pollution • Reduction of disparities in access to green spaces: Their geographic insertion and recreational functions matter • The impact of climate change on the food systems in Toronto
Race/ethnicity/ culture/language	Indigenous populations	• Identifying and achieving consensus on health-related indicators of climate change in Nunavut • Food insecurity among Inuit women exacerbated by socioeconomic stresses and climate change • Health effects of flooding in Canada: A 2015 review and description of gaps in research • "From this place and of this place:" climate change, sense of place, and health in Nunatsiavut, Canada • Vulnerability of Aboriginal health systems in Canada to climate change • What we know, do not know, and need to know about climate change vulnerability in the western Canadian Arctic • Preparing for the health impacts of climate change in Indigenous communities: The role of community-based adaptation • Use of traditional environmental knowledge to assess the impact of climate change on subsistence fishing in the James Bay Region of Northern Ontario, Canada • Frequent flooding and perceived adaptive capacity of subarctic Kashechewan First Nation, Canada

		• Spring flooding and recurring evacuations of Kashechewan First Nation, northern Ontario, Canada • Climate change impacts on health and wellbeing in rural and remote regions across Canada • Community-based monitoring of Indigenous food security in a changing climate: Global trends and future directions • Evacuating First Nations during wildfires in Canada • "We're people of the snow" Weather, climate change, and Inuit mental wellness • Indigenous mental health in a changing climate • Inuit vulnerability and adaptive capacity to climate change in Ulukhaktok, Northwest Territories, Canada • Protective factors for mental health and well-being in a changing climate: Perspectives from Inuit youth in Nunatsiavut Labrador • Community vulnerability to climate change in the context of other exposure-sensitivities in Kugluktuk, Nunavut • Using qualitative scenarios to understand regional environmental change in the Canadian North • Like the plains people losing the buffalo: Perceptions of climate change impacts, fisheries management, and adaptation actions by Indigenous peoples in coastal British Columbia, Canada
	Immigrant populations	• Risk and resilience: How is the health of older adults and immigrant people living in Canada impacted by climate- and air pollution related exposures?
Occupation	-	•
Gender/sex	Gender/sex	• Risk of hospitalization for fire-related burns during extreme cold weather • Spatial variability of climate effects on ischemic heart disease hospitalization rates for the period 1989-2006 in Quebec, Canada • Food insecurity among Inuit women exacerbated by socioeconomic stresses and climate change • A difference-in-difference approach to assess the effect of a heat action plan on heat-related mortality, and differences in effectiveness according to sex, age, and socioeconomic status (Montreal, Quebec) • Threats to mental health and well-being associated with climate change
Religion	-	
Education	Education levels	• A difference-in-difference approach to assess the effect of a heat action plan on heat-related mortality, and differences in effectiveness according to sex, age, and socioeconomic status (Montreal, Quebec)

		• Threats to mental health and well-being associated with climate change
Socioeconomic status and social capital	Low socioeconomic status or experiencing material deprivation	• Nature-based equity: An assessment of the public health impacts of green infrastructure in Ontario Canada • Spatial variability of climate effects on ischemic heart disease hospitalization rates for the period 1989-2006 in Quebec, Canada • A multilevel analysis to explain self-reported adverse health effects and adaptation to urban heat: A cross-sectional survey in the deprived areas of 9 Canadian cities • Neighbourhood and dwelling characteristics associated with the self-reported adverse health effects of heat in most deprived urban areas: A cross-sectional study in 9 cities • A difference-in-difference approach to assess the effect of a heat action plan on heat-related mortality, and differences in effectiveness according to sex, age, and socioeconomic status (Montreal, Quebec) • Quantifying vulnerability to extreme heat in time series analyses: A novel approach applied to neighborhood social disparities under climate change • Factors influencing the mental health consequences of climate change in Canada • Threats to mental health and well-being associated with climate change • Risk and protective factors for heat-related events among older adults of Southern Quebec (Canada): The NuAge study • Reduction of disparities in access to green spaces: Their geographic insertion and recreational functions matter • The role of maps in neighbourhood-level heat vulnerability assessment for the City of Toronto
Personal characteristics associated with discrimination and/or exclusion	Infants and children	• The association between climate, geography and respiratory syncitial virus hospitalizations among children in Ontario, Canada • Extreme heat and paediatric emergency department visits in Southwestern Ontario
	Older adults	• Risk of hospitalization for fire-related burns during extreme cold weather • A difference-in-difference approach to assess the effect of a heat action plan on heat-related mortality, and differences in effectiveness according to sex, age, and socioeconomic status (Montreal, Quebec) • Incidence of hot tap water scalds after the introduction of regulations in Ontario • Reducing the risks of extreme heat for seniors: Communicating risks and building resilience • Risk and protective factors for heat-related events among older adults of Southern Quebec (Canada): The NuAge study • Canadian forest fires and the effects of long-range transboundary air pollution on hospitalizations among the elderly

		• How do non-catastrophic natural disaster impact middle-aged-to-older persons? • Risk and resilience: How is the health of older adults and immigrant people living in Canada impacted by climate- and air pollution related exposures? • Effects of climate and fine particulate matter on hospitalizations and deaths for heart failure in elderly • Effects of diurnal variations in temperature on non-accidental mortality among the elderly population of Montreal, Quebec, 1984-2007
	Unhoused or homeless	• Health effects of flooding in Canada: A 2015 review and description of gaps in research • Cold weather conditions and risk of hypothermia among people experiencing homelessness: Implications for prevention strategies
	People who use substances	• Ambient air pollution exposure and emergency department visits for substance abuse
Time dependent relationships	-	

Appendix 3b: Identified systematic reviews about adaptation and mitigation strategies that include an equity focus, organized by PROGRESS-Plus

Progress-Plus characteristics	Progress-plus characteristics identified in included documents	Identified documents
Place of residence	Arctic (or sub-arctic)	What we know, do not know, and need to know about climate change vulnerability in the western Canadian Arctic
	Rural and remote regions	
Race/ethnicity/ culture/language	Indigenous populations	Community-based monitoring of Indigenous food security in a changing climate: Global trends and future directions What we know, do not know, and need to know about climate change vulnerability in the western Canadian Arctic Civil society organizations and adaptation to the health effects of climate change in Canada
Occupation	-	
Gender/sex	Gender/sex	Community-based monitoring of Indigenous food security in a changing climate: Global trends and future directions
Religion	-	
Education	-	
Socioeconomic status and social capital	Low-income and materially deprived neighbourhoods	Evaluating risk communication during extreme weather and climate change: A scoping review
Personal characteristics associated with discrimination and/or exclusion	Older adults	Evaluating risk communication during extreme weather and climate change: A scoping review
	People with physical disabilities	Evaluating risk communication during extreme weather and climate change: A scoping review
Time dependent relationships	-	

Appendix 4: Evidence syntheses excluded because were not focused on options and response

Type of evidence synthesis	Identified documents
Systematic review	A systematic review of waterborne disease burden methodologies from developed countries
Systematic review	Development of key indicators to quantify the health impacts of climate change on Canadians
Systematic review	Geospatial indicators of exposure, sensitivity, and adaptive capacity to assess neighbourhood variation in vulnerability to climate change-related health hazards
Systematic review	Association of climatic factors with infectious diseases in the Arctic and subarctic region - a systematic review
Systematic review	The Climate Change, Food Security and Human Health Nexus in Canada: A Framework to Protect Population Health
Systematic review	Indigenous mental health in a changing climate: a systematic scoping review of the global literature
Scoping review	Effective Community-Based Interventions for the Prevention and Management of Heat-Related Illnesses: A Scoping Review
Systematic review	Vulnerability of Aboriginal health systems in Canada to climate change
Systematic review	Research on the Human Dimensions of Climate Change in Nunavut, Nunavik, and Nunatsiavut: A Literature Review and Gap Analysis
Scoping review	Criteria for the prioritization of public health interventions for climate-sensitive vector-borne diseases in Quebec
Systematic review	Contribution of bioaerosols to airborne particulate matter
Scoping review	The psychosocial impacts of wildland fires on children, adolescents and family functioning: A scoping review
Systematic review	The impact of flooding on aquatic ecosystem services