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Adapting to Extreme Heat Events:

Guidelines for Assessing Health Vulnerability

Canada

Adapting to Extreme Heat Events:

Guidelines for Assessing Health Vulnerability

Prepared by:
Water, Air and Climate Change Bureau
Healthy Environments and
Consumer Safety Branch

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Foreword

A number of studies have documented the growing risks to the health of Canadians from more frequent and severe extreme heat events. Such risks were identified as a key concern in Health Canada's report *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity.*[1] Public health officials have recognized the need to prepare their communities and vulnerable populations for extreme heat events, and are seeking information about the best ways to safeguard health. To this end, Health Canada is taking action to help Canadians become more resilient in the face of a changing climate. As more communities in Canada begin to develop systems to reduce risks to health from extreme heat, they require knowledge about strategies and actions that can be taken to effectively address local vulnerabilities.

A major component of public health efforts to protect people from extreme heat events centres on assessments of individual and community level vulnerability. *Adapting to Extreme Heat Events: Guidelines for Assessing Health Vulnerability* provides an overview of the vulnerability assessment methodology that has been developed by Health Canada, with support from a range of partners active in efforts to prepare people for climate change. In developing this guidance, leading experts and stakeholders from local communities helped to identify and articulate the risks to the health of Canadians from extreme heat and the range of viable adaptation options.

The assessment steps and methods set out in this document were tested through the completion of four extreme heat and health vulnerability assessments in partnering pilot communities—Winnipeg, Manitoba; the town of Melita in the Assiniboine Regional Health Authority, Manitoba; Windsor, Ontario; and Fredericton, New Brunswick. Lessons learned, as well as best practices for investigating risks and necessary adaptation actions, are provided here to help public health and emergency management officials better protect the health of Canadians from extreme heat events.

1. Introduction

It is now well established that climate change poses significant risks to the health of Canadians and people around the world.[1-3] One of the key issues—health risks from extreme heat events[a]—is an emerging public health concern. The 2003 extreme heat event in Europe that resulted in 70,000 deaths[4] and the 2010 event in Russia that resulted in an estimated 55,000 deaths[5] demonstrate the significant toll on health that such events can have.

Extreme heat is a health concern in Canada as well; research indicates that in Toronto alone an average of 120 people died from extreme heat annually between 1954 and 2000.[6] In 2005, Toronto experienced 41 extremely hot days exceeding 30°C/86°F[7] during which health officials called a total of 26 heat alert days to warn the public of the dangerous conditions.[b] In British Columbia, an extreme heat event from July 27 to August 3 in 2009 resulted in 156 excess deaths as temperatures reached 34.4°C/93.9°F.[8]

Heat-related deaths are preventable, and assessments of individual and community vulnerability can help in efforts to reduce mortality associated with extreme heat events. The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability to climate change as the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate variability and change.[18] Current and future factors influencing health outcomes, including potential risks and protective measures, are investigated when assessing heat-health vulnerability.[9]

The vulnerability of individuals and communities will vary according to the level of exposure to extreme heat, the sensitivity of individuals to health impacts, and the programs and activities that directly or indirectly lower risks to health.

Examples of factors that affect vulnerability include regional climate, population health status, socio-economic conditions, the state of local infrastructure, knowledge of heat-health risks and protective measures, the presence or absence of Heat Alert and Response Systems (HARS), and the strength of social networks and agencies. A vulnerability assessment examining these kinds of factors can provide decision makers and the public with the knowledge of characteristics and trends that increase or decrease their communities' resilience to extreme heat events. This knowledge then allows for the development of effective interventions (e.g., public health programs, transportation services, urban heat island mitigation) so that individuals and communities can protect those most vulnerable to extreme heat-health impacts.[1,3]

Several documents and conceptual frameworks provide direction for the application of methods to assess vulnerability to a broad range of climate change impacts and to develop adaptation strategies.[11-15] In this regard, the World Health Organization (WHO) and the Pan American Health Organization (PAHO) have developed guidance to be used by both developing and developed countries for assessing the vulnerability of individuals and communities to all climate change impacts on health.[16]

However, little information is available to address considerations specific to the assessment of vulnerability to the health impacts of extreme heat events. This document, *Adapting to Extreme Heat Events: Guidelines for Assessing Health Vulnerability* (the Guidelines), addresses this need. The stakeholders and assessment steps relevant to the investigation of heat-health vulnerabilities in Canadian communities are presented along with examples of method application and information on key challenges and limitations.

[a] *Note that this document uses "extreme heat event" rather than "heat wave."*

[b] *In 2005, the City of Toronto called eight heat alerts (required when the likelihood of excess weather-related mortality exceeds 65%) and 18 extreme heat alerts (required when the likelihood of excess weather-related mortality exceeds 90%).*

1.1 Benefits of Conducting an Extreme Heat and Health Vulnerability Assessment

An extreme heat and health vulnerability assessment is undertaken to determine existing levels of risk, identify and better understand vulnerabilities, and stimulate actions to increase the resilience of individuals and communities.

Assessments can help health agencies manage competing demands by describing current heat-related health risks, vulnerable groups, existing public health interventions, and adaptive actions, thereby focussing attention and resources on addressing specific needs. A well-designed and executed assessment provides sufficient information to assist in making policy and program recommendations to agencies that lead community efforts to reduce heat-health risks. In Canada, the responsibility for mobilizing these efforts can reside with a range of agencies—local, regional, or provincial public health departments, and emergency management organizations. Partnering organizations and officials, such as city planners, parks and recreation departments, transportation planners, health care practitioners, and social service providers (e.g., Canadian Red Cross) can contribute to and benefit from the results of an assessment. The process of completing an assessment will identify key players and establish a set of cross-cutting institutional linkages, and can be used to garner senior management support that can convert the recommendations into action.

Other benefits that result from completing an assessment include the development of baseline information about vulnerability to extreme heat events as well as an increased capacity to acquire and analyze needed data. An assessment can also serve as a mechanism to mobilize interdisciplinary groups and stakeholders to come together and collaborate in the identification of actions to increase the resiliency of a community.[1] Whatever the current level of knowledge and coping ability, the long-term benefits of conducting an assessment include moving an organization, or an entire community, towards increased awareness, capacity, and expertise on extreme heat and health issues.

1.2 Structure of the Guidelines

This document is structured to provide practical guidance for conducting extreme heat and health vulnerability assessments as a means to inform actions that can be taken to prepare communities for an increase in the number, intensity, and duration of extreme heat events. Development of the Guidelines was informed by input from a group of international and Canadian experts and stakeholders to ensure that the information presented meets the needs of decision makers tasked with protecting the health of the public.

This document provides information on understanding the health risks of extreme heat events and undertaking an assessment. Section 2 discusses the exposure of Canadians to extreme heat events, provides information on the sensitivity of individuals to health impacts, and highlights the role of HARS as an adaptation strategy. Section 3 presents the assessment steps for identifying current and future vulnerability of individuals and communities to extreme heat events using both qualitative and quantitative methods. Key assessment tasks and methods for each step are explained in table form, and are accompanied by examples to aid in the application of the Guidelines.

2. Vulnerability to the Health Impacts of Extreme Heat

Every individual reacts differently to heat stress, and some communities in Canada are at much greater risk from extreme heat events than others. The health impacts from extreme heat depend upon the vulnerability of individuals and communities; this vulnerability is a function of exposure to extreme heat, physiological sensitivity to heat stress, and the capacity to adapt by taking measures to protect health. Assessments of vulnerability use analyses of data and expert knowledge acquired through consultation with local stakeholders to identify the factors that are most relevant to an investigation for a specific community. Vulnerability to the health effects of extreme heat can often be traced to a combination of factors operating at both the individual and community levels as is shown in Figure 1.

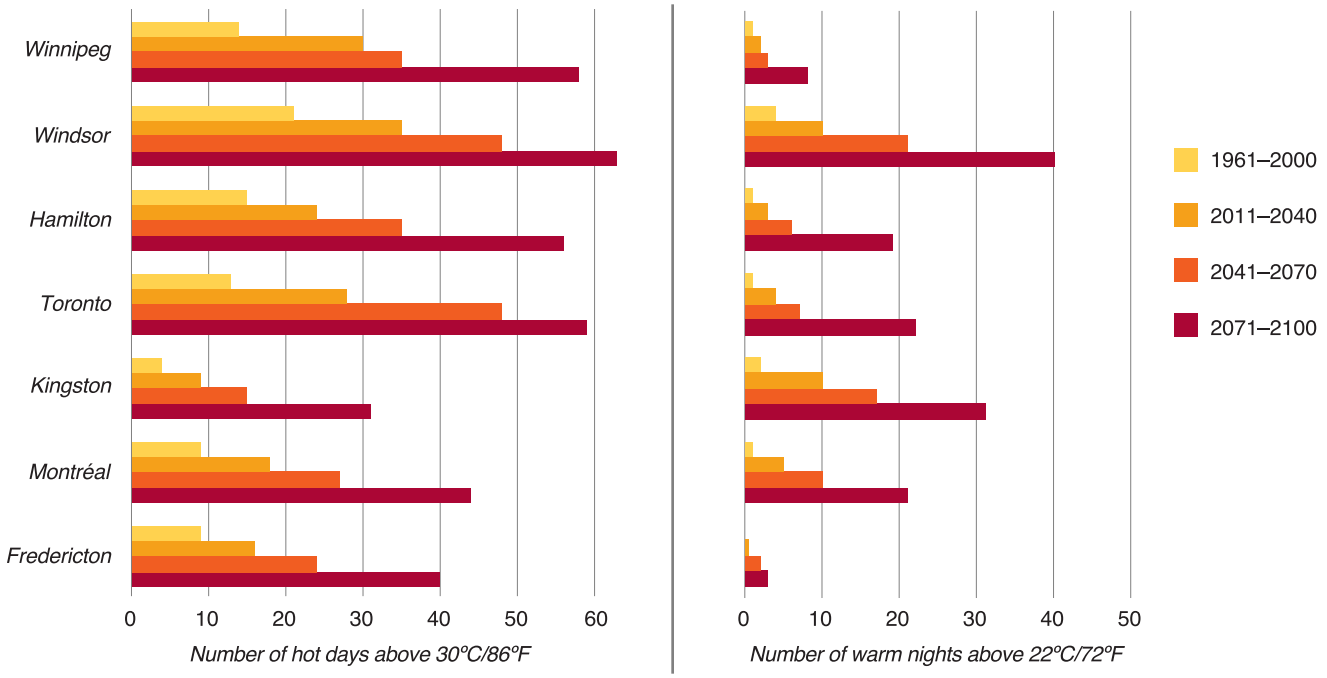
Figure 1: Factors that influence individual and community level vulnerability to extreme heat events

2.1 Exposure to Extreme Heat

Extreme heat as a health risk is a growing concern to individuals and communities in Canada. Most jurisdictions define extreme heat events based on the potential for hot weather conditions to result in an unacceptable level of health effects, including increased morbidity and mortality. Given the differing nature of meteorological factors and heat-related vulnerabilities across Canadian communities, and the requirement to set different alert triggers to reduce impacts on health, multiple definitions are used in practice. Environment Canada defines a "heat wave" as "three or more consecutive days in which the maximum temperature is greater than or equal to 32°C/90°F."[7] However, temperature is only one component of heat, which also depends on humidity, wind speed, and radiant load. At the level of the individual, health risks depend on exposure, sensitivity, acclimatization, and adaptability to extreme heat—that is, heat vulnerability.

Climate projections reveal that many Canadian communities can expect a significant increase in extreme heat events (hot days and warm nights) that can negatively impact health (Figure 2). Without effective actions to reduce health risks, the impacts of climate change could increase heat-related illness and deaths among Canadians.

Figure 2: Historical and projected number of hot days and warm nights for selected cities in Canada[c]



Source: Casati, B. and Yagouti, A. (In Press).[23]

[c] *Temperature projections are obtained from the Canadian Regional Climate Model developed by the Ouranos Consortium on Regional Climatology and Adaptation to Climate Change, and using the Special Report Emission Scenario A2.*[18] *The A2 scenario describes "a very heterogeneous world with high population growth, slow economic development and slow technological change."*[18] *The number of hot days and warm nights for each city is based on the observed temperature data between 1961 and 2000, and projected for 2011–2040, 2041–2070, and 2071–2100.*

Box 1: What is the Urban Heat Island Effect?

The term "urban heat island effect" refers to how urban centres tend to have air and surface temperatures hotter than those of nearby rural areas. This local human-induced condition is caused by the higher heat absorption of urban materials (e.g., concrete, brick, asphalt), the reduction of natural convective cooling due to the presence of tall buildings, and the lack of green spaces that decrease evaporative cooling.[21] The air temperature difference can be as high as 12°C/22°F in the evening.[22] Climate change may intensify the urban heat island effect in metropolitan areas. The urban heat island effect can be reduced by increasing the reflectivity of urban surfaces or by increasing green cover in a community through the development of urban forests, parks, or rooftop and vertical gardens.[22]

Larger cities can be especially susceptible to extreme heat events because of the urban heat island effect (Box 1). Furthermore, high temperatures can increase the chemical reactions involved in the creation of air pollution resulting in greater risks to health.[19,20]

2.2 Sensitivity of Canadians to the Health Impacts of Extreme Heat

Physiologically, extreme heat can affect the body's thermoregulation by impairing the mechanisms that allow it to maintain a constant core temperature. During extreme heat events, many people with underlying health conditions (e.g., respiratory and cardiovascular conditions) may experience a worsening of, or succumb to, those conditions.[24] Some may experience direct impacts on health, such as heat stroke, exhaustion, fainting, cramps, rash, and edema.[d] Access to intervals of cooler temperatures (e.g., air conditioning or cool nights) helps to reduce heat stress. Longer durations of extreme heat including high nighttime temperatures, and poor air quality are all factors that can negatively affect health outcomes.

Heat illness and deaths are preventable, but they do occur—mainly because people have been overexposed by not changing their behaviours to adjust to the heat. For example, individuals are at a greater risk if they overexert themselves for their age and physical condition or do not check with their medical practitioner about how the medications they are taking may increase their sensitivity to heat. Moreover, the health risks are higher for those who are not regularly exposed to hot environments.[25,26]

Extreme heat events early in the summer generally result in higher morbidity and mortality than those later in the season partially because of a lack of acclimatization.[25] Acclimatization occurs owing to gradual exposure to heat resulting in physiological changes that make a person better able to handle heat.[27] The body's ability to acclimatize may be limited for some vulnerable populations—older adults, infants and young children, and people with chronic illnesses.[28] Table 1 describes heat-vulnerable groups and their challenges, which have been identified in the literature. Understanding heat vulnerabilities of specific populations is important for identifying effective public health interventions that can reduce the harmful effects of extreme heat.

[d] *See Health Canada (2011), "Extreme Heat Events Guidelines: Technical Guide for Health Care Workers."*[54]

Table 1: Heat-vulnerable groups and examples of challenges they may face in adapting to extreme heat events

Heat-Vulnerable Groups	Examples of Challenges

Older adults[29]	• Physiological characteristics that may contribute to increased vulnerability to heat:
	  ◦ reduced thirst sensation[30]
	  ◦ reduced fitness level
	  ◦ reduced sweating ability[31]
	  ◦ increased susceptibility to chronic dehydration[30]
	• Visual, cognitive, and hearing impairments
	• Agility and mobility challenges
	• Differing perceptions of risks and vulnerabilities based on life experiences
	• Reduced literacy
	• Social isolation

Infants and young children[32]	• Physiological and behavioural characteristics that may contribute to increased vulnerability to heat:
	  ◦ increased body heat production during physical activity[33]
	  ◦ faster heat gain from the environment if air temperature is greater than skin temperature owing to greater surface-area-to-body weight ratio[33]
	  ◦ inability to increase cardiac output[34]
	  ◦ reduced sweating[35]
	• Dependence on caregiver to recognize heat impacts and take recommended actions

People with chronic illness or who are physically impaired[36]	• Physiological characteristics that may amplify health risks, such as failing cardiovascular or respiratory system,[28] psychiatric illnesses,[36] renal illnesses[37] • Taking certain medications that affect heat sensitivity by interfering with the body's cooling functions or water/salt retention (e.g., antihypertensives,[38] antidepressants,[39] antipsychotics,[39,40] anti-Parkinson's agents[40]) • Confined to bed or dependence on caregiver, family or friends for assistance with daily living (e.g., water access) • Communication, sensory or cognitive impairment • Characteristics related to health status or behaviour (e.g., chronic dehydration, shut-in or does not leave home) • Social isolation

Continue to next page

Heat-Vulnerable Groups	Examples of Challenges
Socially disadvantaged individuals and communities: • Low income[41] • Homeless[42] • Living alone[36]	• Limited financial resources to adequately take protective actions • Reduced access to clean water and cool places • Limited access to health care and social services • More environmental exposures (e.g., homeless, living on higher floors with no air conditioning)[43] • Higher rates of alcohol and drug dependency • Social isolation
Newcomers to Canada and transient populations, such as tourists	• Language and literacy barriers for non-English or non-French speakers • Cultural differences, such as food consumption habits, clothing choices, and pre-existing social or cultural beliefs • Unique media use patterns • Limited knowledge of local alert systems, health and social service programs
Occupational groups	• Environmental and workplace exposures (e.g., farmers, construction workers, miners, tree planters) • Increased physical strain • Variation in health and safety regulations, codes and standards • Irregular exposure to heat (i.e., lack of acclimatization) for new workers with job-related heat exposures and those faced with early season extreme heat events[28]
The physically active[44,45]	• Greater environmental exposures (e.g., marathon runners, recreational athletes, people who walk or bike) • Increased physical strain • Reduced perception of risks and heat vulnerabilities • Expectation of usual performance in the heat

Source: Reprinted from Health Canada (2011), "Communicating the Health Risks of Extreme Heat Events: Toolkit for Public Health and Emergency Management Officials."[46]

2.3 Adapting to Protect Health: Heat Alert and Response Systems

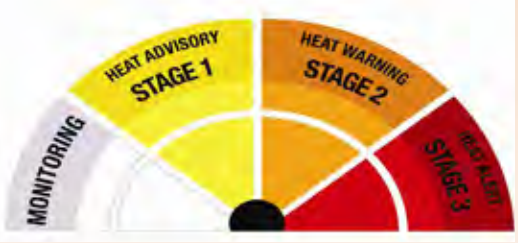
To reduce negative health impacts from extreme heat events, public health and emergency management officials should assess local vulnerabilities and develop necessary policies and programs, such as HARS. Heat alert and response systems centre on efforts to alert health authorities and the public when hazardous conditions arise, provide advice on how health risks can be minimized, and offer assistance to those in need during emergency situations. Although these systems have been in place in some cities across the United States since the mid-1990s and in Toronto since 1999, only during the last few years have a number of Canadian cities and communities begun to develop formal HARS. Typically, HARS include some or all of the following components:

Alert Protocol – identifies extremely hot weather conditions that could result in increased morbidity and mortality in a region; alerts government officials and stakeholders (e.g., managers of long-term care facilities) who can then take actions to reduce health risks (e.g., inform the target audience and/or provide emergency cooling relief).

Community Response Plan – facilitates actions by individuals to protect themselves during periods of extreme heat; directs public health interventions aimed at reaching vulnerable individuals who require assistance; develops a network of stakeholders with the goals of reducing barriers to action and meeting the needs of people in the community, especially those who are most heat-vulnerable.

Communication and Outreach Plan – raises awareness about heat-health impacts; provides advice on how to reduce health risks by educating audiences about protective actions; provides information on services and resources that are available to service providers and the public (Box 2).

Box 2: Heat Meter Used by the City of Hamilton



Source: City of Hamilton[10]

Evaluation Plan – directs HARS evaluation activities to understand the extent to which the alert protocol and response measures are timely, relevant, and effective; provides continual improvement to the HARS to meet the needs of the community.

An effective HARS requires coordinated action across government authorities, involvement of private sector participants and community service organizations, and the ability to address multiple risk factors in the population.[47] There is wide variation in the types of HARS used in communities across Canada. Box 3 provides information on the City of Greater Sudbury's Hot Weather Response Plan.

Vulnerabilities within a community may increase or decrease over time as demographics, health status, exposure to extreme heat events, and access to health and social services change. Therefore, HARS should be evaluated regularly to ensure that they are contributing to a reduction in heat-related illnesses and deaths. Assessments of vulnerability help to inform the improvement of existing systems and the development of new ones in communities where they do not exist.

Box 3: City of Greater Sudbury – Hot Weather Response Plan

When hot weather conditions exist or are imminent, the City of Greater Sudbury's Hot Weather Response Plan is intended to alert those most at risk of heat-related illness so that they may take appropriate precautions. The system has three levels:

Level 1 – Heat Advisory

- A humidex of 36 for at least 48 consecutive hours is forecast.
- The City Emergency Management Division informs all community heat response partners of the decision to issue an advisory.
- The Health Unit issues a news release and posts a web notice informing the public of the advisory with heat-risk information as well as protective and preventative measures. The emphasis is on the need for citizens to check in on individuals who may be vulnerable.

Level 2 – Heat Alert

- A humidex of 40 for at least 48 consecutive hours OR a humidex of 36 for at least 48 consecutive hours with a smog alert is forecast.
- All actions listed in Level 1 continue.
- News releases are jointly prepared and released by the City and the Health Unit.
- The City may implement any or all of the following actions, as appropriate:
  - Distribute bottled water to vulnerable populations in conjunction with community partners.
  - Expand locations and hours of operation of city pools.
  - Expand hours of operation and supervision at municipal beaches.
  - Request that local utilities halt service cancellations for the duration of the heat advisory.
  - Open cooling centres at city facilities.

Level 3 – Extreme Heat Alert

- A humidex of 45 for at least 48 consecutive hours OR a humidex of 40 for at least 48 consecutive hours with a smog alert is forecast.
- All actions listed in Level 1 and Level 2 continue.
- The City may implement any or all of the following actions, as appropriate:
  - Activate the Municipal Emergency Response Plan.
  - Consider extending hours at cooling centres to 24 hours a day.
  - Evacuate high-risk individuals to cooling centres.
  - Offer free transit service to cooling centres.
  - Increase public outreach, using police, postal workers, and utility staff.
  - Distribute water more broadly and distribute fans.

The City of Greater Sudbury's Hot Weather Response Plan has provisions for deactivation of the heat alerts, as well as for evaluation of the effectiveness of their system.

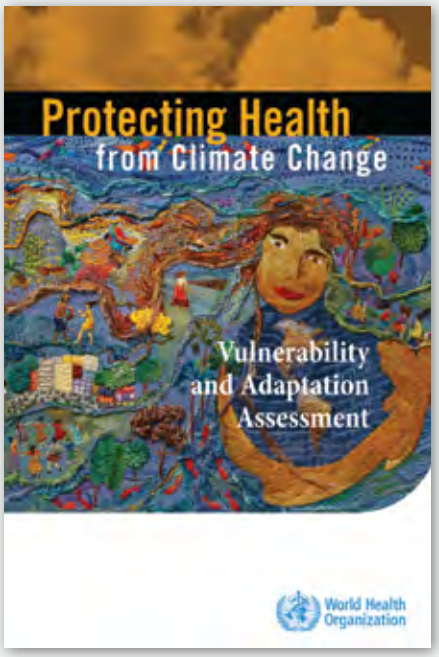
Source: City of Greater Sudbury and Sudbury and District Health Unit, 2010.[48]

3. Guidelines for Conducting Extreme Heat and Health Vulnerability Assessments

3.1 Assessment Methodology

The methodology for conducting extreme heat and health vulnerability assessments presented below is based on the WHO/PAHO report *Protecting Health from Climate Change: Vulnerability and Adaptation Assessment.*[16] This document presents a framework for conducting a vulnerability, impact, and adaptation assessment at the community, regional, or national levels for all climate change and health issues of concern. Drawing from the direction provided by WHO/PAHO, the Guidelines presented here provide information on:

- engaging stakeholders throughout the assessment process
- describing existing vulnerability to extreme heat events



- projecting future extreme heat events and possible increases in morbidity and mortality
- identifying and prioritizing adaptation options to address current and projected heat-related health risks
- determining the potential health risks and benefits of adaptation and mitigation measures implemented in other sectors
- developing protocols for monitoring heat-health risks and evaluating the adaptation options

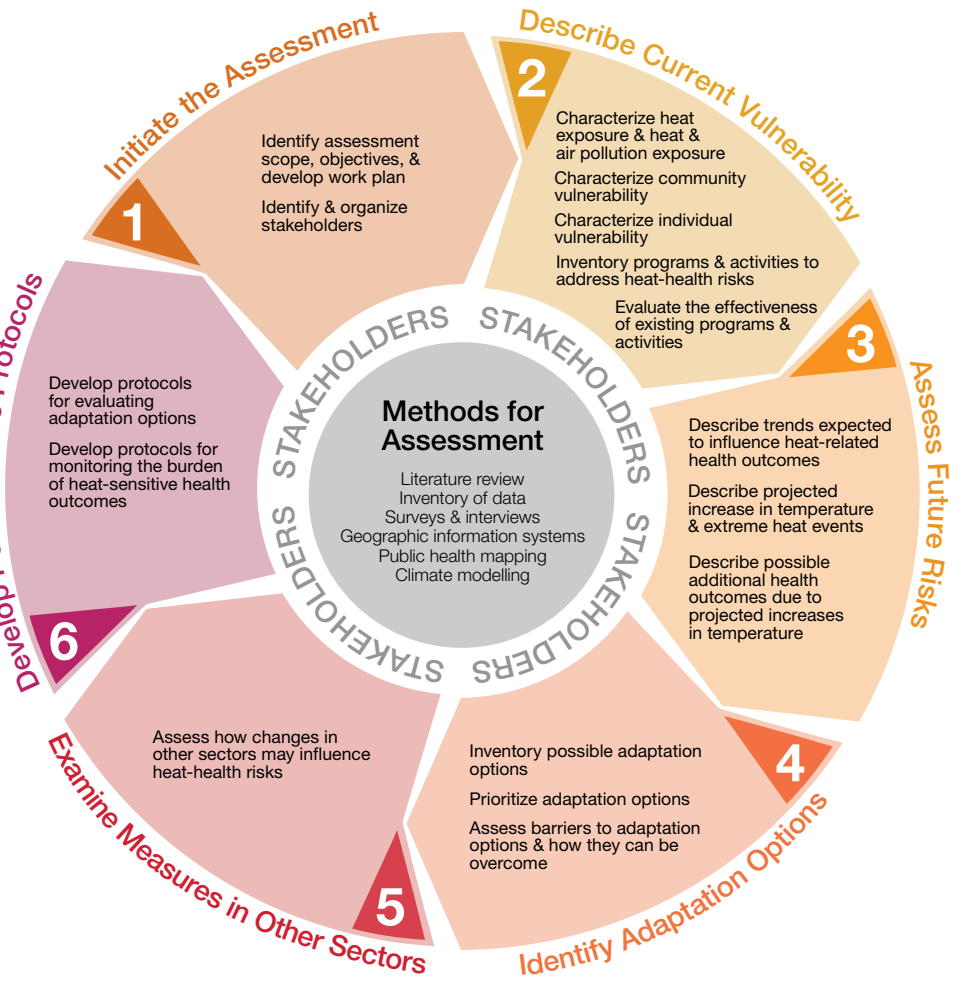
Assessments may employ a broad range of health data, analytical methods, and tools. Key methods are likely to include literature reviews, stakeholder consultations, epidemiological studies, expert judgement, climate models, and climate scenarios.

3.2 Assessment Steps

To conduct a comprehensive assessment of health vulnerability to extreme heat events, six steps should be completed. Figure 3 identifies key components of each step, and emphasizes that stakeholder engagement should occur throughout the entire assessment. Examples of the types of methods that can be used to investigate and reach a step's desired outcome are provided in the centre of the figure. Some methods (e.g., literature review) may be used in a number of steps, whereas other methods (e.g., developing climate projections) may be employed only for a specific component of the investigation. An assessment need not cover all steps if public health authorities determine that a focus on specific aspects of current or future vulnerability is warranted, if there are certain limitations (e.g., time, data, expertise), or because of the nature of the objectives identified through stakeholder consultation.

The steps for conducting an assessment follow. Each step is accompanied by a table providing detailed information on key tasks, methods, and expected outcomes. The implementation of each step should be tailored to meet the specific objectives of the individual assessment being undertaken.

Figure 3: Steps for conducting an extreme heat and health vulnerability assessment



1 Initiate the assessment

An important first activity in initiating the assessment is defining its scope; this requires engaging knowledgeable participants to identify the geographic region to be studied, the objectives of the assessment, measures of success, the audience, and potential partners. Assessment objectives and measures of success should be tailored to meet the needs of the decision makers and organizations that are the target audience for the report. The main users of the assessment should be asked to review the proposed scope and objectives.

It is at this point that limitations (e.g., time, data, expertise) should be identified. This will require an initial investigation of the types of data and information that are necessary to complete the assessment and that are available at community, provincial, and national levels. If not all assessment steps can be undertaken, focus should be placed on those steps that are needed to achieve priority objectives. Reviewing previously conducted heat-health vulnerability assessments or consulting with officials that have undertaken assessments can be helpful when defining the scope of the assessment (Box 4).

Identifying the health outcomes of interest is important in the initial phase of the assessment. Studies have indicated that increases in ambient temperature have important impacts on morbidity as well as mortality.[50] If morbidity is being examined, then decisions will need to be made as to how it will be assessed (e.g., hospital admission records), which illnesses associated with heat will be investigated (e.g., ischemic stroke, respiratory diseases, dehydration, diabetes, renal failure),[50] and whether sufficient local data exists for this type of analysis.

Engaging Stakeholders

Special consideration needs to be given to the identification and engagement of stakeholders that should be included in the assessment. In general, stakeholders may come from local, regional, or provincial public health departments, emergency management organizations, parks and recreation departments, transportation planning agencies, health care organizations, and social service providers. Community planners, citizen groups, faith-based organizations, and private sector officials who provide essential services may also be included.

When identifying possible stakeholders, consideration should be given to the degree to which they:

- will be involved in the design, implementation, and monitoring of public health and health care interventions to reduce risks from extreme heat
- are affected by the issue
- represent vulnerable populations
- can facilitate achievement of the assessment objectives
- can influence policy and program development

Because some organizations may not have the breadth or depth of in-house expertise available to conduct or participate in some aspects of an assessment, the addition of external expertise may be both desirable and necessary.

Once stakeholders are identified, the project lead will need to develop a process for acquiring input from them to contribute to the design and conduct of the assessment, and communication of the results. Developing a stakeholder engagement plan may assist in organizing stakeholders into categories, such as stakeholders who are partners and directly involved and those who may be consulted or regularly informed of progress. Community consultations, a community committee, a project advisory committee, and an expert review group are mechanisms to engage various stakeholders throughout the assessment.

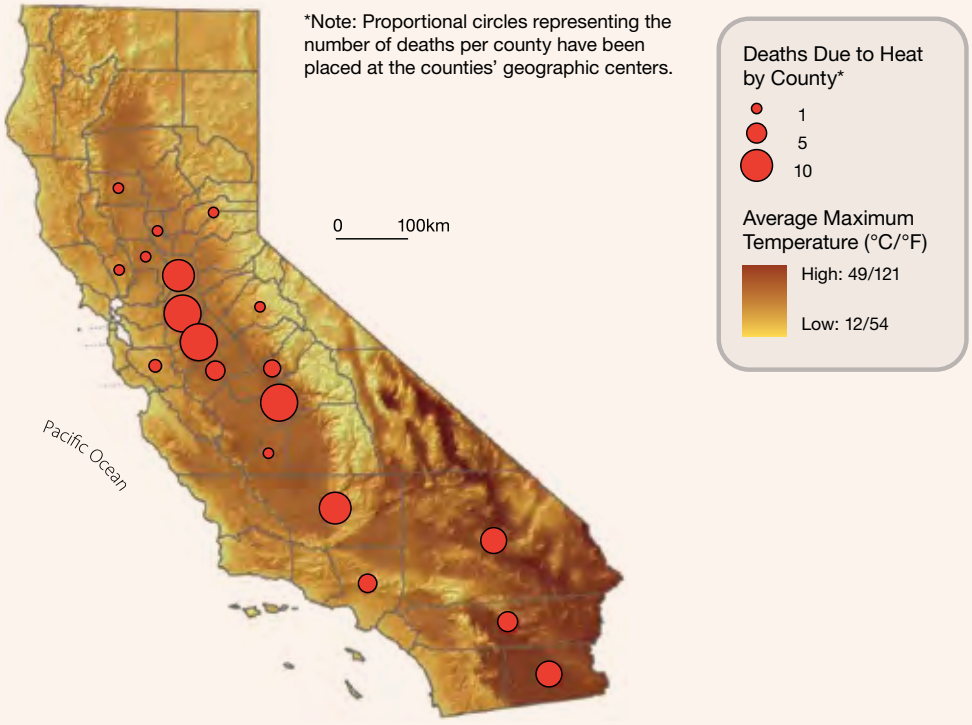
If necessary, training workshops can be hosted by the project lead to build capacity and increase the

Box 4: Assessment of Vulnerabilities to Extreme Heat in California

As part of a series of scientific studies on climate change health impacts, the California Climate Change Public Health Impacts Assessment and Response Collaborative conducted an assessment of vulnerability to heat-related illness and mortality in 2007.[49] The report identified county- and community-specific risks and vulnerabilities in California, and preventative actions to protect health. The assessment included the following steps:

- Review the clinical spectrum of heat-related illness.
- Develop a model of population vulnerability based on
  (1) historic heat data in California,
  (2) characteristics of the heat deaths in California during the summer of 2006 (Figure 4), and
  (3) identification of demographic characteristics associated with population vulnerability to heat.
- Identify vulnerable geographic areas based on adaptive capacity.

Figure 4: Geographic distribution of deaths in California due to heat – July, 2006



The assessment results are helping decision makers in California facilitate the development of effective public health interventions, such as the provision of targeted information, so that individuals can take the measures necessary to protect themselves and their family members.

Source: English et al., 2007.[49]

knowledge of stakeholders about issues relevant to the assessment. Stakeholders should be engaged throughout the entire assessment process. However, stakeholders may change at various steps of the assessment as different information requirements arise—for example, input from experts in other sectors (e.g., transportation, infrastructure, urban planning, energy systems).

Step 1.1

Identify assessment scope and objectives and develop a work plan

Task: Identify the assessment objectives and scope

Methods	Outcomes
• Consult with decision makers and other users to define the objectives • Conduct literature review on vulnerability assessments • Survey the type of data available to answer assessment questions • Review assessments in other jurisdictions • Engage in consultations with individuals who have experience in conducting assessments	Identification of: • objectives of the assessment • questions to be addressed by the assessment • geographic region under investigation • heat-related health risks under investigation (i.e., morbidity, mortality) • measures of success • target audience for disseminating the results • time frame for completing the assessment

Task: Develop an assessment work plan

• Meet and consult with the research team and key users to develop the work plan	Work plan that includes: • lead organization and secretariat • core project team and writing teams • advisory committee and/or expert review group • existing access to resources, data, and information • project timelines • milestones and key deliverables • available methods for collecting information • stakeholder engagement approach • assessment communications activities

Step 1.2

Identify and organize stakeholders to be engaged in the assessment

Task: Identify stakeholders

Methods	Examples	Outcomes
• Conduct a review of relevant government, non-governmental organizations, community groups, and academia to identify who should be involved during each step of the assessment • Meet and consult with the advisory committee, research team, and key users to identify the organizations and experts who should be included in the development of the assessment	• Public health officials • Health care providers • Emergency managers • Professional associations (medical, nursing, public health, emergency management) • Canadian Red Cross • Vulnerable population support groups (e.g., community shelters, mental health) • Aboriginal groups • Eldercare and services (e.g., Meals on Wheels, home-care nurses) • Citizen and faith-based groups • Utility and transportation authorities • City planners, parks and recreation officials • Businesses and non-governmental organizations • Meteorologists • Climate modellers	• An inventory of key stakeholders and their desired contributions to the assessment

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Step 1.2

Identify and organize stakeholders to be engaged in the assessment

Task: Organize stakeholders

Methods	Examples	Outcomes
• Organize stakeholders according to the roles they may play in the various steps of the assessment	• Key community contacts (assessment champions, community leaders) • Experts capable of conducting data analysis and interpretations • Climate modellers • Community participants (landlords and tenants, business owners, farmers, occupational standards association) • Experts to inform and review assessment • Vulnerable population support groups • Peer review groups	• List of stakeholder groups and individuals to participate in advisory groups and individual steps of the assessment as needed
• Assign responsibility, authority, and resources to the research team to engage stakeholders	• Project timelines and budgets • Expectations for stakeholder engagement • Skill and equipment requirements	• Determination of roles, responsibilities, and resources for stakeholder engagement activities for each stakeholder group

2 Describe current vulnerability to extreme heat events

The objective of this step is to describe the current vulnerability of individuals and the community to extreme heat events. This is accomplished by examining the current burden of heat-related health outcomes, social and personal factors that affect the ability to cope with extreme heat, current exposure at the community level to extreme heat events, and current programs and activities that address existing health risks. The description of the current distribution and burden of heat-related health outcomes may be qualitative or quantitative, depending on the information and resources available. It should include the consideration of individuals and regions that are most vulnerable to the effects of extreme heat. The types of data and information necessary for the assessment at this stage may be available at community, provincial, and/or national levels (Table 2).

Table 2: Examples of data sources for conducting extreme heat and health vulnerability assessments

Data Source	Description
Heat exposure	
Natural Resources Canada: The Atlas of Canada *http://atlas.nrcan.gc.ca/site/english/index.html*	• On-line climate information, such as seasonal daily minimum and maximum temperatures (e.g., July mean daily minimum and maximum temperature maps)
Environment Canada: National Climate Data and Information Archive *www.climate.weatheroffice.ec.gc.ca/Welcome_e.html*	• Official climate and weather observations (e.g., temperature, humidity) for Canada
Natural Resources Canada: Canada Centre for Remote Sensing *http://ccrs.nrcan.gc.ca/index_e.php*	• Centre of expertise for space-based remote sensing science and satellite data in Canada (e.g., products and resources: scientific publications, geomatics training, on-line retrieval for archived publications)
Individual and community level vulnerability factors	
Statistics Canada: 2006 Community Profiles *www12.statcan.ca/census-recensement/index-eng.cfm*	• Community level information from the Canadian 2006 census; downloadable data presented in tabular and graphical forms (e.g., community age characteristics, occupied private-dwelling characteristics, first language (mother tongue), knowledge of official languages, immigrant status and period of immigration, Aboriginal population, educational attainment, occupations, earnings, income)

Continue to next page

Data Source	Description
Statistics Canada: Maps and Geography *www.statcan.gc.ca/mgeo/thematic-thematique-eng.htm*	• Thematic maps by subject for census subject areas including agriculture, environment, and health; map series at national, provincial/territorial, and regional levels, as well as for census of metropolitan areas and census subdivisions (e.g., percentage of population aged 65 years and older, aged 80 years and older, with low income, adult obesity, circulatory and respiratory diseases and deaths, asthma by health region)
Natural Resources Canada: The Atlas of Canada *http://atlas.nrcan.gc.ca/site/english/index.html*	• On-line maps of health topics including health behaviours, non-medical determinants of health, health resources, rural health, and health status; people and society section topics including age, education, language, and literacy (e.g., age structure, old-age dependency ratios, performance on adult literacy skills, educational attainment, foreign-born population)
Statistics Canada Population Health Surveys *www.statcan.gc.ca/concepts/hs-es/index-eng.htm*	• Population health surveys including the Canadian Community Health Survey, National Population Health Survey, Canadian Health Measures Survey, Health Services Access Survey
Municipal and Provincial Government Reports and Websites	• Various demographic information at the municipal level (e.g., maps on average household income, low-income households, population over 65 years of age by neighbourhood; tables on Aboriginal identity, dwelling condition, income, labour force activity, population, recent immigration, community area profiles) • Mortality data from local (coroner's), regional (health authority), and provincial (ministry) levels; accessibility and confidentiality issues may be factors in obtaining this data
Statistics Canada: Canadian Vital Statistics Program Death Database *www.statcan.gc.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=3233&lang=en&db=imdb&adm=8&dis=2*	• Demographic and medical (cause of death) information annually from all provincial and territorial vital statistics registries on all deaths in Canada for calculation of basic indicators (e.g., counts and rates) on deaths of residents of Canada and statistical analyses (e.g., cause-specific death rates, life expectancy)

Continue to next page

Data Source	Description
Environment Canada and Health Canada: Air Quality Health Index (AQHI) *www.airhealth.ca*	• Public information tool that helps Canadians protect their health on a daily basis from the negative effects of air pollution, including current and forecasted air quality levels for most Canadian communities and information about who is "at risk" from air pollution
Institut national de santé publique du Québec: Infocentre de santé publique *www.inspq.qc.ca/infocentre/*	• 215 indicators on social, environmental, and health topics; downloadable data presented in tabular and graphical forms over several years; accessible for health sector personnel from the Quebec health Intranet only (Available only in French)
Institut national de santé publique du Québec: Éco-Santé Québec 2008 *www.inspq.qc.ca/pdf/publications/eco-sante.asp?E=p*	• 150 indicators for the 18 health regions of the province, available on the Internet; downloadable data presented in tabular, graphical, and cartographic forms over several years (Available only in French)

Mortality data obtained from provincial health departments (available in some regions) or Statistics Canada can be used to quantify the relationship between extreme heat events and excess deaths. The historical temperature record can be compared to trends in excess deaths to identify any association between these two variables (Box 5).

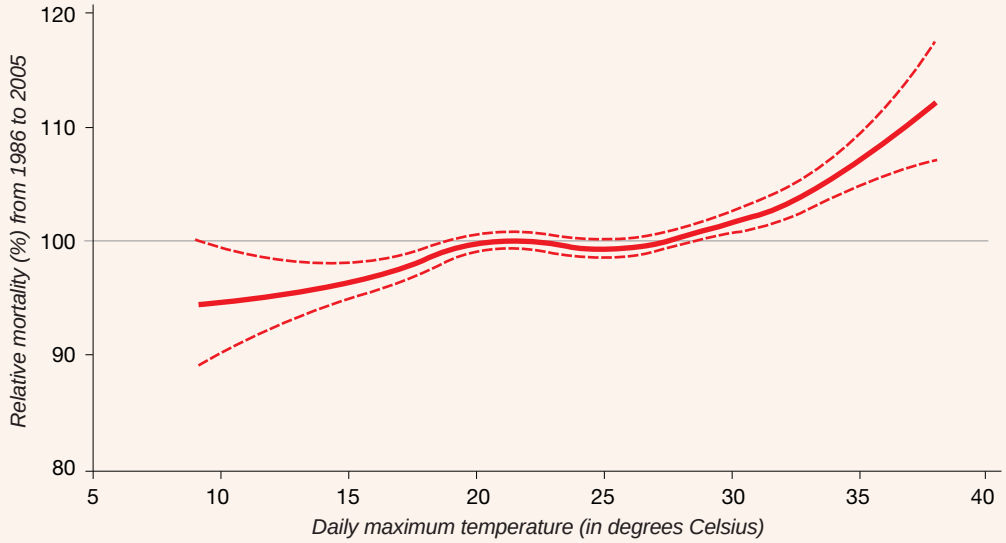
The description of community vulnerability to extreme heat should capture the existence of both preventative (e.g., reduction of the urban heat island effect) and responsive (e.g., cooling centres) programs, and activities addressing the burden of heat-related health outcomes, as well as planned changes to them. Different metrics can be used to measure levels of exposure to extreme heat and the effectiveness of programs and policies aimed at reducing health risks. Examples of measures that can be used when evaluating programs include trends in heat-related health outcomes, utilization of community cooling centres during extreme heat events, percentage of vulnerable people receiving assistance during extreme heat events (e.g., distribution of water), and audience penetration of heat-health communications messages.

To provide information about vulnerability for planning public health interventions, the results of the analysis can be mapped using geographic information systems (GIS) at the community level. Information about current individual and community-level vulnerability (i.e., challenges and opportunities faced by people in efforts to protect their health) acquired from citizens and stakeholders should be included in the analysis, when available.

Box 5: Relationship Between Temperature and Mortality in Winnipeg, Manitoba

To investigate health risks associated with extreme heat in the City of Winnipeg the relationship between temperature and excess mortality was examined. The association between all non-traumatic daily deaths that occurred from June 1, 1986, to August 31, 2005, and the corresponding maximum daily temperatures was plotted on a graph (Figure 5).

Figure 5: Association between non-traumatic daily deaths and maximum daily temperatures in Winnipeg from 1986 to 2005



The statistical "generalized additive model" was used to establish the association between mortality and temperature. Daily maximum temperature data were measured during June, July, and August from 1986 to 2005, and were correlated with all non-traumatic deaths (i.e., excluding motor vehicle accidents, homicides, falls, drownings). Meteorological data from Environment Canada's National Climate Archive were selected, based on the proximity of meteorological stations to Statistic Canada's census subdivisions of death. Mortality data were obtained for the same years from Public Health Agency of Canada or Health Canada databases.

The mortality data were first analyzed to determine an average ("normal") for June, July, and August of each year; this is each year's "reference value." Then, a mortality rate for each day was expressed relative to that reference value as a percentage (%). This normalization was performed to account for changes (e.g., demographics, urban landscape, etc.) over the time period analyzed. Mortality curves are generally used to establish a relationship by incorporating data over a long period of observations to deal with inter-annual trends. Figure 5 shows a strong association between temperature and excess mortality in the City of Winnipeg. At approximately 26°C/78.8°F excess mortality begins to increase as ambient temperatures increase; the increase in deaths becomes much more pronounced above 35°C/95°F.

Source: Casati and Yagouti, (In Press).[23]

Step 2.1

Describe the current burden of heat-sensitive health outcomes, including populations and regions that are most vulnerable

Task: Characterize heat exposure for the community or region being assessed

Methods	Examples	Outcomes
• Investigate historical climate records for trends in extreme heat events • Spatially map temperature trends in communities • Assess urban heat island effects and community design and building practices (e.g., how building materials are used) that contribute to the effects • Examine relationship between temperature and mortality and morbidity	• Maximum daily summer temperatures • Average daily summer temperatures • Number of days with temperatures over 30°C/86°F per year (or a specific community-based threshold) • Timing of extreme heat events • Number of days with high minimum temperatures • Number of heat events per year • Examination of urban heat island factors contributing to urban heat island effect (e.g., transportation surfaces, green spaces, building materials) • Materials used in building structures (e.g., types of roofs, shutters on windows, screen doors)	• Maps showing temperature trends in communities • Estimates of urban heat island intensity • Charts depicting various temperature trends for a community or region • Temperature mortality curves or qualitative assessments of temperature–mortality relationship • Definition of an extreme heat event • Qualitative or quantitative estimates of current excess morbidity and mortality associated with heat in a region

Task: Characterize heat and air pollution exposure for the community or region being assessed

• Examine the historical relationship between poor air quality and heat episodes	• Number of poor air quality episodes occurring during the summer • Number of poor air quality days correlating with heat days • Excess mortality during air pollution episodes	• Quantitative and qualitative estimates of current morbidity and mortality relating to the combined effects of heat and poor air quality • Graphic or chart showing temporal relationship between poor air quality and heat episodes

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Step 2.1

Describe the current burden of heat-sensitive health outcomes, including populations and regions that are most vulnerable

Task: Characterize other community vulnerability factors associated with heat risks within community or region being assessed

Methods	Examples	Outcomes
• Conduct literature reviews (e.g., grey literature, website reviews) • Conduct key informant interviews and/or questionnaires with stakeholders • Hold workshops with key stakeholders to collect information on community vulnerability to heat	• Number and nature of outdoor events that occur in the summer (e.g., marathons, sporting events, outdoor concerts and festivals) • Number of tourists visiting community during heat season • Location and percentage of population that work outdoors or in occupations with high heat exposure (e.g., bakers, dry cleaners) • Distribution of buildings with or without air conditioning (e.g., libraries, malls, nursing homes, daycares, hospitals) • Location of swimming pools • Effect of heat on critical infrastructure (reliability of power grid)	• Characterization of factors contributing to community vulnerability • Maps depicting factors that contribute to community vulnerability

Task: Characterize individual vulnerability to heat risks within the community or region being assessed

• Conduct a literature review of epidemiological studies of heat and health risk factors
• Conduct key informant interviews and/or questionnaires with stakeholders responsible for caring for sensitive individuals
• Survey the public including vulnerable populations
	• Locations of sensitive populations within community:
	  • Poor health status: chronic illness, need for medications that increase heat-health risks, dependence on caregiver
	  • No access to air conditioning
	  • Social isolation
	  • Living alone
	  • Low income
	  • Homelessness
	  • Dangerous behaviours during extreme heat events: strenuous physical activity, inadequate hydration
	  • Older adults
		• Characterizations of the vulnerability of specific populations to extreme heat in the community or region

Step 2.2

Describe current programs and activities, and planned changes to them, and assess their effectiveness in addressing health risks from extreme heat events

Task: Inventory the programs and activities that have been developed specifically to address risks from extreme heat, and account for planned changes to these program and activities

Methods	Examples	Outcomes
Conduct: • Key informant interviews • Facilitated workshops • Decision-maker surveys • Literature reviews • Website reviews	• HARS or components, such as public alerting, media releases, fact sheets, distribution of bottled water • Outreach programs to protect vulnerable populations from heat • Labour codes and standards addressing occupational heat stress • Eldercare homes' protocols for heat • Public health surveillance of heat morbidity and mortality • Increased access to public buildings with air conditioning and swimming pools	• Identification of applicable programs and activities directly relating to heat and health

Task: Inventory programs and activities relating generally to health protection and/or emergency preparedness that may address risks from extreme heat, although not developed exclusively for that purpose

Conduct: • Key informant interviews • Facilitated workshops • Decision-maker surveys • Literature reviews • Website reviews	• All hazards emergency management plans • Existing emergency communication systems for alerting the public (newspapers, radio, television, public service announcements) • Emergency health services • Community greening initiatives (e.g., tree planting, urban park development) • Building codes and related city planning • Air-conditioning accessibility and use	• Identification of general programs that may reduce health risks related to heat

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Step 2.2

Describe current programs and activities, and planned changes to them, and assess their effectiveness in addressing health risks from extreme heat events

Task: Evaluate the effectiveness of specific and general programs and activities that have been developed to address risks from extreme heat

Methods	Examples	Outcomes

Conduct:
• Public health program and activity evaluation
• Focus groups
• Key informant interviews
• Surveys
• Pre- and post-heat season evaluation meetings, including stakeholders involved in HARS
	• Evaluation of the effectiveness of the HARS related to:
	  • Alert Protocol
	  • Community Response Plan
	  • Communications and Outreach Plan
	  • Evaluation Plan
	• Evaluation of the effectiveness of community response efforts during public health emergencies
		• Description of effectiveness of current HARS and communication activities
		• Characterization of current program and/or activity strengths and limitations
		• Description of current capacity to respond to extreme heat

3 Assess future health risks associated with extreme heat events

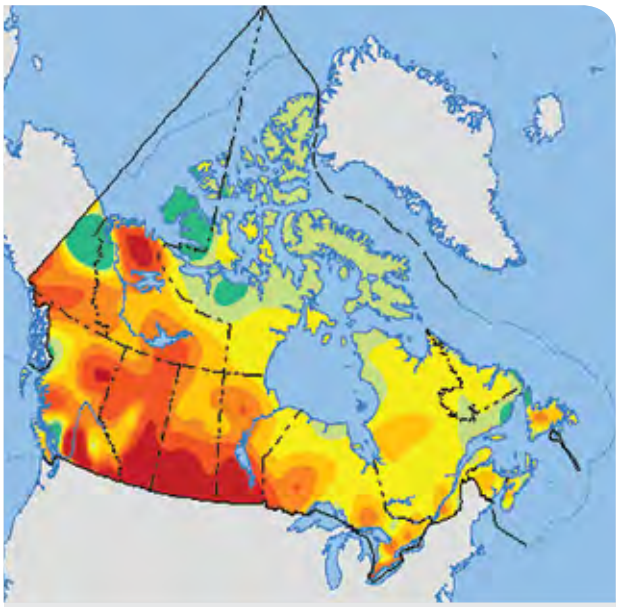
The objective of this step is to characterize increased risks to health from future extreme heat events due to a changing climate in conjunction with other expected societal changes. This can be done either qualitatively or quantitatively. First, an estimate is needed of how the current burden of heat-related health outcomes is likely to change over coming decades, irrespective of climate change. The burden of heat-related health outcomes (e.g., illnesses and deaths) may increase or decrease in the future because of changes in vulnerable populations (e.g., more seniors, fewer outdoor workers) and/or changes in adaptive capacity (e.g., improved health care services, implementation of a HARS). The description of how the current burden of heat-sensitive illnesses is likely to vary without climate change is a baseline against which the possible additional health risks of climate change should be assessed. The implications of expected increases in the number, intensity, and duration of extreme heat events for a community or region are then assessed. Climate and temperature projections for Canada are produced by federal government agencies and by the Ouranos Consortium (Table 3); the Ouranos Consortium also works closely with other partners in Canada, such as Environment Canada, Ontario Power Generation, and Manitoba Hydro.

Table 3: Examples of data sources for climate and temperature projections

Data Source	Description
Climate and Temperature Projections	
Natural Resources Canada: The Atlas of Canada *http://atlas.nrcan.gc.ca/site/english/index.html*	• On-line climate change maps, including global and national temperature and precipitation projections for 2050 and 2100 (e.g., national average summer temperature projection, 2050; global average summer temperature projection, 2050 and 2100)
Environment Canada: Canadian Centre for Climate Modelling and Analysis *www.cccma.ec.gc.ca/eng_index.shtml*	• Information on coupled and atmospheric climate modelling, climate variability, and predictability; data from climate models available for downloading (e.g., change in annual mean Canadian temperature in 2041–2060 relative to 1971–1990; projected change in 5-year mean near-surface Canadian air temperature for 2000–2100 relative to 1981–2000; observed and projected change in surface-air temperature in Canada; projected changes in surface-air temperature over the Earth and North America)
Ouranos: Consortium on Regional Climatology and Adaptation to Climate Change *www.ouranos.ca/en/scientific-program/general-information.php*	• Bringing together some 250 scientists and professionals from different disciplines to provide timely information on simulation data and climate scenarios; quantifying impacts of climate change on the environment, public and socio-economic activity; assessing vulnerabilities of systems; identifying and recommending to decision makers best approaches for adapting to climate change

There are challenges associated with estimating future vulnerability based on projections of climate conditions, air quality, and expected demographic, health status, and socio-economic changes in society. In particular, use of this data requires specialized knowledge of climate science and health models, as well as their assumptions, limitations, and the degree of uncertainty associated with their application (Figure 6). Public health officials need to build expertise and capacity in this area and collaborate closely with the climate science community to address risks to health from extreme heat events. This collaboration will help to ensure that the communication of assessment results to decision makers will clearly convey information about any uncertainties related to possible future vulnerabilities. Assessment findings that suggest trends in key vulnerability factors are increasing

Figure 6: Projected forest fire severity level from 2050 to 2059



Note: The figure shows projected seasonal severity ratings across Canada from 2050 to 2059, based on a climate with doubled carbon dioxide concentrations (based on the Canadian General Circulation Models). This rating is a measure of fire danger conditions over a complete season and has a relative scale with values above 5 being extreme.

Source: Atlas of Canada, 2007.[56]

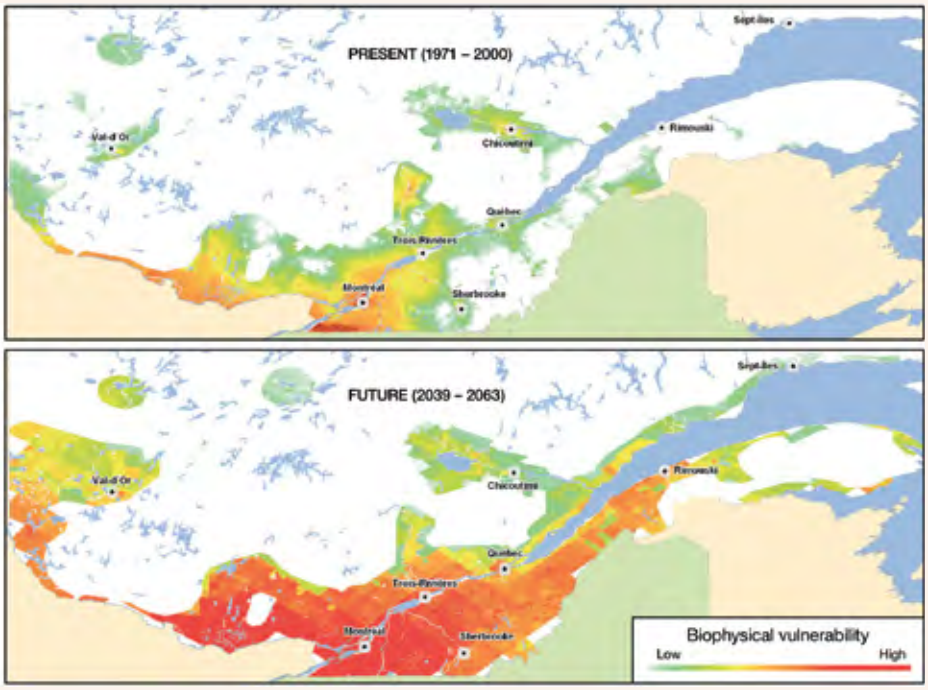
within a population or community may be sufficient to warrant the adoption of proposed adaptation options.

Meteorological variables (e.g., temperature, humidity), and demographic, health status, and socio-economic data can be plotted on maps using GIS to spatially show current and future health vulnerabilities associated with extreme heat events (Box 6).

Box 6: Using GIS to Assess Health Risks due to Extreme Heat Events in Quebec

Vescovi *et al.*, (2005) plotted climate variables and vulnerability parameters (age, poverty, social isolation, education, and income) for southern Quebec on maps to show current and projected health risks associated with extreme heat events.[51] The maps show that the number of locations where vulnerable populations will be at risk from extreme heat events will dramatically increase in Quebec over the next few decades (Figure 7).

Figure 7: Map of current and future vulnerability to extreme heat events in Quebec based on the projected number of hot days and four underlying indicators (i.e., age, poverty, social isolation, education)



Source: Vescovi et al., 2005.[51]

Public health officials in this province are already using and maintaining an on-line portal including web-based GIS technology to identify areas vulnerable to climate change and relevant indicators for preventative or emergency actions. The tool allows decision makers to conduct analysis with the best available data to better understand vulnerabilities to extreme heat in their respective jurisdictions. The available data will soon be extended to cover other extreme meteorological events. While currently accessible only through the provincial health ministry's Intranet in its full format, a partial cartographic application showing the most important urban heat islands and some other indicators can be accessed at: http://geoegl.msp.gouv.qc.ca/inspq_icu/.

Step 3.1

Describe how current demographic, health status, and socio-economic trends affecting the burden of heat-related health outcomes are likely to change over coming decades

Task: Describe the trends that are expected to influence how the burden of heat-related health outcomes may change over coming decades irrespective of climate change

Methods	Examples	Outcomes

• Review literature on projected health status, and demographic and socio-economic trends that increase susceptibility to heat-related health outcomes	• Demographic and health status data and projections for:
	  • seniors
	  • young children
	  • chronic diseases (e.g., cardiovascular disease, respiratory disease, obesity)
	• Socio-economic projections for:
	  • older adults living alone
	  • low income levels
	  • single-parent homes
	  • homelessness
		• Documentation of trends that are relevant to how the burden of heat-related health outcomes may change over coming decades irrespective of climate change

Step 3.2

Estimate the increased risks to health from extreme heat events exacerbated by climate change

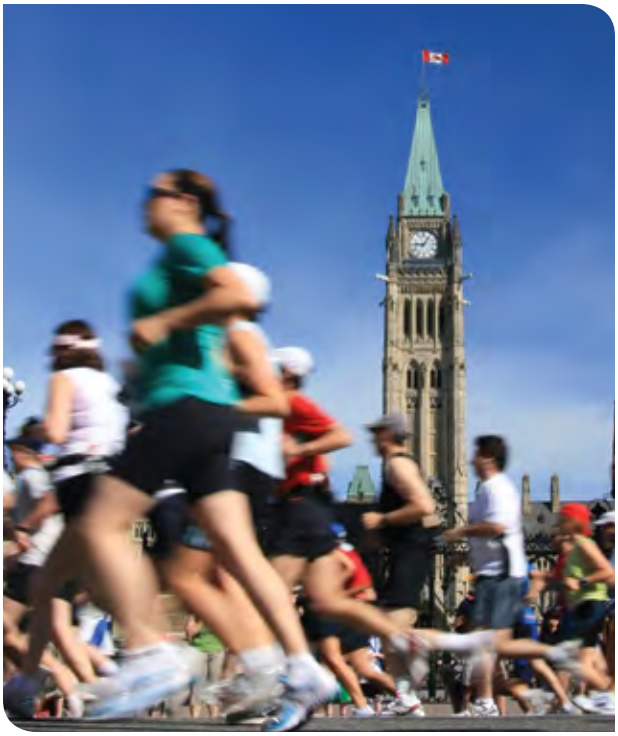
Task: Describe the projected increase in average temperatures and the number, intensity and duration of extreme heat events

Methods	Examples	Outcomes
• Conduct climate modelling to obtain projections of average temperatures and extreme heat events or use available or published projections	• Projected increase in the number, intensity and duration of extreme heat events (e.g., projections of maximum and minimum daily temperatures at regional levels)	• Characterization of average temperatures and future extreme heat events under a changing climate: graphic or chart showing maximum and minimum daily temperatures at regional levels • Description of assumptions and time frames used in the analysis

Task: Describe the possible additional health outcomes due to projected increases in temperature in a changing climate

• Extrapolate current heat-health morbidity and mortality to future temperature increases under the assumption of current adaptations level (i.e., if all else stayed constant)	• Estimated increase in excess mortality and morbidity due to increased temperatures	• Characterization of the possible additional health risks due to increases in temperature in a changing climate • GIS maps that identify communities and regions vulnerable to future extreme heat events

4 Identify and prioritize adaptation options to address current and projected health risks from extreme heat events



The objective of this step is to identify possible adaptation options that can address the current and projected health risks related to extreme heat. It may be necessary to augment current programs to take into account the new conditions, pressures, or challenges that climate change is expected to pose for health—in this case, a greater number, intensity, and duration of extreme heat events. Examples include changing current practices related to the identification of alert triggers that are community specific (Box 7); organizing and holding outdoor festivals and events (e.g., marathons and outdoor concerts) earlier in the season; providing assistance during extreme heat events to people living on the street (e.g., providing water); and caring for vulnerable people in their homes (e.g., public education about heat-health risks to eldercare providers). During this step, possible co-benefits associated with the proposed adaptation measures to reduce heat-health risks need to be considered. For example, immediate health benefits, such as reduced respiratory illnesses from improved air quality, can accrue from appropriately designed adaptations (e.g., development of green spaces and bicycle paths) to reduce the urban heat island effect. Health co-benefits of taking actions can help to drive or motivate community efforts to prepare for extreme heat events.

Prioritizing potential adaptation options requires an evaluation of their effectiveness, feasibility, and costs. Measures of program effectiveness may be obtained from existing evaluation practices used by public health officials in their respective fields.[e] Key factors and processes that may be barriers to achieving the goals of the adaptation options should be investigated, and opportunities for overcoming these barriers should be identified. Stakeholders play a key role in this process. Assessments should document the results of stakeholder discussions concerning the proposed adaptation options.

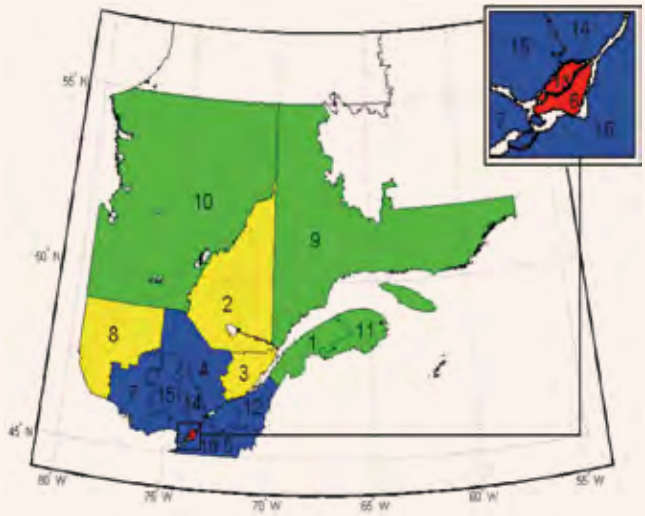
[e] *See Health Canada (In Press), "Heat Alert and Response Systems to Protect Health: Best Practices Guidebook" for information on assessing the effectiveness and impact of a HARS.*[55]

Box 7: Developing Heat Alert Thresholds in Quebec, Taking Latitude and Place into Account

Large-scale emergency interventions during extreme heat events can save hundreds of lives, but they also can be very costly; this is because they require the mobilization of policemen and other officials to locate individuals in need of help, distribute water to the homeless, open cooling centers and the like. Decision makers require that such interventions take place at the right time to save lives, with false alarms kept to a minimum. Science tells us that extreme heat events should be defined differently within a country (latitude, elevation, and proximity to bodies of water matter) and across the globe because of variations in normal physiological acclimatization among populations.[52]

The extreme heat thresholds used in Quebec to trigger large-scale emergency response interventions are now based on the analysis of heat-related mortality (Quebec mortality data and Environment Canada meteorological archives for 1981–2005), similar to the analyses used by several European countries. Historical mortality and temperature data (i.e., periods of high temperatures) were used to determine what threshold heat values (daily minimum and maximum temperatures taken together) are associated with a significant increase in mortality. To identify thresholds for the whole province, the health regions of Quebec were divided into classes that are homogeneous from a meteorological standpoint and that have sufficiently high daily mortality rates to permit analysis. These constraints necessitated the use of a mortality increase of 60% over the historical average as the threshold for identifying the triggers for a full heat alert.

Figure 8: Health regions of southern Quebec grouped into homogenous climatic classes



Source: Martel et al., 2010.[52]

Note: The numbers refer to the health regions. The inset (red portion) is an enlargement of the Montreal Island and Laval regions.

A weighted temperature forecast over three days was identified as optimal; this measure was able to reflect regional differences, and thus assign thresholds across the province that were regionally specific. For instance, the city of Montréal area threshold (Figure 8: in the number 6 red zone) was identified as a daily maximum of 33°C/91.4°F, a daily minimum of 20°C/68°F (i.e., nighttime) and a humidex of 40, with daily weights of 40%–40%–20%. The city of Québec, which is only 250 km northeast (Figure 8: in the number 3 yellow zone), would reach the same risk at 31°C/87.8°F and 16°C/60.8°F with the same weights and a humidex of 37.[52]

Step 4.0

Identify and prioritize adaptation options to address current and projected health risks from extreme heat events

Task: Inventory and prioritize all possible and reasonable adaptation options including those to improve the effectiveness of current programs or new measures to address heat-related health outcomes

Methods	Examples	Outcomes
• Seek expert judgment and stakeholder input • Develop questionnaire assessing decision-maker views and needs • Review literature on best practices for managing health risks from heat events • Review of regulatory requirements • Analyze options (e.g., cost-benefit analysis or multi-criteria analysis)	• HARS • Awareness raising activities • Extended hours for air-conditioned public places • Provisions for eldercare during heat events • Guidelines for sporting events and outdoor festivals • Urban heat island mitigation	• Description of practical and feasible heat-health adaptation options • Priority list of adaptation options for current and future time frames

Task: Assess critical factors that may be barriers to implementing adaptation options and identify how barriers can be overcome

• Seek expert judgment and stakeholder input • Conduct public awareness surveys • Analyze broader benefits of options (e.g., cost-benefit analysis or multi-criteria analysis) • Develop questionnaire assessing decision-maker views and needs • Assess required resources (e.g., additional personnel and equipment)	• Economic costs • Social implications • Political sensitivity and implications • Influential champion for the issue • Leveraging resources through collaborative partnerships • Including provisions to maximize access to services by vulnerable populations	• List of possible barriers to implementing adaptations options • Description of how barriers may be overcome

5 Examine the potential health risks and benefits of adaptation and mitigation measures implemented in other sectors

Existing practices and planned changes to programs in other sectors may also affect risks to health posed by extreme heat (e.g., water restrictions, power outages, lack of air conditioning in public transportation). The objective of this step is to assess the possible health impacts of measures or interventions implemented in other sectors. This would include, but is not limited to, adaptation and greenhouse gas mitigation measures that may impact heat-related health risks. Adaptation and greenhouse gas mitigation measures in other sectors may have both positive and negative health impacts; however, activities with unintended negative consequences are of particular concern. The focus should be on changes or disruptions in other sectors with the greatest potential to influence the burden of heat-related health outcomes in order to maintain a manageable scope. Some functions and sectors that may be affected, and for which consideration should be given when assessing health vulnerability to extreme heat events, include:

- infrastructure planning, renewal, and management
- building engineering and codes
- water and energy supply
- transportation systems and design
- parks and recreation planning and operation
- emergency preparedness and management

Many of these sectors are integral to the performance of health and social services, particularly in times of emergency (Box 8).

Box 8: Power Outage During an Extreme Heat Event in Toronto – July 5, 2010

On July 5, 2010 a power outage left approximately 250,000 people living in Toronto without electricity. This occurred while the city and most of Ontario were in the grip of an extreme heat event and smog advisory—with temperatures in the 35°C/95°F range and humidex values in the 40 range. A fire at a transformer station sapped some 1,000 megawatts from the city. People were forced to walk down dozens of flights of stairs because buildings were without power to run the elevators. To the extent that older adults and people with limited mobility were unable to leave high-rise buildings to escape the heat, their health could have been seriously impacted. Traffic lights went out, and two subway stations in the west end were affected. The outage was substantial enough to cause blips on the provincial power grid, with reports of lights flickering as far away as Ottawa. If the extreme heat event and the power outage had lasted longer, it could have compromised the ability of public health officials and social service providers to disseminate messages (via radio, television, and Internet) to reach vulnerable populations requiring assistance.

Source: Boesveld, 2010.[53]

Step 5.0

Examine the potential health risks and benefits of adaptation and mitigation measures implemented in other sectors

Task: Assess how changes in critical infrastructure, transportation systems, land-use planning, and housing may influence heat-health risks

Methods	Examples	Outcomes
Conduct: • Key informant interviews • Literature and website reviews • Service-provider surveys	• Changes in the stability of electrical power supplies • Changes in water quality and quantity • Changes in the amount of green spaces influencing the urban heat island effect • Building codes and standards (e.g., air conditioning, white or green roofs)	• Description of the beneficial and adverse effects that changes in other sectors may have on possible health risks from extreme heat

Green roof in Vancouver

6 Develop protocols for evaluating adaptation options and monitoring heat-health risks

The final step of an assessment is to establish an iterative process for monitoring heat-health risks and evaluating the adaptation options that are recommended for implementation. This ensures the measures adopted by public health and emergency management officials are effective in reducing health risks from extreme heat events. Monitoring the burden of heat-sensitive health outcomes is necessary for the continued effectiveness of interventions in a changing climate.

Evaluating programs and initiatives may be challenging. For example, the analytical basis for monitoring may involve very long time frames, such as the development of a long-term record of extreme heat events and health impacts. Indicators that provide evidence of success or failure of public health efforts to protect citizens can be used to assess the effectiveness of programs and ensure that appropriate improvements to practices can be made.

Step 6.0

Develop protocols for evaluating adaptation options and monitoring heat-health risks

Tasks: Develop protocols for evaluating the adaptation options to be implemented to reduce the burden of heat-sensitive health outcomes

Methods	Examples	Outcomes
• Conduct key informant interviews • Review of literature • Conduct decision-maker surveys • Facilitate workshops	• Number of heat alert media releases • Heat-health web-page usage by the public • Adoption of individual protective measures (e.g., use of fans, use of cooling centres, shifting exercise routine, use of hats) • Implementation of urban heat island mitigation measures • Participation of community agencies in HARS, outreach activities (e.g., distributing bottled water, cancelling sporting events, reverse 911 calling)	• Evaluation protocols • Heat-related morbidity and mortality data for use in program evaluations

Tasks: Develop protocols for monitoring the burden of heat-sensitive health outcomes during heat events and conduct the monitoring

• Review of literature • Surveillance of extreme heat morbidity and mortality (i.e., syndromic surveillance) • Conduct key informant interviews • Facilitate workshops	• Number of heat-related deaths • Number of heat-related illnesses and injuries • Increase in ambulance and telehealth calls during an extreme heat event • Health system utilization during an extreme heat event	• Monitoring protocols • Heat-related morbidity and mortality data for use in program monitoring • Heat-related morbidity and mortality data for use in calling heat alerts (if real-time surveillance used)

4. Conclusion

Climate change is expected to increase risks to the health and well-being of Canadians from extreme heat events. With sufficient knowledge of existing vulnerabilities and the coping capacities of individuals and communities, public health and emergency management officials can develop effective interventions to safeguard health. Extreme heat and health vulnerability assessments can provide this information to decision makers, along with a range of responses needed to reduce adverse health impacts.

Assessments can mark an important starting point in efforts to protect health by developing information about vulnerability to extreme heat events in a community. If no previous investigation of vulnerability has been conducted, an assessment is an opportunity to bring together relevant data and information sources, conduct the analysis through stakeholder engagement, and develop a definitive baseline. In this regard, an assessment serves as a mechanism to mobilize interdisciplinary groups to come together and collaborate to identify actions to increase the resiliency of the community.

Broad communication of the assessment findings is critical to support the mobilization of a community or region in order to prepare for future extreme heat events. The assessment should influence policy development and the adoption of practical public health interventions to reduce heat-health vulnerabilities. Therefore, results should be shared in a timely fashion with all partners as well as relevant users of the information (e.g., public health officials, emergency management officials, urban planners, social service providers).

A well-communicated assessment that follows a participatory approach is instrumental in directing the needed attention of both stakeholders and decision makers to the health risks of extreme heat events. It provides the opportunity to identify heat-related health risks, vulnerabilities, and adaptation options as priority issues to be addressed by a community in partnership with other levels of government. Awareness can be one of the least expensive and effective methods for decreasing risks. Ultimately, an assessment of community vulnerability and the implementation of adaptation measures reduce the vulnerability of a population to extreme heat events, now and in a changing climate.

Glossary

Adaptation: Process by which strategies and measures to moderate, cope with, and take advantage of the consequences of climatic events are enhanced, developed, implemented, and monitored.[11] In public health, the analogous term is prevention. Various types of adaptation exist, including anticipatory and reactive, private and public, autonomous, and planned.

Adaptive Capacity: General ability of individuals, communities, and institutions to effectively prepare for and cope with the consequences of climate variability and change.

Climate: "Average weather" in a particular place over a particular time period. It is the statistical description of the mean and variability of weather variables (i.e., temperature, precipitation) over a period of time ranging from months to thousands or millions of years; the typical time period is 30 years.

Climate Change: Statistically significant variation in either the mean state of the climate or in is variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere. The *United Nations Framework Convention on Climate Change* defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."[18]

Climate Model: Numerical representation of the climate system based on the physical, chemical, and biological properties of its components, and the interactions and feedback processes that account for all or some of the known properties. Models may vary in complexity; as research tools, they are applied to study and simulate the climate, but are also used for operational purposes including monthly, seasonal, and inter-annual climate predictions.

Climate Scenario: Plausible and often simplified representation of the likely future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, and often serving as an input to impact models.

Climate Variability: Variations in the mean state and other statistics (e.g., standard deviations, the occurrence of extreme events) of climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system or to variations in natural or anthropogenic external forcing.

Co-Benefits: Benefits (often health benefits) associated with reductions in greenhouse gas emissions. For example, reduced emissions of air pollutants can have immediate health benefits such as reduces respiratory and cardiovascular diseases. In addition, co-benefits can be associated with adaptation measures, such as new surveillance systems that monitor climate-related and non-climate-related infectious diseases.

Epidemiological Study: Science of public health and preventative medicine that studies the distribution and determinants of health-related states or events in specific populations, and that applies study findings to control and/or mitigate health problems.

Expert Judgement/Key Informant Interviews: Statements that represent a process of evaluation, which can be a set of conditions and criteria, by someone widely recognized as a reliable source of knowledge, technique, or skill, and whose judgement is accorded authority and status by the public or their peers.

Health: state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity.

Literature Review: Comprehensive survey of publications that aims to critically analyze, summarize, and compare prior research in a specific field of study. This may also include "grey literature" refering to a body of materials that is produced by all levels of government, academia, business, and industry in electronic and print formats, but is not traditionally published. Examples of grey literature include technical reports, policy frameworks, and guidance documents from government agencies, scientific research groups, or related committees.

Mitigation: Policies and measures to reduce greenhouse gas emissions and/or enhance carbon sinks.

Resilience: Ability of a natural or human system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Risk (i.e., Climate-Related Risk): Product of likelihood of exposure and the consequence(s) of exposure. It arises from the interaction of a physically defined hazard (i.e., floods and other extreme weather events, increasing temperature) with the properties of the exposed system (vulnerability).[11] System vulnerability is a critical determinant of the risk a region or subpopulation faces when exposed to a particular hazard. This means that programs to decrease vulnerability will decrease risk.

Sensitivity: An individual's or subpopulation's increased responsiveness, primarily for biological reasons, to a particular exposure. Biological sensitivity may be related to developmental stage, pre-existing medical conditions, acquired factors (e.g., immunity), and genetic factors.[9] Socio-economic factors also play a critical role in altering vulnerability and sensitivity by interacting with biological factors that mediate risk (e.g., nutritional status), and/or lead to differences in the ability to adapt or respond to exposures or early phases of illness and injury.

Stakeholder Consultation: Canvassing the views of stakeholders in the process of developing useful information, often through forums, round tables, and advisory bodies. Stakeholders may be drawn from governments, non-governmental organizations, research institutes, and private entities focussing on the issue being investigated.

Vulnerability: Susceptibility to harm, which can be defined in terms of a population or a location. Vulnerability to climate change is the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate variability and change. Vulnerability is dynamic and may itself be influenced by climate change (e.g., extreme weather events affecting health infrastructure). From a health perspective, vulnerability can be defined as the summation of all risk and protective factors that ultimately determine whether a subpopulation or region experiences adverse health outcomes due to climate change.[18] Characteristics of a region, such as baseline climate, abundance of natural resources (i.e., access to fresh water), elevation, infrastructure, and other factors can alter vulnerability.

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