



Contents lists available at ScienceDirect

Global Environmental Change

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



Vulnerability of Aboriginal health systems in Canada to climate change

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ARTICLE INFO

Article history:

Received 17 December 2009

Received in revised form 17 May 2010

Accepted 18 May 2010

Keywords:

Climate change

Health

Adaptation

Vulnerability

Aboriginal

Inuit

Métis

First nations

Canada

Social determinants of health

Inequality

Indigenous

ABSTRACT

Climate change has been identified as potentially the biggest health threat of the 21st century. Canada in general has a well developed public health system and low burden of health which will moderate vulnerability. However, there is significant heterogeneity in health outcomes, and health inequality is particularly pronounced among Aboriginal Canadians. Intervention is needed to prevent, prepare for, and manage climate change effects on Aboriginal health but is constrained by a limited understanding of vulnerability and its determinants. Despite limited research on climate change and Aboriginal health, however, there is a well established literature on Aboriginal health outcomes, determinants, and trends in Canada; characteristics that will determine vulnerability to climate change. In this paper we systematically review this literature, using a vulnerability framework to identify the broad level factors constraining adaptive capacity and increasing sensitivity to climate change. Determinants identified include: poverty, technological capacity constraints, socio-political values and inequality, institutional capacity challenges, and information deficit. The magnitude and nature of these determinants will be distributed unevenly within and between Aboriginal populations necessitating place-based and regional level studies to examine how these broad factors will affect vulnerability at lower levels. The study also supports the need for collaboration across all sectors and levels of government, open and meaningful dialogue between policy makers, scientists, health professionals, and Aboriginal communities, and capacity building at a local level, to plan for climate change. Ultimately, however, efforts to reduce the vulnerability of Aboriginal Canadians to climate change and intervene to prevent, reduce, and manage climate-sensitive health outcomes, will fail unless the broader determinants of socio-economic and health inequality are addressed.

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1. Introduction

Climate change has been identified as potentially the biggest health threat of the 21st century (Costello et al., 2009). Addressing the challenge will be a defining question for public policy (Campbell-Lendrum et al., 2009; Costello et al., 2009; Lim et al., 2009; Parry et al., 2009). While reducing greenhouse gas emissions responsible for climate change is essential (i.e. mitigation), health systems will have to adapt to climate change through interventions to manage climate-sensitive health outcomes, many of which are now unavoidable (Belanger et al., 2008; Ebi and Semenza, 2008; Frumkin et al., 2008; Furgal and Prowse, 2009). Without such intervention, the burden of climate-sensitive health outcomes will increase (Belanger et al., 2008; Confalonierei et al., 2007).

International assessments have highlighted that developed nations have a high capacity to adapt to the health effects of climate change (Confalonierei et al., 2007; Costello et al., 2009). On the whole, this is true: individuals, communities, and governments have access to significant resources and engage in a range of actions to manage and control climate-sensitive health outcomes (Ebi, 2009; Ebi et al., 2009; Watson et al., 2005). This assumption, however, does not adequately consider the persistence of within-country economic and health inequities and their implications for vulnerable populations. This is particularly pertinent for developed nations with Indigenous populations living in what has been referred to as the 'fourth world' (O'Neill, 1986). Indigenous peoples in Canada, New Zealand, United States, and Australia all experience a disproportionate burden of morbidity and mortality, with many social, economic, and health indicators similar to those in middle-income nations (Cooke et al., 2007; Green et al., 2009; Smylie et al., 2006; Smylie and Anderson, 2006; Stephens et al., 2006). The existing burden of ill-health increases the sensitivity of Indigenous peoples to the adverse impacts of climate change, which combined with a proportionally higher dependence of many Indigenous

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livelihoods on the environment, spiritual and cultural ties to the land, demographic trends, and experience of marginalization, makes Indigenous peoples particularly vulnerable (Furgal, 2008; Furgal and Seguin, 2006; Green et al., 2009).

Public health interventions focused on Indigenous peoples are needed to prevent, prepare for, and manage climate change risks (i.e. adaptation). Assessing vulnerability is essential to this end, locating at-risk populations, identifying vulnerability determinants that need to be addressed, and directing attention to the most appropriate level for intervention (IPCC, 2007b). Canada has been a leader in vulnerability assessment in public health (Berrang-Ford, 2009; Berrang-Ford and Noble, 2007; Berrang Ford et al., 2009; Charron, 2002, 2003; Charron et al., 2004; Doyon et al., 2008; Health Canada, 2007a,c; Ogden et al., 2006; Thomas et al., 2006). Natural Resources Canada's *From impacts to adaptation: Canada in a changing climate 2007* (Lemmen et al., 2008), for example, assesses the current state of knowledge on climate change for six regions of Canada, and Health Canada's *Human Health in a Changing Climate* (Seguin, 2008) specifically focuses on climate change and health. However, there remains a significant deficit in information required to inform and guide adaptation among Aboriginal peoples—part of what we broadly term an Indigenous peoples 'vulnerability deficit.' Major Canadian assessments of climate change, for example, identify research on Aboriginal health a priority for action (Lemmen et al., 2008), and while Furgal and Prowse (2008) focus on the health of mostly Inuit inhabitants in the north, other Aboriginal populations have been less studied (Healey and Meadows, 2007; Wilson and Young, 2008). This lack of information leaves Aboriginal health systems insufficiently prepared to identify the risks of climate change and develop adaptations (Seguin, 2008). The vulnerability deficit is further evident in the peer-reviewed literature. A review of PubMed (1990–2009), for example, reveals only 7 articles referring to a combination of "Indigenous or Aboriginal" and "health" and "climate change" and "Canada." Of this literature, only 1 article formally assesses vulnerability with a focus on the North (Furgal and Seguin, 2006), and only 3 are explicitly concerned with aspects of health in a changing climate. For comparison, 104 articles match the search criteria for Canada if "Indigenous or Aboriginal" are excluded.

Addressing the vulnerability deficit should be a priority for Aboriginal health research and planning on climate change (Furgal, 2008; Green et al., 2009; Seguin, 2008). A common approach to examining health vulnerability begins with the question, 'Given projected climate changes, how will this affect health systems?' The long range future is the focus of interest here (often 2050 or 2100), with assessment starting by modeling how health exposures will be affected by climate projections. An alternative approach starts with the question 'What predisposes health systems to be negatively affected by climate change.' The first step here is to characterize the current structure and functioning of health systems, and identify the processes and conditions which affect how health risks are experienced and managed: these characteristics in turn will determine sensitivity and adaptive capacity to climate change (Smit and Wandel, 2006). Given that the second approach focuses on current

capacity and vulnerability of the health system, we can use existing literature to characterize sensitivity and adaptive capacity to climate changes. This is important given the volume of research on all aspects of Aboriginal health: 896 articles using search terms "Indigenous or Aboriginal" and "health" and "Canada" in PubMed (1990–2009).

In this paper we systematically review the literature on Aboriginal health in Canada to identify health outcomes, determinants, and trends, and use a vulnerability framework to synthesize how these factors will affect the vulnerability (and resilience) of Aboriginal health systems to climate change. On this basis we identify strategic priorities for policy intervention and research needs.

2. Canada's Aboriginal population

Aboriginal peoples in Canada are constitutionally defined as North American Indian (commonly referred to as First Nations), Métis, and Inuit (Table 1). In 2006, Aboriginal peoples accounted for 4% of Canada's population, numbering approximately 1.2 million, and are the fastest growing segment of the population (Table 2). In many instances, indicators of economic, social and health well-being among Aboriginal Canadians compare unfavorably with the Canadian population in general (Table 2) (Adelson, 2005; Cooke et al., 2007; PHAC, 2008; Stephens et al., 2006). Aboriginal peoples experience lower life expectancy, higher incidence of chronic diseases (e.g. diabetes), higher rates of infectious diseases (in particular tuberculosis and childhood RSV bronchiolitis), and higher rates of substance abuse, suicide, and addiction, than Canadians in general (Table 1) (Adelson, 2005; Banerji et al., 2009; Clark and Cameron, 2009; Frohlich et al., 2006; Macdonald et al., 2010; MacMillan et al., 1996; McDonald and Trenholm, 2010).

Canada's Aboriginal population is diverse, including people living on reserves, in the territories, and in rural communities—these groups account for approximately half the Aboriginal population. We collectively refer to this segment of the population as the 'remote Aboriginal population': they are generally remote and rural in character, maintain a close and intimate relationship with the environment, with many still practicing aspects of traditional lifestyles (Table 1 and Fig. 1) (Furgal and Seguin, 2006; Richmond and Ross, 2009). This remoteness, combined with close links to environmental conditions for livelihoods, creates particular sensitivity to climate change. The remainder of the Aboriginal population lives in urban areas, and this population is growing rapidly with migration from remote communities, particularly among young people seeking education and employment (Siggner and Costa, 2005; Statistics Canada, 2006a). Urban Aboriginal peoples, in many respects, are engaged in livelihood activities similar to non-Aboriginal people and are often disconnected from land based activities. Nevertheless, many retain connections with their traditional home (INAC, 2009). We recognize that focusing on all Aboriginal subpopulations risks overgeneralization as there is significant heterogeneity in health outcomes and determinants of health between urban and remote and rural Aboriginal populations, and also between and within First Nations, Inuit, and Métis.

Table 1
Characteristics of Aboriginal habitation.

- Reserves are tracts of land, the legal title to which is held by the Crown, set apart for the use and benefit of First Nations with constitutional responsibility resting with the federal government. There are approximately 552 reserves in Canada.
- The territories are administrative subdivisions of Canada which, unlike provinces, derive their mandate and powers from the federal government. A significant proportion of the population of territories is Aboriginal, residing in approximately 92 communities.
- Over half of the Aboriginal population lives in urban centres. Winnipeg, Edmonton, Saskatoon, and Regina are major urban areas where Aboriginal people make up >5 of the population.
- Aboriginal people also reside in rural settlements outside of the territories and not on reserves, data on this segment of the Aboriginal population is lacking.

Table 2

Selected socio-economic and health indicators for Aboriginal peoples and Non-Aboriginal peoples in Canada.

Data	Aboriginal peoples			Non-Aboriginal
	Total	On-reserve	Off-reserve	
Population: Canada				
Population in 2006	1,172,790	308,490	864,300	30,068,240
Median age	27	N/A	N/A	40
% of people under age 24	48	N/A	N/A	31
Growth rate (96–06)	45%	N/A	N/A	8%
Vital stats (2001)				
Life expectancy				
Males	N/A	67.1	N/A	76
Females	N/A	73.1	N/A	81.5
Household conditions (2006)				
% of population living in crowded conditions ^a	11	26	7	3
% of households requiring major repairs	23	44	17	7
Health				
% reporting at least one chronic health condition (Tjepkema, 2002)	N/A	N/A	60.1	49.6
Income				
% of government support beneficiaries (2006)	18.1	N/A	N/A	10.9
Average income ^b	25,961 ^c	28,355 ^d	34,696 ^d	36,616 ^c
Incidence of low income in total population of private households in (low income occurring when >20% of income spent on food, clothing and shelter) (2000)	34.2	N/A	31.5	15.8
Labour Force (2006)				
Participation rate	63.0	52.3	N/A	66.9
Unemployment rate	14.8	24.8	10.6 ^e	6.3
Employment rate	53.7	39.3	59.0 ^e	62.7
Human Development Index (2001)	.815 (ranked 32nd)	N/A	N/A	.900 (ranked 8th)

^a More than one person per room.^b For persons with employment income.^c Census 2006.^d Census 2001.^e Stats Can, Labour Force Survey (2007).

There are, however, shared experiences of health inequalities which result in a unique vulnerability to climate change.

3. Climate change and Aboriginal health

The focus in this paper on Canada's Aboriginal population reflects the serious risks posed by climate change to Aboriginal health. Canada has already experienced disproportionate warming with climate change, with average temperatures in some northern regions increasing beyond 2 °C (ACIA, 2005; Barber et al., 2008; Ford, 2009a; IPCC, 2007a; Prowse et al., 2009b,c). Implications for Aboriginal health have already documented, particularly in the Arctic (Ford, 2009b; Ford et al., 2010a; Furgal, 2008; Furgal and Prowse, 2008; Furgal and Seguin, 2006). Projections of relevance to Aboriginal health include:

Changing temperature and precipitation regimes will increase the probability and severity of extreme events including heat-waves, storms, floods, drought, and wildfire with implications for asthma, chronic respiratory disease, water quality, cardiovascular disease, and the health effects of dislocation and displacement (Fig. 2) (Charron et al., 2004; Doyon et al., 2008; Hess et al., 2008; Thomas et al., 2006). Sea level rise and associated coastal erosion are already threatening the viability of some Aboriginal settlements (Lemmen et al., 2008). Remote Aboriginal settlements are particularly sensitive to these impacts, with many dependent on water delivery and sewage collection by truck, basic water treatment facilities, and some settlements located on marginal and hazardous locations, a consequence of government relocation in the 1950s and 1960s (Furgal and Prowse, 2008; Lemmen et al., 2008).

Warmer, wetter summers have the potential to increase the incidence of water and insect borne disease (e.g. *Entamoeba*

histolytica, *Giardia lamblia*, *Cryptosporidium parvum*) (Hennessy et al., 2008; Martin et al., 2007), while rising temperatures are expected to increase the incidence of temperature-dependant food-borne diseases, including *Salmonella* as well as toxins produced by *Staphylococcus aureus* and *Clostridium botulinum* (Hess et al., 2008; Parkinson et al., 2008). These are important in an Aboriginal context given traditional food cultures, which includes the consumption of raw meats, in which small changes in storage and transport temperatures can significantly increase the risk of food-borne diseases.

There will be a number of indirect pathways through which climate change will affect health involving second, third, or even fourth order indirect impacts. These are generally less researched and understood but could be more extensive and disruptive (Hess et al., 2008; McMichael, 2006) Changing temperatures, for example, are likely to impact the distribution and availability of animal populations important in Aboriginal subsistence hunting with implications for community health, nutrition, and well-being (Fig. 2) (Ford, 2009b; Furgal and Seguin, 2006). Climate change could result in increased migration to urban centres as traditional activities and livelihoods are compromised, with implications for disease transmission and diagnosis (Parkinson et al., 2008). Changes to the incidence and prevalence of some infectious diseases will also be indirect, stemming for example from climate impacts in other countries from which diseases may be introduced into Canada, or changes in the distribution and densities of vector habitat or animal hosts of zoonotic and vectorborne diseases (Berrang-Ford, 2009; Berrang Ford et al., 2009). There might also be positive health implications associated with increased economic opportunity with improved transportation in areas currently inaccessible (e.g. by melting sea ice).

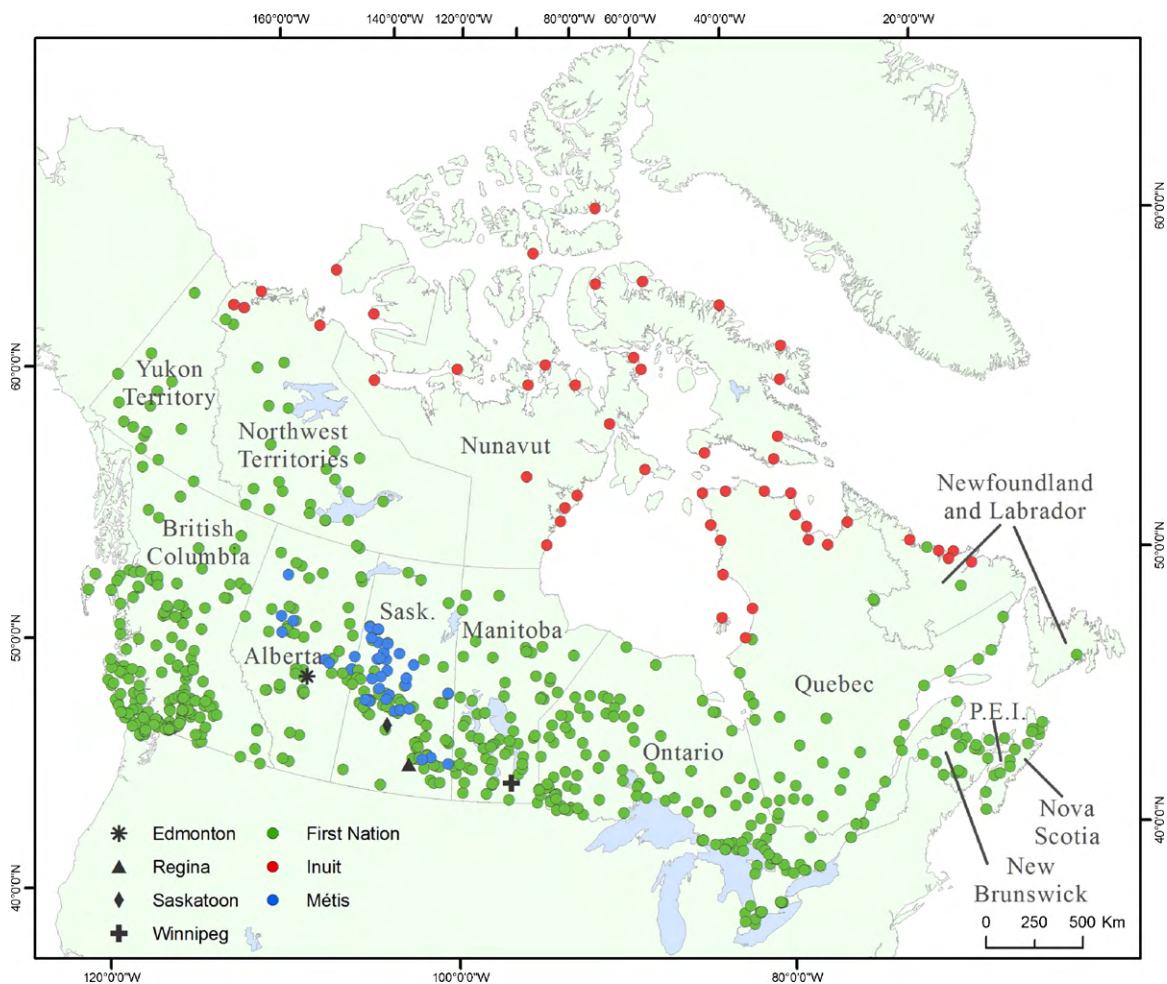


Fig. 1. Location of all reserve and territory based settlements and urban areas where Aboriginal peoples comprise >5% of the population (mapped from data provided by the Aboriginal Canada Portal).

4. Methodology

4.1. A vulnerability framework

We structure the literature review using the concept of vulnerability—a concept that underpins much of the research in the human dimensions of climate change (HDCC) field. Vulnerability is a measure of the susceptibility to harm in a system in response to a stimulus or stimuli, and can essentially be thought of as the ‘capacity to be wounded,’ (Smit and Wandel, 2006). In this paper we are interested in *Aboriginal health systems*, defined collectively as organizations, institutions (formal and informal) and resources whose primary purpose is Aboriginal health. This includes frontline health personnel, community and territorial health authorities, federal agencies, Aboriginal organizations, research bodies, and also individuals and households who are an important informal component of health care provision and advice in many Aboriginal communities. The stimulus or stimuli are health risks linked directly or indirectly to climate change.

A general model of vulnerability has emerged in climate change scholarship that conceptualizes vulnerability as a function of exposure and sensitivity to climate change and adaptive capacity (Ebi et al., 2006; IPCC, 2007b; Smit and Wandel, 2006). In a health context, exposure refers to the nature of climate-related (direct or indirect) health outcomes. Sensitivity concerns the organization and structure of health systems relative to the climate-related health outcomes and determines the pathways through which

exposure is manifest. Adaptive capacity reflects the ability of health systems to address, plan for, or adapt to adverse climate-related health outcomes and take advantage of new opportunities (Ebi and Burton, 2008; Ebi et al., 2006; Ebi and Semenza, 2008; Ford and Smit, 2004). Exposure, sensitivity, and adaptive capacity are not mutually exclusive, with interaction between these components potentially moderating or exacerbating vulnerability. The recognition of the role of adaptive capacity and sensitivity is important, directing attention to health systems themselves and the non-climatic factors operating at multiple spatial-temporal scales that determine how climate change will be experienced and responded to (Ebi and Burton, 2008; Ebi et al., 2006; Ford and Smit, 2004; Ford et al., 2006b).

This general model of vulnerability has been applied essentially in two main ways in vulnerability research (Burton et al., 2002; O'Brien et al., 2007; Ford et al., 2010b). Firstly, ‘end point’ approaches begin by projecting climate change impacts and then estimate potential vulnerabilities to future conditions, and have historically dominated the HDCC literature in general. The first step towards tackling the vulnerability deficit for Aboriginal health using this approach would be to develop climate scenarios to model changing exposure. This is a time consuming and intensive process, however, and is particularly problematic in a Canadian Aboriginal context where baseline data that is needed for health modelling is lacking (Smylie et al., 2006; Smylie and Anderson, 2006). More generally, ‘end point’ assessments have been criticized for neglecting the complex dynamics that shape how climate

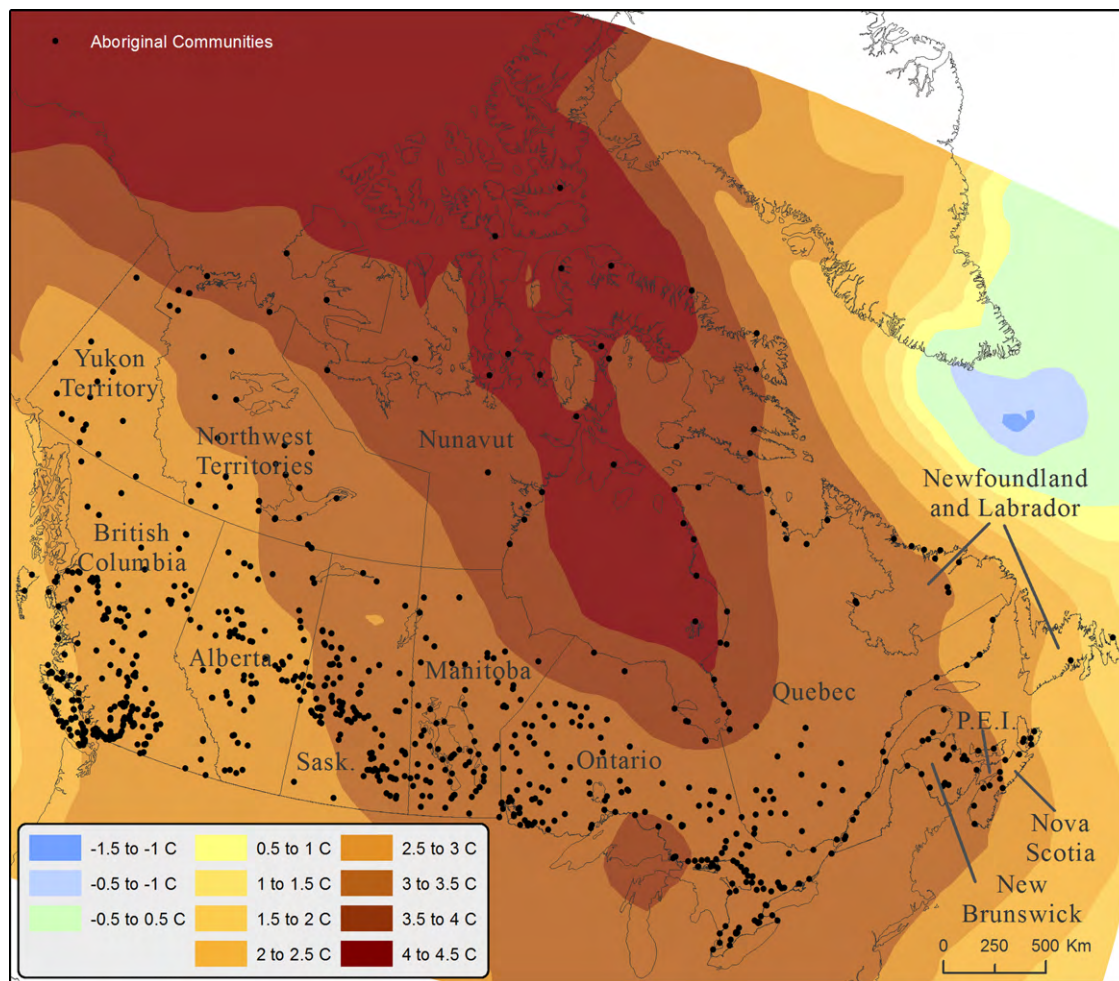


Fig. 2. Projected change in mean annual temperature across Canada by 2041–2060 compared to 1941–1960, based on A1B emissions scenario (data from CCCma). Temperature projections are superimposed on the map of reserve and territory based settlements.

change is experienced and responded to, focus on future conditions and risks as opposed to current stresses that are relevant to the people being affected, neglect of indirect health risks that cannot easily be modeled, and failure to capture the dynamic nature of vulnerability (Brooks et al., 2005; Ford and Smit, 2004; O'Brien et al., 2004, 2007; Smit and Wandel, 2006). Conversely, 'starting point' approaches begin with the system of interest, examining the factors that determine sensitivity and adaptive capacity to climate related risks and change (Burton et al., 2002; O'Brien et al., 2007). Common in the HDCC literature in general (Adger, 2006; Burton et al., 2002; O'Brien et al., 2007; Smit and Wandel, 2006) and increasingly in a health context (Ebi and Burton, 2008; Ebi et al., 2006; Ebi and Semenza, 2008; Furgal and Seguin, 2006), vulnerability here is viewed as a state or condition, not an outcome, continually evolving and changing. The 'starting point' approach seeks, therefore, not to identify vulnerability independently attributable to climate change, but to understand the conditions and processes that predispose a system to negative effects. In the context of the vulnerability deficit this approach directs attention to Aboriginal health systems themselves, a topic which has been the focus of significant research. Recurring themes in this literature concern the social, economic, political conditions that affect Aboriginal health outcomes. This work has renewed importance for understanding climate change vulnerability, and we use a 'starting point' approach to identify and examine the broad characteristics of Aboriginal health systems that influence their sensitivity and adaptive capacity.

4.2. Literature review

We used keyword combinations to search for peer reviewed articles on Aboriginal health published from 1990 to July 2009 using PubMed database. Keywords used included: "Aboriginal" or "Indigenous" or "First Nations" or "Inuit" or "Métis" linked with "climate change," "health," "determinants of health," "climate," "impacts," "vulnerability," "adaptation," "policy," "inequality," "health problems," and "social determinants of health." Information was also obtained from other sources, including Aboriginal organization websites, government reports about the status and health of Aboriginal peoples and health of Canadians in general. Our search was limited to publications in English. Once all relevant sources were identified and retrieved, pertinent information on Aboriginal health outcomes, determinants, and trends, was extracted, categorized, and analyzed using the vulnerability framework described above.

5. Results

In this section we examine the broad characteristics of Aboriginal health systems that will determine vulnerability to climate change. These determinants do not exist in isolation and Fig. 3 captures important interactions and highlights how these broad scale or underlying factors provide the context within which local to regional health systems will experience and respond to

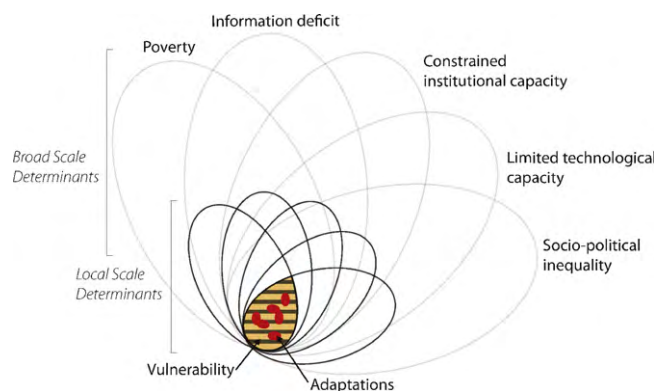


Fig. 3. The broad scale or underlying determinants of vulnerability identified in this review and how they interact together and influence vulnerability at lower levels (based on Smit and Wandel, 2006).

climate change. Table 3 provides an overview of the determinants of vulnerability.

5.1. Poverty

Canada is a wealthy nation consistently placed near the top of the United Nations Develop Programs Human Development Index, and as such is expected to be less vulnerable to climate change (Cooke et al., 2007; O'Brien et al., 2006). National level indicators, however, hide significant disparities, with Aboriginal peoples at substantively higher risk of living in poverty and experiencing housing and food insecurity (Adelson, 2005; McDonald and Trenholm, 2010; PHAC, 2008; Raphael et al., 2008). These gaps continue to grow despite policy intervention, and are particularly pronounced among the remote Aboriginal population (Table 1). A complex interplay of factors has been identified to contribute towards high rates of poverty including low labour force participation, lack of employment opportunities, low educational attainment, loss of land and sovereignty, high cost of living in

remote areas, job market discrimination, and the burden of ill-health (RCAP, 1996; Adelson, 2005; PHAC, 2008).

Poverty influences climate vulnerability at two main levels: individual/household level and institutional level. *Firstly*, at an individual and household level, poverty translates to negative health outcomes through material conditions and associated behavioural factors (Frohlich et al., 2006; Woolf, 2007) increasing the *sensitivity* of Aboriginal Canadians to climate risks. Poverty forces many to live in suboptimal conditions, engage in dangerous livelihood activities, live in areas at high risk, and increases the risk of engaging in unhealthy behaviours (e.g smoking, drinking). Overcrowding in inadequate housing and food and water insecurity, for example, are chronic poverty-related problems facing Aboriginal people across Canada (Boult, 2004; Dunn et al., 2006; Egeland et al., 2010; Ford and Berrang-Ford, 2009; Hamelin et al., 1999, 2002; Lawn and Harvey, 2003, 2004; Shaw, 2004). Those who are nutritionally challenged will be particularly vulnerable to changing access, availability, and quality of traditional foods with climate change, and susceptible to increasing incidence of climate-sensitive infectious diseases (Ford, 2009b; Furgal and Seguin, 2006). Similarly, house overcrowding and high rates of tobacco use increase the risk of person-to-person spread of infectious diseases, favor transmission of respiratory and gastro-intestinal diseases, and increase susceptibility to heat stress; health outcomes with a strong link to climate and expected to increase in prevalence with warming temperatures and changing precipitation regimes (Furgal and Seguin, 2006; Orr et al., 1994; Parkinson et al., 2008). The sensitivity of Aboriginal Canadians will result in health impacts of climate change occurring faster, sooner, and of a greater magnitude than for non-Aboriginal people. This will challenge the ability of health systems to adequately invest time and resources in prevention, preparedness, and response (Lemmen et al., 2008; Seguin, 2008).

Adaptive capacity at an individual and household level is also negatively affected by poverty, with many adaptations exceeding financial means. Poverty has already been noted as a major constraint to adaptation to climate change related disruptions to subsistence hunting and fishing in Arctic regions with implications

Table 3
Conditions increasing sensitivity and constraining adaptive capacity of Aboriginal health systems to climate change.

Determinant	Sensitivity	Adaptive capacity
Economic poverty Low household income, income disparity, high unemployment	<ul style="list-style-type: none"> Individual/household level: unhealthy activities, habitation in hazardous locations, poor nutrition 	<ul style="list-style-type: none"> Individual/household level: constrained access to financial resources, weakening of sharing networks Institutional level: limited resources, other policy priorities
Technological capacity Constraints to health care access, limited early warning/surveillance, high turnover of health personnel	<ul style="list-style-type: none"> Constraints to access to information on existing and new health risks limited Reluctance to seek medical advice 	<ul style="list-style-type: none"> Ability to identify emerging risks, provide early warning, and develop proactive adaptation constrained Reduced trust in medical system
Socio-political values and inequality Marginalization, house overcrowding, food insecurity, cultural links to the land, history of oppression through medical system	<ul style="list-style-type: none"> Cultural activities (traditional foods, camps etc) sensitive to climatic conditions High burden of ill-health Reluctance to seek medical advice 	<ul style="list-style-type: none"> Reduced ability to effect needed change Directs political attention to other, non-climate related, issues Adaptation may not be possible to cultural impacts which imply irreversible loss
Constrained institutional capacity Jurisdictional conflict over health care provision, human and financial resource limits	<ul style="list-style-type: none"> Constrained ability of health systems to identify emerging risks Local understaffing Lack of trust creates reluctance to seek medical advice 	<ul style="list-style-type: none"> Limited long term strategic planning Limited institutional memory Jurisdictional 'turf wars' Local capacity hampered by high staff turnover
Information deficit Limited number of vulnerability assessments specifically at local levels	<ul style="list-style-type: none"> Limited understanding of climate change-related health risks 	<ul style="list-style-type: none"> Lack of knowledge on what to adapt to, available options, and how they would be developed and implemented

for food security (Furgal, 2008; Furgal and Seguin, 2006; Turner and Clifton, 2009; Wolfe et al., 2007). A number of behavioral and psychological conditions associated with poverty including substance abuse, addiction, stress, family disruption, alienation, and compromised education are also strongly associated with limited capacity to identify and respond to risks (Belanger et al., 2008; PHAC, 2008; Tanner and Mithcell, 2008). Research has identified how social networks which increase uptake of adaptive measures and are essential to well-being and managing climate change can be undermined by addictive behaviour (Chan et al., 2006; Beaumier and Ford, in press; Ford et al., 2006a; Pearce et al., 2009). Notwithstanding, a critical factor in moderating the effects of climate change on Aboriginal health lies in the adaptability and the resilience of Aboriginal peoples (Ford, 2009a; Ford and Furgal, 2009; Furgal, 2008; Furgal and Seguin, 2006). Aboriginal peoples have a deep attachment to their lands and their cultures, and this forms part of identity, which is a determinant of health (King et al., 2009). However, Aboriginal cultures and identity are not static or fixed in time. Aboriginal peoples are adaptable if they are allowed to, and current rates of poverty, and associated health impacts challenge this capacity.

Secondly, poverty is a major constraint on institutional capacity to respond to climate change. Institutions with jurisdiction over reserve and territory-based Aboriginal populations are challenged by human and financial resources, and exacerbated by the challenge of poverty (Adelson, 2005; Smylie et al., 2006; Smylie and Anderson, 2006). Substantial shortfalls remain in meeting basic needs, and planning for future health problems frequently ranks behind other existing challenges (Mathias et al., 2008). Even in Nunavut, which is globally believed to be a climate change 'hot spot' and where awareness of climate change is high, health systems at a local and territorial level have not had the financial or human resources to assess or plan for climate change health impacts; poverty related issues are more pressing (Boyle and Dowlatabadi, in press; Ford et al., 2007). To compound these difficulties, it has also been argued by some policy makers that resources and attention directed to climate change should be invested in poverty alleviation, with climate change perceived as a distant, diffuse, and uncertain threat (Mathias et al., 2008). This is ill-advised on a number of levels yet is challenging institutional response to climate change. Firstly, climate change has the potential to exacerbate poverty, further increasing health vulnerability to climate change. Secondly, climate change projections for Canada in the IPCC (IPCC, 2007c) and Lemmen et al. (2008) are now widely believed to be conservative, with significantly greater impacts projected (Barber et al., 2008; Schellnhuber, 2008). Finally, addressing climate change and poverty need not be a zero sum game: climate policy has significant potential for co-benefits and can be mainstreamed into ongoing health activities and planning (Campbell-Ledrum and Woodruff, 2007; Ebi and Burton, 2008; Ebi and Semenza, 2008; Patz et al., 2008).

Ameliorating poverty is a key challenge to improving Aboriginal health, reducing vulnerability to the health effects of climate change, and creating an enabling environment for adaptation. As long as Aboriginal people experience a higher prevalence of poverty than Canadians in general they will bear a disproportionate vulnerability to climate change. Reversing the current state of poverty is a significant undertaking requiring long term strategic investments in sustainable economic development, education, infrastructure, health care, the settlement of outstanding land claims, and greater involvement of Aboriginal communities and organizations in decision making (RCAP, 1996). There is evidence that the cycle of poverty is being broken in some communities and regions, offering hope for the future. The Assembly of First Nations, for example, has recently launched a strategic plan to decrease poverty through creating opportunities, building on community

assets and structural change for management of resources (Assembly of First Nations (AFN), 2007) while the northern territories are trying to harness resource development to provide a basis for creating new and lasting economic opportunities.

5.2. Limited technological capacity

Technological capacity refers to the ability of health systems to identify, respond to, and manage health risks, including those associated with climate change, through the application of appropriate technical strategies or interventions in the areas of diagnosis, treatment, surveillance, early warning, and planning. The Canadian health system generally has a high technological capacity: geographical information systems are widely utilized to project future health burden and optimize planning, advanced treatments and preventive care are universally available, a strong educational and scientific base underpins a vigorous health research sector, and effective surveillance and early warning systems are in development or operation (Davidson, 2004; Gosselin et al., 2005). This capacity reduces vulnerability to climate change and provides a strong basis for adaptive planning (Belanger et al., 2008; IPCC, 2007b; PHAC, 2008).

Aboriginal Canadians enjoy many of the health benefits of the technologically sophisticated Canadian health system. Diagnosis and treatments, for example, are provided to Aboriginal peoples through Canada's universal and comprehensive health care system (Madore, 2001). However, technological capacity to address health outcomes for Aboriginal peoples and plan for future risks is constrained by the *accessibility* of health services and *availability* of technology to health systems, contributing to unequal health burden (Romanow, 2002). This increases the sensitivity of Aboriginal health systems to climate-related health outcomes and compromises adaptive capacity.

Firstly, Canada's remote Aboriginal population frequently note barriers to *accessing* health services, ranging from wait times, a shortage of doctors/nurses in the area, limited access to specialty and emergency services, the cost of transportation to health centres, to complaints that services provided are inadequate or not culturally sensitive (MacKinnon, 2005; Minore et al., 2004b; Muttitt et al., 2004; NTI, 2008; Wardman et al., 2005). This is partly a function of geography. Servicing small communities located in remote regions, many only accessible by air, is difficult and poses significant strain on health budgets. Frontline health care in communities therefore often only involves basic diagnostic and treatment services, with other services provided in regional centres which may require significant travel and associated family disruption and financial stress (Anderson et al., 2009; Muttitt et al., 2004; Wardman et al., 2005). Challenges of geography are compounded by the cross-cultural context of health provision. In particular, high turn-over of frontline health personnel, lack of training on working in Aboriginal contexts for health professionals, language, and history of oppression through the medical system, have been noted to create reluctance among Aboriginal people to seek health advice (Adelson, 2005; Bird et al., 2008; Minore et al., 2004b; Tester and Irniq, 2008). Urban Aboriginal populations generally face fewer problems with health care services widely available. Physical availability of services however, does not ensure health services are accessed or considered accessible; in many ways challenges associated with cultural sensitivity are more pronounced among urban Aboriginal populations as they leave community health networks to the anonymity of urban health systems (Adelson, 2005).

Improving access and reducing inequalities to health services is a major challenge and has significant importance for climate change vulnerability. Preventing, reducing, and managing the health burden of climate change requires individuals having access

to timely and effective information, diagnosis, and treatment (Berrang-Ford, 2009; Kovats and Haines, 2005). While some barriers to health service access reflect the reality of living in remote areas and others will only be overcome over time (e.g. trust in health system), some of the more egregious determinants can be addressed. Entry points suggested in the literature include: collaboration between Aboriginal stakeholders, policy makers, and frontline health workers to improve cultural sensitivity, training of health practitioners in both traditional and western health systems, and improved use of multi-media technology to communicate health messages (Abonyi and Jeffery, 2006; Minore et al., 2004b; Muttitt et al., 2004; Smylie and Anderson, 2006).

Secondly, effective surveillance and early warning systems are critical components of efforts to anticipate and respond to the effects of climate change and other risks on health (Ebi and Semenza, 2008; Harrell and Baker, 2006; Parkinson et al., 2008). Surveillance involves the systematic collection of information on health determinants and outcomes necessary to determine the occurrence and spread of health risks, identify the emergence of new risks, and disseminate information to relevant actors. Early warning systems provide timely information to populations and frontline health personnel when a threat is expected. Current surveillance and early warning capacity for Canada's remote Aboriginal population, is underdeveloped (Furgal, 2008; Furgal and Prowse, 2008; Parkinson et al., 2008). The fundamental challenge, as Smylie and Anderson (2006) note, is the inadequacy of health data for planning: data sources that do exist are often inconsistent, sometimes based on faulty calculation methods, and are of limited coverage, baseline data do not exist for some health conditions and universally accepted measures, collection methods and techniques vary over time limiting the possibility for longitudinal analyses, surveillance among small populations limits analytical capacity for identifying significant changes and thresholds, and culturally and locally specific indicators have not been developed. These problems are compounded by challenges to institutional memory and high staff turnover in Aboriginal health systems noted in Sections 5.3 and 5.4. Early warning and surveillance capacity in Canada's urban centres is generally more advanced, and information on a range of emerging health risks is available to urban Aboriginal populations as part of broader health initiatives. Nevertheless, problems surrounding culturally specific communication, surveillance of Aboriginal-specific health sensitivities, and lack of baseline data on health outcomes, have also been noted in urban contexts (Health Canada, 2007b; Smylie and Anderson, 2006; Tudiver et al., 2004).

For remote Aboriginal populations, existing surveillance is insufficient to detect the occurrence and spread of climate change related health risks, and early warning systems are insufficient to deliver projections in a timely and effective manner (Kondro, 2008; Smylie et al., 2006; Smylie and Anderson, 2006), increasing sensitivity and reducing adaptive capacity to climate-related risks negative health outcomes. Investments are needed to increase surveillance and early warning capacity, including the identification and monitoring of culturally specific and locally relevant health indicators in a systematic manner, examination of the potential to use sentinel health events as indicators, identification of indicators to monitor emerging climate change impacts and vulnerabilities, and development of infrastructure to link indicators to early warning (Eyles and Furgal, 2002; Furgal and Gosselin, 2002). Several Aboriginal groups have initiated projects to develop indicators for surveillance, including climate change indicators, and offer insights for the development of national level systems (Abonyi and Jeffery, 2006). Researchers have also started to work with communities to develop innovative surveillance approaches (Martin et al., 2007; Tremblay et al., 2008). Continuation and expansion of these initiatives requires addi-

tional financial and human resource commitments at all levels of government.

5.3. Socio-political values and inequality

Climate change will result in the emergence of health risks which cross borders, extend over multiple spatial-temporal scales, and span jurisdictions of government departments (Campbell-Lendrum and Woodruff, 2006). Addressing these risks will require new governance structures, including increased participation of vulnerable peoples in decision making, increased accountability, and financial commitments (Costello et al., 2009). Aboriginal Canadians, however, face unique political challenges to achieving a range of social, economic, environmental, and health goals, with implications for sensitivity and adaptive capacity to climate change effects on health. As Damman et al. (2008) note, government policies and actions often do not sufficiently address Aboriginal interests, culture and lifestyle, specifically socio-economic and spiritual connections to the land. Inequality is evident in the neglect of Aboriginal rights which are – in theory – protected by the Canadian Constitution and international human rights obligations of the Canadian state (Damman et al., 2008; Nilsson, 2008; Raphael et al., 2008). Overcrowded living conditions, food and water insecurity, discrimination, and outstanding land claims are a few examples of this neglect, earning Canada rebukes from the United Nations (INAC, 1996; Statistics Canada, 2006b; United Nations Human Rights Council, 2009). Marginalization of Aboriginal peoples has been compounded by refusal of the Canadian government to ratify international treaties which establish obligations for states towards Indigenous peoples including the UN Declaration on the Rights of Indigenous Peoples (UN, 2007), and domestic initiatives including the Kelowna Accord which aimed to substantively invest in programs to address Aboriginal inequality (Government of Canada, November 24–25, 2005; Patterson, 2006).

Political inequality links to climate change vulnerability in a number of ways. Firstly, political inequality has been linked to a range of negative social, economic and health outcomes which increase sensitivity to climate-related health outcomes (Adelson, 2005; Richmond and Ross, 2009). Secondly, concerning adaptive capacity, inequality reduces the political power of Aboriginal peoples to draw attention to pressing issues and develop interventions to manage emerging threats including climate change. This is evident in the reluctance of successive federal governments to advocate Aboriginal rights on an international stage and develop effective policy domestically, for example with regards food and water security, and health inequality (Budreau and McBean, 2008). This is also evident with climate policy. Canada has made limited progress towards meeting its ratified commitments under the UN Framework Convention on Climate Change (FCCC), specifically its mitigation commitments to “stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system,” (FCCC, 1992); indeed emissions have rapidly increased since the signing of Kyoto (Weaver, 2008). The fact that this commitment is unmet has particular relevance for Aboriginal Canadians whose livelihoods are sensitive to climate change, particularly in Arctic regions where a strong climate change signal has already been detected (CBC, 2009; Prowse and Furgal, 2009; Prowse et al., 2009a).

The Canadian state nevertheless has obligations to Aboriginal peoples through the Constitution and human rights treaties. While these obligations have often been overlooked, increasing public sympathy with Aboriginal issues, visibility of inequality, and increasing political power of Aboriginal peoples as reflected in self government for some regions, provides a basis for renewed

political lobbying. The recent apology by the federal government to Aboriginal Canadians for past abuses of the state also potentially signals willingness for a new era of cooperation. This will be important with climate change which has the potential to compromise the basic human rights of many Aboriginal peoples in absence of intervention, particularly in remote and northern regions (Crump, 2008; Ford, 2009a; Lukovich and McBean, 2009). Open and meaningful dialogue will be essential to ensure that policies respect, protect and fulfill the rights of Aboriginal peoples. Federal departments (e.g. Health Canada, Indian and Northern Affairs Canada, Public Health Agency) are also working with Aboriginal communities in vulnerable, mostly Arctic, regions to develop programs and measures to facilitate adaptation.

Aboriginal Canadians are also uniquely sensitive to climate change deriving from the cultural and spiritual relationship to “the land.” The ability to engage in traditional activities (e.g. hunting and fishing) and environmental stewardship remain central to Aboriginal identity and culture and are closely linked to health, even for many urban Aboriginal populations who no longer live on traditional lands or regularly engage in traditional activities. Climate change threatens this: changing ice regimes are limiting access and availability of culturally and nutritionally important animal species, warming temperatures are increasing incidence of abnormalities and certain diseases in animals with implication for meat consumption, coastal erosion is threatening important cultural sites, and changing weather and wind patterns are challenging traditional environmental knowledge (Belanger et al., 2008; Lemmen et al., 2008). Policy intervention can help manage some of these changes but some predicted impacts will result in irreplaceable cultural loss. In Arctic regions, for example, climate change will make some communities uninhabitable and necessitate relocation, in other instances changing access to traditional areas and loss of livelihood may precipitate increased migration away from Aboriginal communities (Parkinson and Berner, 2009). Relocation could lead to an exacerbation of loss of culture and disconnection from the land, with implications for depression, anxiety, and substance abuse (Berry et al., 2010; Hess et al., 2008; Kvernmo and Heyerdahl, 2003). These socio-cultural impacts present *limits* to adaptive capacity, where a limit implies an absolute barrier to adapting (Adger et al., 2009) and indicates the continued importance of mitigation.

5.4. Constrained institutional capacity

Health systems are composed of multiple institutions, including government health departments at municipal to federal levels, frontline health provision, research institutions, international donors, and informal community wellness groups. High income countries including Canada are generally believed to have well developed institutional capacity underpinning the ability to identify, recognize, evaluate, anticipate and respond to health risks and learn from past mistakes. Recent experiences in Canada and developed nations more generally, however, including severe acute respiratory syndrome (SARS), H1N1, and hurricane Katrina, have challenged this complacency (Ebi, 2009; Ebi and Semenza, 2008).

The institutional capacity of Aboriginal health systems in remote areas is a particular concern, and is constrained by two key challenges: jurisdictional conflict over health care provision and human and financial resource limits. Firstly, health care provision in Canada for First Nations and Inuit falls under two jurisdictions, federal and provincial. All Canadians are entitled to comprehensive, accessible, portable and universal health care as stated in the Canada Health Act, 1984, with provinces responsible for providing and financing the majority of health care services. However, provincial jurisdiction on health care in most instances does not

extend to reserves which, along with the territories, fall directly under the jurisdiction of the federal government. Through the First Nations and Inuit Health Branch, the federal government is mandated to provide a range of services to Aboriginal people not covered by provincial jurisdiction, including primary health care and mental health (Madore, 2001). More recently, health transfer initiatives have sought to empower Aboriginal communities and regions directly to manage their own health care with varying degrees of success. Many services remain federally directed however. While in theory this model should cover Aboriginal health needs, the reality is often much different. As documented in the literature, jurisdictional responsibility is not always clear and in some instances is shared, the status of health as a treaty right has not been settled with implications for local level health provision, decision making is often fragmented, and disputes within and between federal and provincial agencies regarding a range of health services for which there are pressing needs impedes health care access (Adelson, 2005; MacKinnon, 2005; Minore et al., 2004b). Urban Aboriginal populations receive health care through provincial health care systems and do not generally face the same jurisdictional challenges.

The consequences of this jurisdictional predicament are fragmented delivery of health care for Aboriginal peoples on reserves and in the territories, uncoordinated management, constrained and short-term policy development, and a bureaucratic maze that constrains health provision and compromises health (King et al., 2009; Kirby, 2003; Romanow, 2002). These problems have implications for climate change vulnerability. Indirectly, institutional constraints increase sensitivity and reduce adaptive capacity to climate change and act as a barrier to adaptation by limiting access to health services, constraining technology transfer and development, and posing barriers to developing baseline information on health vulnerabilities. Directly, institutions characterized by jurisdictional conflicts, limited accountability, and complex bureaucracy are less likely to be able to identify, prepare for, and manage emerging risks like climate change, and learn from past mistakes (Adger, 2000; Berkes et al., 2005; Gunderson and Holling, 2002; Keskitalo and Kulyasova, 2009).

Secondly, institutional capacity, particularly in remote areas, is constrained by human and financial resources. This has direct implications for sensitivity and adaptive capacity to climate change because local capacity is important for identifying and managing risks: evidence from multiple contexts has shown that well developed local health capacity increases the likelihood that policies and actions will be appropriate, effective and acceptable (Blas et al., 2008; Ford et al., 2007). Difficulty in recruiting and retaining human health resources has been widely noted (Bird, 2008; Boyle and Dowlatabadi, in press; Marrone, 2007; Minore et al., 2004a). High staff turnover presents barriers to developing relationships with community members and stakeholders and creates problems for basic service delivery with employees often overworked and fatigued, key positions vacant, and inexperienced personnel undertaking responsibilities for which they do not have the necessary training or expertise. In this context, action on climate change is often undermined by other priorities, dependant on personnel, and subject to sudden change.

If the health of Aboriginal peoples is to be improved, sensitivity to climate change reduced and adaptive capacity enhanced, there is a need to build health systems that work well, provide universal care, ensure enough staff, and provide adequate health education (Adelson, 2005). Policy discussion has focused on numerous ways to address institutional problems including resolving Aboriginal land claims, consolidating fragmented funding, adapting health programs to local priorities, giving Aboriginal people a direct voice in health planning, making Aboriginal health the responsibility of

provincial and territorial governments, and increasing self reliance (MacKinnon, 2005; PHAC, 2008; Richards, 2003; Romanow, 2002). As Romanow (2002) reports, this will require a new structured approach that cuts across jurisdictional barriers and develops a new ethos of coordination and cooperation among government levels. The inadequacy of attempts to address the institutional determinants of poor health that have been widely recognized since the 1990s is discouraging. However, increased self government, self determination, community level health initiatives, and the recent apology to Aboriginal peoples by the federal government provide a strong basis from which to build.

5.5. Information deficit

As Fankhuaser and Tol (1997) argue, “Successful adaptation requires a recognition of the necessity to adapt, knowledge about available options, the capacity to assess them, and the ability to implement most suitable ones.” Without this information, health systems are less likely to develop anticipatory adaptation interventions, leaving them sensitive to climate change risks and constraining adaptive capacity. Vulnerability assessment is an important first step for providing the necessary information for adaptation. As noted in the introduction, however, information on Aboriginal health system vulnerability is limited. This paper goes some way towards addressing this deficit, developing an understanding of the broad level or underlying determinants of vulnerability (Fig. 3). This needs to be complimented by in-depth vulnerability assessments at local to regional scales to examine how broader determinants interact and shape local level factors, and specifically identify high risk regions and groups, characterize sensitivity to important health outcomes, evaluate current health planning in light of current impacts and future projections, and assess and prioritize response options (Fig. 3). Such initiatives require close collaboration with Aboriginal communities, organizations, and policy makers, integrating local expertise, knowledge, and understanding of health determinants (Adelson, 2005; Green et al., 2009; Pearce et al., 2009, 2010; Raphael et al., 2008; Richmond and Ross, 2008).

There is also need for a comprehensive assessment of the various pathways through which climate change will affect the incidence and prevalence of various outcomes affecting Aboriginal health systems, many of which will be unique influenced by livelihoods, living conditions, and traditional food cultures. Uncertainty about climate change impacts on Aboriginal health characterises much current scientific understanding, and is magnified at regional and local levels where risks are largely unknown among policy makers and communities. This constrains effective risk assessment and planning. Improved scientific understanding needs to be complimented by more effective partnerships with Aboriginal communities and organizations and culturally relevant knowledge translation.

6. Conclusion

The significant body of literature on Aboriginal health provides considerable insights on the broad level determinants of vulnerability which will shape the extent to which Aboriginal health systems are able to prevent, prepare for, and manage the effects of climate change. A number of key trends are highlighted in the review:

- Material conditions and behaviours associated with poverty will increase sensitivity and constrain adaptive capacity to climate change.
- Surveillance and early warning capacity for those living in remote regions is underdeveloped for identifying emerging risks and vulnerable populations.

- Comprehensive, reliable, and culturally specific health assessment measures from which to assess climate change impacts are absent.
- Access to health information, diagnosis, and treatment is insufficient for timely and effective intervention to manage climate-sensitive health outcomes.
- The special rights and needs of Aboriginal peoples have often been neglected, resulting in continued and persistent inequality which exacerbates climate change health vulnerability.
- Institutions responsible for Aboriginal health are challenged by jurisdictional conflict and resource constraints, limiting the ability to identify and prepare for future risks and address inequalities.

These underlying determinants provide the context within which health system vulnerability at regional to local levels will be influenced. How they influence vulnerability at lower scales, however, will not be uniform. Inuit will probably experience the greatest vulnerability to climate change on account of the sensitivity of Arctic environments to climate change, magnitude of projected changes, remoteness of communities, dependence on the environment, burden of poor health, and limited institutional capacity (Furgal and Prowse, 2008; Furgal and Prowse, 2009). However, the settlement of outstanding land claims with Inuit could provide the basis for progress in addressing inequalities that lie at the heart of many health problems (Tester and Irniq, 2008). The challenges facing First Nations and Métis will be similarly diverse, reflecting colonial history, extent of environmental dispossession, existence of outstanding land claims, and local institutional capacity and accountability. Geography also matters. Aboriginal peoples living in remote areas generally face more challenges and enhanced climate vulnerability than urban populations on account of their remoteness, close links to the land, and more pronounced socio-economic-political marginalization. Access to informal health networks (e.g. through family, community wellness initiatives), however, remain strong in remote settlements and more is known about the burden of ill health among remote Aboriginal populations than urban-based populations (Adelson, 2005; Wilson and Young, 2008).

The factors that are identified here as creating Aboriginal health system vulnerability in Canada are also evident among Indigenous populations in other ‘fourth world’ contexts. Similarly, many adaptation challenges noted here are comparable to those documented by other studies in mostly middle- and some low-income nations, challenging the generalization that developed nations have a high capacity to adapt to climate change. Yet despite this, there are few examples of systematic attempts to assess the vulnerability of Indigenous peoples, identify adaptation needs, or initiate adaptation action. As has been argued in the general climate change and health literature, a new public health movement is required to promote adaptation to the health effects of climate change (Costello et al., 2009). For Indigenous peoples in developed nations this movement needs:

- **Interdisciplinary scientific research** to characterize climate vulnerabilities specifically at local and regional levels and identify and prioritize opportunities for adaptation.
- **Health sector leadership** to integrate climate change into health planning and provide guidance on the risks of climate change and importance of adaptation.
- **Effective communication** from frontline health professionals on actions that can reduce sensitivity and increase adaptive capacity to climate change effects on health.
- **Government action** to uphold the rights of Indigenous peoples, tackle inequality, coordinate climate change adaptation planning across departments, and provide financial and human resources.

- **Institutional reform** to improve health care access and delivery.
- **International cooperation** to transfer experience and knowledge from other contexts.
- **Co-ordination and collaboration** between clinicians, public health officials, scientists and policy makers.

And most importantly

- **Partnership with Indigenous peoples and organizations** is imperative to identify health needs, generate knowledge, prioritize adaptations, and improve the functioning of health systems.

Acknowledgements

This project was supported by the Social Sciences and Humanities Research Council of Canada, the Canadian Institutes of Health Research, ArcticNet, and the International Polar Year CAVIAR project. Two anonymous reviewers provided detailed and constructive feedback. Thanks to Adam Bonnycastle for figures 1 and 2.

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