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Peter Berry, Anna Yusa*, Toni Morris-Oswald, Anastasia Rogaeva

Heat Alert and Response Systems in Urban and Rural Communities in Canada

Abstract: Health Canada reviewed national and international literature to develop a framework that identifies best practices for developing and implementing Heat Alert and Response Systems (HARS) to protect citizens from extreme heat events. A comparative case study was conducted based upon the framework and the experiences of two Canadian jurisdictions that piloted many of the best practices in the development of new HARS. Table-top exercises, heat-health vulnerability assessments, and community consultations were used to inform the development and implementation of HARS plans. Implementation of the framework by local authorities revealed different and unique challenges facing rural and urban communities in protecting people from extreme heat events. Opportunities within each pilot for taking effective public health adaptive actions that draw upon existing strengths and resources were also identified. Key aspects of HARS development including those related to education and engagement, development of an alert protocol, creation of a heat response plan, and identification of communication activities should be tailored to the needs of individual communities or regions and be informed by specific characteristics related to existing and future vulnerability.

Keywords: climate change, extreme heat events, heat alert and response systems, adaptive capacity, resiliency, rural, urban, urban heat island

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***Corresponding author: Anna Yusa:** Environmental Health Program, Health Canada, E-mail: anna.yusa@hc-sc.gc.ca
Peter Berry, Anastasia Rogaeva: Climate Change and Health Office, Health Canada
Toni Morris-Oswald: Office of Disaster Management, Manitoba Health

1 Introduction

There is widespread agreement among scientists that climate change poses significant risks to the health of Canadians and people around the world; therefore, efforts are needed to adapt [1-3]. Health risks from extreme heat events – a climate-related hazard that is exacerbated by climate change – are a significant public health concern [4,5]. Extreme heat events are associated with short-term increases in mortality, particularly among vulnerable populations such as older adults, those with chronic illnesses, and socially disadvantaged people [6-10]. Extreme heat events in Canada can result in significant loss of life. In British Columbia, an extreme heat event over an eight-day period in 2009 resulted in an estimated 156 excess deaths in the lower mainland area [11]. In Europe, there have been examples of catastrophic impacts from extreme heat as illustrated by an event in 2003 which resulted in an estimated 70,000 deaths [12]. More recently, the 2010 heat event in Russia led to an estimated 55,000 deaths [13]. Heat events can also result in significant increases in morbidity related to heat rash, heat edema, loss of consciousness, heat cramps, heat exhaustion, and heat stroke [4,14,15].

Heat exposure is influenced by environmental factors which may differ significantly between rural and urban areas. The "urban heat island" (UHI) effect is one well known example. There can be differences in temperature between an urban and surrounding rural area due to the UHI effect, whereby the urban area may be warmer as a result of development-related changes that have been made to the physical environment [16]. Less vegetation, more asphalt and concrete surfaces, reduced airflow and anthropogenic heat sources (e.g. factories) in urban areas can result in temperatures several degrees higher than the surrounding countryside [5,17,18]. However, the effects of heat on health are observed in both urban and rural communities [19,20].

The World Health Organization (WHO) has called on health agencies to take actions to protect people from the impacts of climate change [21], including risks associated

with extreme heat events [22]. The development of HARS is a key adaptation to the increased frequency and severity of extreme heat events [23,24]. National, regional and local health agencies in various countries such as Canada [4], the United States [25], Australia [26], England [27], France [23], and Italy [23], have begun developing these systems to reduce heat-health risks. Due in large part to differences in local context, extreme heat planning and response activities that are developed and implemented as part of HARS often differ in scope, types of public health interventions employed, target populations for outreach and communications, and the degree and nature of stakeholder involvement [4,23].

Examination of HARS plans and guidance documents from the WHO, the United States Environmental Protection Agency (EPA), Europe, Australia, and Canada suggested that a few core elements are commonly included by many international agencies and local communities involved in reducing health risks from extreme heat [22,25-28] (See Table 1). Based on this information, Health Canada identified a framework for developing and implementing HARS to protect citizens from extreme heat events [4] (See Figure 1).

Heat alert and response systems have the following core elements:

Community Mobilization and Engagement — A coordinating agency is required to prepare a community for the upcoming heat season by identifying community needs, recruiting stakeholders and developing plans to implement a HARS. This coordinating body should have capacity to review plans in the off-season and implement improvements from heat season to heat season.

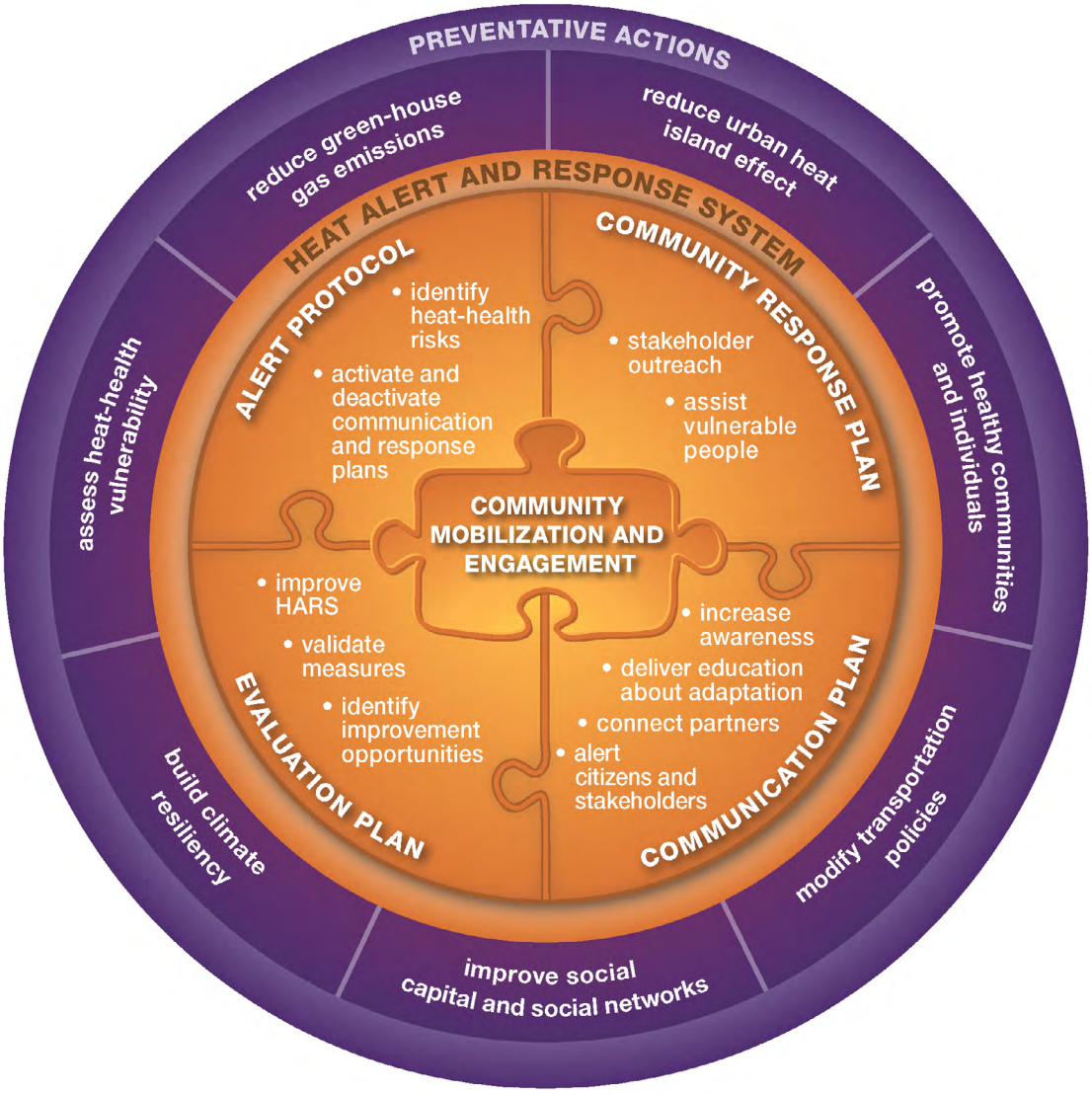

Figure 1: Community HARS and preventative actions to reduce heat-health risks [4].

Table 1: Core elements of HARS and preventative actions [4].

	WHO	EuroHEAT	U.S. EPA	Australia	England	Canadian Communities
Community mobilization and engagement--Requires a coordinating agency to prepare the community for the upcoming heat season by identifying community needs, recruiting stakeholders and developing plans to implement a HARS.						
Identify a principal coordinating agency	X	X	X	X	X	X
Engage broad stakeholders	X	X	X	X	X	X
Organize and develop HARS	X	X	X	X	X	X
Mobilize community	X	X	X	X	X	X
Lead pre-heat season preparations	X	X	X	X	X	X
Alert protocol--Identifies weather conditions that could result in increased morbidity and mortality in the region. The protocol is used to alert the public, as well as government officials and stakeholders, who then take pre-determined actions to protect health.						
Establish formal alert protocol	X	X	X	X	X	X
Reflect local weather conditions	X	X	X	X	X	X
Reflect heat-health vulnerabilities	X	X	X	X	X	X
Include activation protocol	X	X	X	X	X	X
Include deactivation protocol						X
Community response plan--Facilitates actions by individuals to protect themselves during periods of extreme heat by directing public health interventions aimed at reaching vulnerable individuals who require assistance.						
Establish formal community response plan	X	X	X	X	X	X
Include measures tailored to the needs of vulnerable populations	X	X	X	X	X	X
Stakeholder driven	X	X	X	X	X	X
Communication plan--Raises awareness about the impacts that heat may have on health and provides advice through media releases, interviews and websites on how to reduce health risks.						
Establish formal communication plan	X	X	X	X	X	X
Develop pre-season education and awareness campaign	X	X	X	X	X	X
Identify and plan to address contradictory messages	X		X	X	X	X
Include audience-specific heat-health messages and outreach strategies	X	X	X	X		X
Evaluation plan--Assesses HARS activities and facilitates improvements. Aims to evaluate the extent to which implemented measures are timely, relevant, effective and meet local priorities and contribute to the reduction of health impacts.						
Establish formal evaluation plan	X	X	X	X	X	X
Implement real-time health surveillance	X	X			X	X
Hold end-of-season evaluation	X	X	X		X	X
Preventative action: --Reducing the urban heat island--Addresses heat-health risks through measures designed to reduce urban heat.						
Investigate the urban heat island effect		X		X	X	X
Plan long-term (e.g. implement urban heat island mitigation measures)	X	X	X		X	X

1 Heat-health documents and plans were reviewed to populate this table. They included *Heat-Health Action Plans: Guidance* (WHO) [22], *Improving Public Health Responses to Extreme Weather/Heat-Waves-- EuroHEAT: Technical Summary* (EuroHEAT) [28], *Excessive Heat Events Guidebook* (U.S. EPA) [25], *Heatwave Plan for Victoria: Protecting Health and Reducing Harm from Heatwaves* (Australia) [26], H*eatwave Plan for England: Protecting Health and Reducing Harm from Extreme Heat and Heatwaves* (England) [27]. In addition, HARS plans from six Canadian communities (four Health Canada pilot communities and the cities of Toronto and Montréal) were reviewed. The existence of a specific HARS element in three or more of the six communities was required for this core element to be positively identified in the chart.

Alert Protocol — A key element of the alert protocol is identification of weather conditions that can result in increased local morbidity and mortality. The protocol is used to alert the public to the level of risk, and alert a wide range of stakeholders – governmental and nongovernmental – who have a role in mitigating the heat-health impacts through pre-determined actions.

Community Response Plan — A community response plan identifies and supports actions by individual community members to protect themselves during periods of extreme heat; it emphasizes and directs public health interventions aimed at reaching vulnerable individuals who are likely to require additional assistance. Actions that can be undertaken within the community to reduce negative health impacts may include, for example, extension of hours of operation of local shopping malls or swimming pools to provide additional cooling options to residents or distribution of water to homeless populations.

Communication Plan — Communication plans developed as part of a HARS raise awareness about the impacts that heat may have on health. The plans provide advice on individual actions that can mitigate harm from extreme heat exposure through various communication mechanisms such as carefully timed media releases, interviews and website information.

Evaluation Plan — Evaluation plans are required to assess HARS activities and facilitate improvements through an iterative process. Evaluations must consider the extent to which implemented measures are timely, relevant, effective, meet local priorities, and contribute to the reduction of health impacts.

A HARS contributes to long-term heat resiliency among a population when the five key components (described above) are delivered in conjunction with preventative actions that provide sustainable protection from extreme heat events (e.g., reducing the urban heat island, modifying transportation policies, improving social networks). In development of the core components of a HARS, there is evidence that the health risks associated with extreme heat events are most effectively reduced by [4]:

- identifying target population groups and geographical areas by conducting community based vulnerability assessments
- ensuring that a HARS plan is designed to address local needs and priorities
- engaging stakeholders who are best positioned to add value to a HARS
- issuing alerts with a community-specific trigger that is established based on knowledge of the relationship between heat and health
- providing response measures that reduce heat-health risks and meet the needs of those people most vulnerable to heat
- choosing communication strategies that increase awareness and change behaviours
- monitoring HARS activities and evaluating them at the end of the heat season
- implementing long-term preventative actions that reduce heat exposure and negative health outcomes (e.g. mitigation of the urban heat island)

Information and advice are available to assist health sector decision makers develop and implement HARS [4,22,25,29,30,72]. However, evaluations of the effectiveness of these systems are few in number [4,23,29]. One study of the July 2010 extreme heat event in Quebec, Canada suggested that the province-wide HARS in combination with the increased use of air conditioning have led to a reduction in heat-related deaths over the last 20 years in that province [32]. Guidance for conducting evaluations of HARS was recently developed [31].

While key components of a HARS have been broadly identified, public health authorities in Canada are seeking information about the best ways to protect health that are tailored to the unique circumstances of their jurisdictions and that can address sources of local vulnerability. Differences in the vulnerability of rural and urban communities to the impacts of climate change have been highlighted in the literature [18,35,50]. Vulnerability of individuals and communities to impacts varies with the level of exposure to climate hazards, the sensitivity of individuals to health impacts, and the programs and activities that can lower risks to health. For example, communities with well-established health and medical facilities are better able to protect the health of citizens from climate change impacts [1,33]. The ability to prepare for and respond to these impacts, including those on health, varies across Canadian communities [34,36] and significant differences in vulnerabilities and in the capacity to develop and implement HARS can exist between urban and rural communities in Canada. Unique challenges are faced by these communities and unique strengths can be harnessed in an effort to protect health.

A comparative case study of HARS development within the rural southwest section of the Assiniboine Regional Health Authority (ARHA) of Manitoba[1] and

1 In 2012, the province of Manitoba reduced the number of health regions from 11 to 5. At this time, the ARHA and two other regional health authorities merged to form the Prairie Mountain Health Authority.

the City of Windsor, Ontario is described in this study. Challenges faced and strengths identified by these health authorities in developing and implementing effective programs and activities to reduce heat-health risks are highlighted. The paper concludes by recommending actions to aid in HARS development in rural and urban communities.

1.1 Abbreviations / Acronyms / Terms:

ARHA - Assiniboine Regional Health Authority
First Nation - Usage of the term includes reference to both Status and non-Status Aboriginal people in Canada from one of three cultural groups (recognized under the Canadian Constitution Act) as well as the Inuit and Métis [37]
HARS - Heat Alert and Response Systems
Humidex (Canada) – Indicates perceived temperature by taking into account both temperature and relative humidity [38]
UHI - Urban heat island

2 Methods

The comparative case study was conducted from the experiences of the community of Melita within the ARHA and the City of Windsor in their development of HARS from conception to implementation. Both communities collaborated with Health Canada to pilot the development of their HARS based upon the core elements identified in the guidance document [4]. The communities chosen for the comparative case study experience four distinct seasons and are known to have high summer temperatures. Windsor, located along the Canada–US border, is the southernmost city in Canada with a population of 216,473 [39]. It is located in the Little River, Turkey Creek, and Detroit River watersheds on relatively flat land [40] (See Figure 2). Windsor is known for its high summertime temperatures and has the highest annual number of days with a humidex value above 35 in Canada [41].

Melita is a small farming community in the rural municipality of Arthur, located in southwestern Manitoba. It is approximately 320 km southwest of Winnipeg, 30 km north of the US border, and 35 km east of the Saskatchewan border (See Figure 3).

Melita has a population of 1,051 people and can experience temperature extremes in the summer. On average, between 1971 and 2000, the nearby climate station in Pierson, Manitoba recorded over 18 days above 30°C; such days are often accompanied by high humidity [41]. The ARHA provided a wide array of health services (e.g. public health, health promotion, emergency medical services, personal care home services, mental health services) to 25 communities in rural southwestern Manitoba, including Melita, at the time of this study. It has since amalgamated into a larger health region, the Prairie Mountain Health Authority. The town of Melita, which was the focus of the HARS pilot within the ARHA, participated in an extreme heat table-top exercise and a local vulnerability assessment.

To inform the development and implementation of their HARS plans, health authorities within each pilot used results from the community-based table-top exercises and heat-health vulnerability assessments[2]. The table-top exercises simulated the occurrence of an extreme heat event in the respective communities and surrounding areas to test existing emergency plans and procedures for protecting health. They brought together key stakeholders that have a role to play in implementing the HARS in real emergency situations[3].

The heat-health vulnerability assessments gauged overall individual and community vulnerability to extreme heat events through an examination of community-specific sensitivities, exposures and capacities to aid populations requiring assistance during these events. The vulnerability assessments employed a mixed methods approach for investigating risks to populations from extreme heat and the ability to adapt in the respective communities. Participatory approaches were used in conducting both assessments to allow for the involvement of a wide range of community stakeholders with detailed knowledge of vulnerable populations, including local needs during extreme heat events, and community programs and resources in place to address them. Facilitated discussions with stakeholders were primary sources of qualitative data and community-based knowledge used in the assessments.[4] The assessments also included the use of quantitative data including, for

2 From 2008 to 2011, Health Canada collaborated with four communities or regions to pilot development of a new HARS to address heat-health risks. Through this process each community developed a HARS strategy, and implemented alert and response measures and education and outreach activities to raise awareness of heat-health risks among stakeholders and the public. The pilots included the ARHA and the City of Winnipeg in Manitoba, the City of Windsor in Ontario and the City of Fredericton in New Brunswick.

3 See [57,58] for further details on the table-top exercises, including the methods employed.

4 See [49,65,71] for further details on the vulnerability assessments, including the methods employed.

Figure 2: Windsor, Ontario [42].

example, information on current climate-related disease burdens from Statistics Canada and projections of future health risks from climate change in studies already reviewed in the literature.

Assessment workshops were held in May 2010 and June 2010 to obtain input about local understanding of community heat-health risks and vulnerabilities from key informants in the City of Windsor and Windsor-Essex County respectively. The table-top exercise in Windsor occurred on February 24, 2010 and included 41 participants. Although development of the rural HARS pilot in Manitoba was led by personnel from the larger ARHA, the table-top exercise and vulnerability assessment workshops were undertaken within the single community of Melita. The assessment workshop took place in Melita on March 18, 2010. Included among the 18 participants were key informants such as public health staff, community council members, emergency managers, public utilities staff (e.g. Manitoba Hydro) and local opinion leaders. This was followed by an extreme heat event table-top exercise on May 28, 2010 in Melita that included 26 participants from governmental and non-governmental organizations that are involved in implementing the HARS.

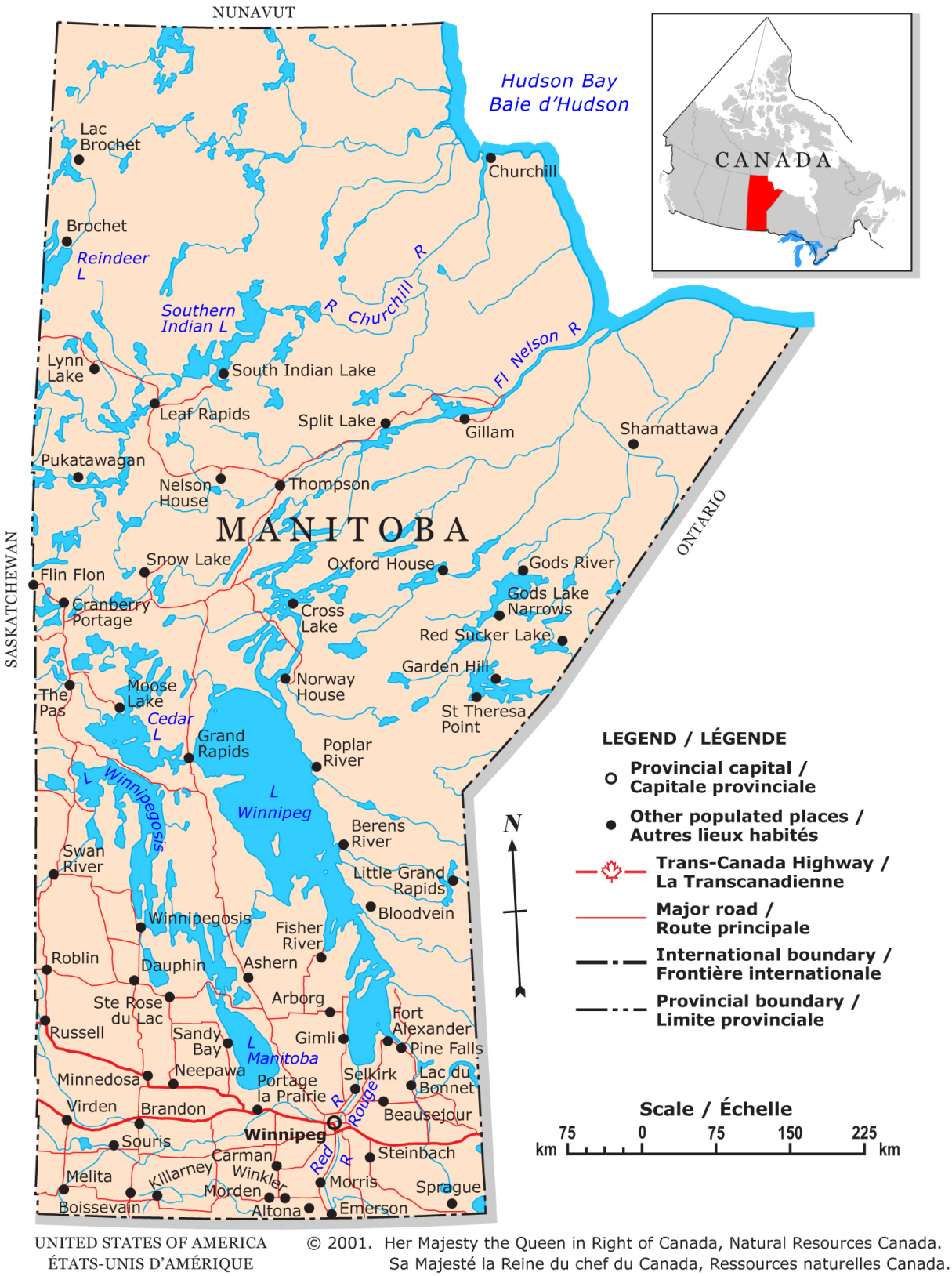

Figure 3: Melita, Manitoba, within the former Assiniboine Regional Health Authority [43].

3 Results

3.1 Urban-Rural Differences: Challenges and Opportunities for Protecting Health from Extreme Heat

Comparison of HARS development in Windsor and ARHA revealed important differences in exposures to extreme heat requiring mitigation, methods used to identify vulnerable populations, cooling options provided for high risk populations, and the extent of efforts to raise awareness to promote protective behaviours.

3.2 Exposure to Heat Stress

The vulnerability assessments in Windsor and Melita highlighted different factors that may increase the exposure of populations to extreme heat events. For example, urban heat islands have been documented in Ontario along the highly developed Toronto–Windsor corridor [49]. To address the contribution of the UHI to heat-health risks in Windsor, the City is undertaking actions to alter the built environment [49]. In addition, Windsor has a long history of poor air quality; warmer temperatures may amplify impacts on health from air pollution in Windsor [47,48,50]. In the case of Melita, air quality data is only available for Brandon, Manitoba, which is located approximately 100 km away from Melita. Brandon is a larger community with many more emissions sources. Even so, in 2006, the seasonal average daily maximum ground-level ozone value reported for an 8-hour period in Brandon was between 35 and 40 ppb which was well below the Canada-wide target standard for ground-level ozone of 65 ppb [65]. There have been no reported UHI effects for the town of Melita or surrounding areas and therefore UHI mitigation measures were not included as part of the ARHA HARS activities. In both communities electrical service interruptions can be common and are of concern as they could increase vulnerability if access to air conditioning is affected during extreme heat events [49,65].

Both communities hold festivals and outdoor events during the summer season that result in an influx of visitors which may increase morbidity and mortality from extreme heat events. In 2002, nearly half of the 211 million tourist-visits in Canada were to predominantly rural regions [51]. Given larger populations in urban areas, rural communities experience proportionally greater influxes of tourists and therefore may have higher vulnerability to extreme heat events in this regard. Summer events held in Windsor often attract large numbers of tourists. Similarly, the town of Melita, and surrounding ARHA area, can receive many visitors during this season who participate in activities such as golfing, camping and children's camps. To avert the risk of heat-health emergencies during these events ARHA included provisions within its HARS [52] that are now being increasingly adopted across the larger region encompassed by the new regional health authority.

3.3 Identifying Vulnerable Populations

Analysis of the relationship between temperature, humidity and excess mortality in the City of Windsor was used to identify an alert trigger for calling heat alerts as part of the community's HARS. Results showed that at approximately 29°C/84°F excess mortality begins to increase as ambient temperatures increase [49]. The following triggers are used to call heat alerts in Windsor [53]:

Heat Advisory Level 1
- one or more days reaching a humidex above 40 is forecasted

Heat Warning Level 2
- four or more days reaching humidex of 40
- one or more days reaching humidex of 45
- four or more nights above humidex of 28

Heat Emergency Level 3
- severe or prolonged emergency

A Heat Advisory (Level 1) draws attention to potential health concerns from heat exposure for populations considered more vulnerable such as seniors, or those who are active outside. It is also intended to raise awareness among agencies participating in the HARS [54]. A Heat Warning (Level 2) is called when conditions may pose health concerns for the broader public and is accompanied by dissemination of information to vulnerable populations. At the same time, local health services and aid agencies prepare for a potential increase in service demand and impacts [54]. A Heat Emergency (Level 3) is called when there is a severe or prolonged emergency in the community during extreme heat, such as power outages or water shortages [54].

In Melita and the ARHA, it was not possible to establish a temperature-mortality relationship due to the large geographic area and low population density which limited the amount of data for analysis. This made development of an alert trigger more difficult. Trigger values were established using the mortality curves for the larger centers of Winnipeg and Brandon. Provincial heat alert triggers have been established in Manitoba and

when the thresholds are forecasted to be reached within the respective regional health authorities, alerts are sent to them so they can implement their regional HARS plans.

A large proportion of the population in both communities was found to be more sensitive to heat stress through analysis of demographic and health data. In 2006, 14% of the population of Windsor was over 65 years of age [39] which is close to the national figure of 13.9%. Similar to the Canadian trend, the number of seniors is expected to grow rapidly in the future [55]. In contrast, the proportion of Melita's population older than 65 (27%), is much higher than the national figure. People in both Windsor and Melita suffer more proportionally than other Canadians from some chronic diseases that are known to exacerbate heat-health risks (e.g. high blood pressure, diabetes, obesity, circulatory diseases) [49,65].

3.4 Cooling Options for High Risk Populations

The City of Windsor offers a variety of recreation and leisure programs and facilities to aid in personal cooling including arenas, indoor pools, outdoor pools, wading pools, splash pads, fitness and leisure centres, community centres and libraries [49]. As part of its HARS the hours for these facilities may be extended. Melita also has a range of facilities that can provide cooling opportunities including a seasonally-operated outdoor swimming pool, an arena, curling rink, bowling alley, seniors centre and library. However, the public buildings are also relatively small, which may necessitate ensuring there are alternative locations for cooling [56]. A lack of air conditioning on school buses or in schools was also identified as of concern to public health officials [57]. Furthermore, in one ARHA (First Nations) community in close proximity to Melita, there are insufficient buildings with air conditioning to provide relief to the local population during extreme heat events. At the time of the Melita table-top exercise, no generators were available in this (First Nations) community in the event of a power outage [57].

The effectiveness of cooling centres requires that populations at higher risk from extreme heat have adequate access to them [4]. The City of Windsor offers transit service for the public that may be used by those seeking respite from the heat. However, transit service is reduced during the summer. One of the recommendations from the Windsor table-top exercise was to develop a strategy for the transportation of people to alternate locations during heat events [58].

The population of Melita is dispersed over a large area and the town lacks regular transit services. This can present challenges for emergency and social services staff to assist vulnerable individuals during emergencies [52] and reduces access to cooler environments during extreme heat events. Higher risk populations, such as those that have mobility challenges living within this area, have access to a Handi-Van service that can provide transport from home to cooler environments. One of the noted advantages of a rural community such as Melita was the strength of social networks; it was cited that community members know each other well, and would assist those needing relocation to a cooling center if necessary [52].

3.5 Raising Awareness to Promote Protective Behaviours

To increase awareness among higher risk populations of the dangers from extreme heat events and of recommended protective actions, both Windsor and ARHA have undertaken or participated in proactive education and outreach activities tailored to their unique circumstances. For example, in Windsor, marketing experts were consulted to develop the STAY COOL Windsor-Essex logo and branding strategy. As well, communications goals were supported by a range of outreach strategies such as [4]:

- Educating the public about heat-health risks and adaptive measures–created a hub for communicating about heat-health issues; developed a media plan; launched an education campaign; informed city residents and visitors about who will issue heat alerts; completed an audit of existing heat alert communication practices.
- Educating emergency responders and service providers–hosted train-the-trainer events to educate community partners on indicators of heat-health messages; made available education tools and key messages; gained support for expanded participation by community partners during heat alerts (e.g. open cooling facilities, check on heat-vulnerable populations).

In the ARHA information about reducing health risks from extreme heat events was made available to the public through the following mechanisms [52]:

- Media communications (e.g. newspaper, radio, television, informational resources such as heat-health fact sheets, brochures, children's coloring sheets)
- Dissemination of information to medical clinics and doctors' offices

- Posting of information on Manitoba Health (provincial) and ARHA websites
- An information line dedicated to providing health advice on a variety of topics (Health Links Info Santé)

However, challenges associated with HARS communications activities in rural regional health authorities like the ARHA can arise. Issuing timely alerts is difficult due to weekly media deadlines and limited local news coverage [52]. As well, the radio stations that people in some southern areas of the province listen to originate across the border in the United States. In Ontario, and within the Windsor area, communications challenges faced by many communities relate to inter-jurisdictional differences (i.e. from one municipality to another) in the use of alert triggers. Confusion due to conflicting messages when heat and smog alerts are issued can also be problematic [45].

In both communities a broad range of stakeholders and organizations participated in development of the HARS and they continue to play important roles in planning, communications and response activities. Social networks and the resultant personal connections between people providing social support services (e.g. services for seniors) to vulnerable persons were reported to be particularly strong in the rural community of Melita. Many higher risk individuals such as seniors requiring in-home assistance, or people with chronic diseases, are well-known to health care providers because of the small population base; there are close connections between community members and health and home care workers [52]. This is important in mitigating social isolation which is an important contributor to vulnerability for heat-related illness and death [9]. In addition, given the social connectedness which is often typified in rural communities [59] there is well-developed volunteer capacity within Melita. This provides an important resource when community members require assistance during extreme heat events.

A key challenge in Melita and in other regions of rural Manitoba in the development of HARS is engaging and maintaining the interest of local leadership, community stakeholders and emergency managers whose role it is to prepare for heat emergencies. This is due, in part, to the fact that representatives responsible for emergency management services in such communities are often volunteers or part-time employees with many demands placed on them [52]. A further concern is the advanced age of many volunteers in the ARHA, making many community volunteers part of the at-risk population during extreme heat [57].

4 Discussion

The adoption of HARS by an increasing number of cities and regions within and outside of Canada has increased knowledge of effective measures to reduce health risks among vulnerable populations. Evidence has shown that a community-specific alert protocol based on available health outcome data, a proactive communications plan with clear and consistent messaging, aggressive community response measures to assist those most vulnerable, regular monitoring of health outcomes and the implementation of preventative actions (e.g. reducing the UHI effect) are necessary to reduce risks from extreme heat [4,22,25-28].

Adaptation efforts to address climate change impacts on health benefit from community approaches to engagement, vulnerability assessment, and actions to increase adaptive capacity [45,60]. Public health officials charged with implementation of HARS to protect health should understand important differences between communities including those linked to their urban/rural nature that impact the ability of residents to be protected from the negative health impacts of extreme heat. As shown in this comparative case study differences may exist with respect to population sensitivity, level of exposure to extreme heat, and in capacity to take protective actions. These differences can present challenges when efforts are undertaken to reduce heat-health risks and may make such measures less effective. For example, evidence suggests that communities with greater resources can take needed steps to reduce climate change-related health risks (e.g. develop HARS) [18]. In contrast, communities with very limited transportation and communications infrastructures experience increased isolation and therefore greater vulnerability of populations to emergencies [61] and extreme heat events [62]. In smaller Canadian communities, formal public transit services are often absent given the smaller and more dispersed populations [62]. Instead, communities may have services for specific groups such as seniors and/or schoolchildren [63]. Small towns and rural communities often face unique challenges in developing and implementing extreme heat and health communication campaigns [72]. In Canada, more generally, there is a considerable gap in the use of information communication technology, such as the Internet, between urban and rural/remote communities [64]. Consequently, the effectiveness of this technology in risk management varies between communities. There are also fewer health care services in rural and remote areas [66], which may increase vulnerability to extreme heat events.

Large urban communities have higher population densities [18] and often have large areas that experience the UHI effect which increases exposure to extreme heat events [67]. Huang et al. [29] suggest that one of the key strategies for reducing heat-health risks includes improvements to housing and urban planning. Windsor is already considering how changes to the built environment can affect heat-health [49]. In other areas of Canada, there are a number of occupations that may increase the exposure of workers to heat stress such as farming, mining, and forestry; these are more prevalent in, or exclusive to, rural areas [68]. In the ARHA, the assessment revealed a need to target occupations such as construction, farming or oil field labour. Education of health care professionals about heat-health impacts among these occupational groups helps increase awareness of risks and enhanced planning. The local HARS plan addresses higher risks from extreme heat in relation to certain occupational groups by recommending, for example, a shift in work hours (e.g. day to evening shifts) during a heat event in order to reduce harmful exposures.

Both Windsor and the ARHA were able to leverage their respective strengths in the development and implementation of their HARS. Social support and social capital have been identified as important resources for coping with extreme weather events [35], including extreme heat [19], and in protecting people from climate change impacts on health more generally [59]. In Canada, some indicators suggest higher social capital in rural areas; the presented Manitoba case study confirmed this as a significant capacity within the Melita community. Individuals living in rural areas are more likely to know their neighbours, trust them, volunteer, attend public meetings and feel strongly that they belong to their community [69,70]. Social capital is high in Melita [56] and volunteer networks are a key component of the HARS in that area [4]. Volunteers could provide assistance with the operation of locally designated cooling facilities and distribute water during an extreme heat event [4].

In contrast, the City of Windsor adopted a resource intensive approach to vulnerability reduction in their HARS through a multi-faceted coordinated communications plan. The City utilized communications with a variety of information products (e.g. flyers, water bottles, magnets), channels (e.g. the mass media) and partners to provide information to its large population about extreme heat and protective measures [4]. With numerous stakeholders, Windsor developed a hub for heat-health communication and information sharing [4].

Results from the comparative case study confirmed the importance of vulnerability factors that differentially affect urban and rural communities but also highlighted the innovative actions that can be taken to overcome challenges facing communities and to capitalize on unique capacities. In a rural area, the dispersion of a small population over a broad geographic area can pose a challenge for establishing the temperature-mortality relationship to support the development of a HARS [4]. Officials overcame the data gap by examining the temperature-mortality curves of larger nearby communities (the cities of Brandon and Winnipeg) together with local (ARHA) historical temperature records to estimate the risk to health from extreme heat in the region [4].

Within the rural area in close proximity to Melita, another significant challenge in planning for extreme heat is the diversity among communities in terms of, for example, health care infrastructure and local governance. There are numerous small municipalities and a local First Nations community, each with unique vulnerabilities and capacities [56]. A longer term goal of the HARS in Manitoba is to have each rural community develop capacity to implement its own plan to protect residents from the health impacts of extreme heat, with the support of the regional health authority.

5 Conclusions

As the climate continues to warm and extreme heat events become more frequent and severe, public health and emergency management officials, those in related sectors (e.g. transportation, urban planning, agriculture, energy), and individual citizens need to increase efforts to take protective measures and reduce risks to health. Effective measures can be taken to protect populations from extreme heat in urban and rural communities. The results of this study can help health authorities prepare for extreme heat events by presenting examples of the diversity of approaches taken by different sized communities to implement best practices for developing HARS in an effort to reduce health impacts.

Programs to protect people from extreme heat such as HARS should be tailored to community and regional needs. As the case studies of Windsor and the town of Melita within the ARHA illustrate, the drivers of heat-health vulnerability and the planned responses may differ significantly among urban and rural communities. Differences between these settings need to be taken into consideration to effectively develop and implement the five core components of HARS described within this study. When vulnerability assessments are conducted in

conjunction with local table-top exercises, new and useful information on key risks, vulnerable populations and existing capacities is generated to help those requiring assistance in heat emergencies. This improves the likelihood of effective community-based measures being undertaken during extreme heat events and of an overall reduction in negative health outcomes. The following actions that recognise the importance of community differences are proposed to increase the effectiveness of community-based HARS:

- Investigation of how general characteristics regarding exposure to extreme heat events, sensitivity of populations, and capacity to adapt may differ between urban and rural communities
- Investigation of the effectiveness of short-term and long-term adaptation measures to reduce heat-health risks in urban and rural communities, including identification of co-benefits of actions that help mitigate risks from multiple hazards (e.g. flooding, severe storms, drought, air pollution)
- Inclusion of both urban and rural decision makers and stakeholders in development of a HARS at the regional or provincial level
- Regular evaluation of HARS effectiveness in addressing local heat-health risks
- Accounting for the differing needs of urban and rural communities to ensure measures are robust within national and regionally based HARS

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References

[1] Costello A., Abbas M., Allen A., Ball S., Bell S., Bellamy R., et al., Managing the Health Effects of Climate Change: Lancet and University College London Institute for Global Health Commission, Lancet, 2009, 373, 1693–1733.

[2] Ebi K.L., Managing the Changing Health Risks of Climate Change, Curr. Opin. Environ.Sustain., 2009, 1 (1), 107-110.

[3] IPCC, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, In C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, et al. (Eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

[4] Health Canada, Heat Alert and Response Systems to Protect Health: Best Practices Guidebook, Health Canada, Ottawa, 2012.

[5] Luber G., McGeehin M., Climate change and extreme heat events, Am. J. Prev. Med., 2008, 35 (5), 429–435.

[6] Gamble J.L., Hurley B.J., Schultz P.A., Jaglom W.S., Krishhan N., Harris M., Climate Change and Older Americans: State of the Science, Environ. Health Perspect., 2012, http://www.ncbi.nlm.nih.gov/pubmed/23033457.

[7] Canadian Institute for Health Information (CIHI), Urban Physical Environments and Health Inequalities, 2011, http://secure.cihi.ca/cihiweb/products/cphi_urban_physical_environments_en.pdf.

[8] Kenny G.P., Yardley J., Brown C., Ronald J., Sigal M.D., Jay O., Heat Stress in Older Individuals and Patients with Common Chronic Diseases, Can. Med. Assoc. J., 2010, 182(10), 1053–1060.

[9] Kovats R.S., Hajat S., Heat Stress and Public Health: A Critical Review, Annu. Rev. Publ. Health, 2008, 29, 41–55.

[10] Bouchama A., Dehbi M., Mohamed G., Matthies F., Shoukri M., Menne B., Prognostic Factors in Heat Wave Related Deaths: A Meta-Analysis. Arch. Intern. Med., 2007, 167, 2170–2176.

[11] Kosatsky T., Hot day deaths, summer 2009: What happened and how to prevent a recurrence, Br. Columbia Med. J., 2010, 52 (5), 261.

[12] Robine J.M., Cheung S.L., Le Roy S., Van Oyen H., Griffiths C., Michel J.P., et al., Death Toll Exceeded 70,000 in Europe during the Summer of 2003, C. R. Biol., 2008, 331, 171–178.

[13] Barriopedro D., Fischer E.M., Luterbacher J., Trigo R.M., García-Herrera R., The Hot Summer of 2010: Redrawing the Temperature Record Map of Europe, Science, 2011, 332, 220–224.

[14] Grubenhoff J.A., du Ford K., Roosevelt G.E., Heat-Related Illness, Clin. Pediatr. Emer. Med., 2007, 8, 59–64.

[15] Naughton M.P., Henderson A., Mirabelli M.C., Kaiser R., Wilhelm J.L., Kieszak S.M., et al., Heat-Related Mortality During a 1999 Heat Wave in Chicago, Am. J. Prev. Med., 2002, 22, 221–227.

[16] Voogt J.A., Oke T.R., Thermal Remote Sensing of Urban Climates, Remote Sensing of Environment, 2003, 86 (3), 370-384.

[17] Bambrick H.J., Capon A.G., Barnett G.B., Beaty R.M., Burton A.J., Climate Change and Health in the Urban Environment: Adaptation Opportunities in Australian Cities, Asia Pac J Public Health, 2011, 23, 67S-79S.

[18] Barata M., Ligeti E., De Simone G., Dickinson T., Jack D., Penney J., Rahman M., Zimmerman R., Climate change and human health in cities, In: Rosenzweig C., Solecki W.D., Hammer S.A., Mehrotra S. (Eds.), Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network, Cambridge University Press, Cambridge, UK, 2011.

[19] Williams S., Bi P., Newbury J, Robinson G., Pisaniello D, Saniotis A., Hansen A., Extreme Heat and Health: Perspectives from Health Service Providers in Rural and Remote Communities in South Australia, Int. J. Environ. Res. Public Health, 2013, 10 (11), 5565-5583.

[20] Gabriel K.M.A., Endlicher W.R., Urban and rural mortality rates during heat waves in Berlin and Brandenburg, Germany, Environ. Pollut., 2011, 159, 2044–2050.
[21] World Health Organization (WHO), Protecting health in Europe from climate change, Menne B., Apfel F., Kovats S., Racioppi F., World Health Organization (WHO), Copenhagen, 2008a.
[22] World Health Organization (WHO), Heat-Health Action Plans, Matthies F., Bickler G., Cardeñosa Marín N., Hales S. (Eds.), World Health Organization (WHO), Copenhagen, 2008b, www.euro.who.int/document/e91347.pdf.
[23] Lowe D., Ebi K.L., Forsberg B., Heatwave Early Warning Systems and Adaptation Advice to Reduce Human Health Consequences of Heatwaves, Int. J. Environ. Res. Public Health, 2011, 8, 4623-4648.
[24] O'Neill M.S., Ebi K.L. Temperature extremes and health: impacts of climate variability and change in the United States, J. Occup. Environ. Med., 2009, 51 (1),13–25.
[25] United States Environmental Protection Agency (U.S. EPA), Excessive Heat Events Guidebook, 2006, www.epa.gov/heatisland/about/pdf/EHEguide_final.pdf.
[26] Victorian Government, Heatwave Plan for Victoria: Protecting Health and Reducing Harm from Heatwaves, 2011, www.health.vic.gov.au/environment/downloads/heatwaveplan_vic.pdf.
[27] Department of Health – United Kingdom, Heatwave Plan for England: Protecting Health and Reducing Harm from Extreme Heat and Heatwaves, 2011, www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_127235.pdf.
[28] World Health Organization (WHO)—Europe. (2009). Improving Public Health Responses to Extreme Weather/Heat-Waves-EuroHEAT: Technical Summary. Menne, B. and Matthies, F. (eds). WHO, Geneva, Switzerland, 70. Retrieved October 6, 2009, from www.euro.who.int/__data/assets/pdf_file/0010/95914/E92474.pdf.
[29] Huang C., Barnett A.G., Xu Z., Chu C., Wang X., Turner L.R., Tong S., Managing the Health Effects of Temperature in Response to Climate Change: Challenges Ahead, Environ. Health Perspect., 2013,http://www.ncbi.nlm.nih.gov/pubmed/23407064.
[30] World Health Organization (WHO), Public health advice on preventing health effects of heat, World Health Organization (WHO), Copenhagen, 2011.
[31] Mehiriz K., Gosselin P., Guide for the Evaluation of a Warning System for People Vulnerable to Heat and Smog, Report prepared for Health Canada, Ottawa, 2013.
[32] Bustinza R., Lebel G., Gosselin P., Belanger D., Chebana F., Health Impacts of the July 2010 heat wave in Quebec Canada, BMC Publ. Health. 2013, 13, 56.
[33] World Health Organization (WHO), Protecting Health from Climate Change: Vulnerability and Adaptation Assessment, Ebi K.L., Berry P., Campbell- Lendrum D., Carlos C., Guillemot J., World Health Organization and Pan American Health Organization, Geneva, 2012, http://www.who.int/globalchange/publications/Final_Climate_Change.pdf.
[34] Berry P., Vulnerabilities, adaptation and adaptive capacity, In: J. Seguin (Ed.), Human health in a changing climate: A Canadian assessment of vulnerabilities and adaptive capacity, Health Canada, Ottawa, 2008.
[35] Wall E., Marzall K., Adaptive capacity for climate change in Canadian rural communities, Local Environ., 2006, 11 (4), 373-397.
[36] Natural Resources Canada, From impacts to adaptation: Canada in a changing climate 2007, Lemmen D.S., Warren F.J., Lacroix J., Bush, E. (Eds.), Government of Canada, Ottawa, 2008.
[37] Aboriginal Affairs and Northern Development Canada (AANDC), Terminology, 2012, http://www.aadnc-aandc.gc.ca/eng/1100100014642/1100100014643.
[38] Environment Canada, Spring and Summer Weather Hazards, 2014, http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=6C5D4990-1#Heat_and_Humidity.
[39] Statistics Canada, Community profile – Canada, 2006, http://www12.statcan.ca/census-recensement/2006/dp-pd/prof/92-591/details/page.cfm?Lang=E&Geo1=PR&Code1=01&Geo2=PR&Code2=35&Data=Count&SearchText=Canada&SearchType=Begins&SearchPR=01&B1=All&Custom=.
[40] City of Windsor, Land use history, 1997, http://www.citywindsor.ca/000499.asp.
[41] Environment Canada, Canadian climate normals 1971–2000: Canada's National Climate Archive: Windsor, 2009, http://www.climate.weatheroffice.gc.ca/climate_normals/results_e.html?Province=ALL&StationName=Windsor&SearchType=BeginsWith&LocateBy=Province&Proximity=25&ProximityFrom=City&StationNumber=&IDType=MSC&CityName=&ParkName=&LatitudeDegrees=&LatitudeMinutes=&LongitudeDegrees=&LongitudeMinutes=&NormalsClass=A&SelNormals=&StnId=4716&.
[42] Natural Resources Canada, Ontario Map, Atlas of Canada, 2002.
[43] Natural Resources Canada, Manitoba Map, Atlas of Canada, 2001.
[44] Environment Canada. 2009. National Climate Data and Information Archive: Canadian Climate Normals 1971-2000, Pierson, Manitoba. Ottawa: Environment Canada.
[45] Paterson, J.A., Ford, J.D., Berrang Ford, L., Lesnikowski, A., Berry, P., Henderson, J., et al., Adaptation to climate change in the Ontario public health sector, BMC Publ. Health, 2012, 12, 452.
[46] City of Windsor, City of Windsor Climate Change Adaptation Plan, 2012,http://www.citywindsor.ca/residents/environment/environmental-master-plan/documents/windsor%20climate%20change%20adaptation%20plan.pdf.
[47] Séguin, J. (Ed.), Health Canada, Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity, Health Canada, Ottawa, 2008.
[48] Canadian Council of Ministers of the Environment (CCME), Guidance document on achievement determination: Canada-wide standards for particulate matter and ozone, Ottawa, 2007.
[49] Berry P., Richters K., Clarke K-L., Brisbois M-C., Assessment of Vulnerability to the Health Impacts of Extreme Heat in the City of Windsor, Report Prepared for the City of Windsor, Ottawa, 2011.
[50] Berry P., Clarke K., Fleury M.D., Parker S., Human Health, in: Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, F.J. Warren and D.S. Lemmen (Eds.), 2014, Government of Canada, Ottawa, ON, p. 191-232.
[51] Statistics Canada, A Visit to Canada's Country Side: Rural Tourism, 2005a, http://dsp-sd.pwgsc.gc.ca/Collection/Statcan/21-006-X/21-006-XIE2005005.pdf.

[52] Shurvell S., Assiniboine Regional Health Authority HARS Pilot Project: End of Season Report – 2010, Report Prepared for Health Canada, Ottawa, 2010.
[53] City of Windsor, Stay Cool Windsor-Essex: When it's Too Hot Outside Protect Yourself, 2013, http://www.staycoolwindsor-essex.com/.
[54] Windsor-Essex County Health Unit, the Corporation of the County of Essex, the City of Windsor, Heat Alert and Response Plan, 2011, http://www.staycoolwindsor-essex.com/HARS_plan.php.
[55] Statistics Canada, Population by sex and age group, 2009, http://www40.statcan.gc.ca/l01/cst01/demo10a-eng.htm.
[56] Morris-Oswald T., Assiniboine Regional Health Authority Heat Alert and Response System (HARS) Pilot Project: End of Season Report – 2009, Prepared for Health Canada, Ottawa, 2009.
[57] Health Canada, Extreme Heat Event: Exercise HARS Reality – ARHA, Health Canada, Ottawa, 2010.
[58] Health Canada, Extreme Heat Event: Exercise HARS Reality – Windsor, Health Canada, Ottawa, 2010.
[59] Cheng J.J., Berry P., Health co-benefits and risks of public health adaptation strategies to climate change: a review of current literature, Int J Public Health, 2013, 58, 305-311.
[60] Ebi K.L., Semenza J.C., Community-based adaptation to the health Impacts of climate change, Am. J. Prev. Med., 2008, 35, 501-507.
[61] Maltais D., The Rural Reality, in Emergency Management: Taking the Health Perspective – Health Policy Research Bulletin, April 2009, Issue 15, Health Canada, Ottawa.
[62] Jennissen T., Health Issues in Rural Canada, 1992, http://dsp-psd.pwgsc.gc.ca/collection_2008/lop-bdp/bp/bp325-e.pdf.
[63] Transport Canada, Improving Travel Options In Small And Rural Communities, 2009.
[64] Statistics Canada, Rural and Small Town Canada Analysis Bulletin: Factors Associated with Internet Use – Does Rurality Matter?, 2007, 7 (3).
[65] Health Canada, Assessment of Vulnerability to the Health Impacts of Extreme Heat: Melita, Manitoba, Health Canada, Ottawa, 2011a.
[66] Public Health Agency of Canada (PHAC), How Healthy Are Rural Canadians? An Assessment of their Health Status and Health Determinants, 2006, Des Meules M., Pong R., Lagacé C., Heng D., Manuel D., Pitblado R., et al. (Eds.),http://www.carrn.com/files/rural_canadians_2006_report_e.pdf.
[67] Harlan S.L., Ruddell D.M., Climate Change and Health in Cities: Impacts of Heat and Air Pollution and Potential Co-Benefits from Mitigation and Adaptation, Curr. Opin. Environ. Sustain., 2011, 3, 1–9.
[68] Statistics Canada, More Than Just Farming: Employment in Agriculture and Agri-Food in Rural and Urban Canada, 2003, http://www.statcan.gc.ca/pub/21-006-x/21-006-x2002008-eng.pdf.
[69] Statistics Canada, Rural and Small Town Canada Analysis Bulletin: The Influence of Education on Civic Engagement: Differences Across Canada's Rural-Urban Spectrum, 2006, 7 (1).
[70] Statistics Canada, Rural and Small Town Canada Analysis Bulletin: Social engagement and civic participation: Are rural and small town populations really at an advantage?, 2005, 6 (4).
[71] Health Canada, Adapting to Extreme Heat Events: Guidelines for Assessing Health Vulnerability, Health Canada, Ottawa, 2011b.
[72] Health Canada, Communicating the Health Risks of Extreme Heat Events: Toolkit for Public Health and Emergency Management Officials, Health Canada, Ottawa, 2011c.