Extreme Heat and Human Mortality: A Review of Heat-Related Deaths in B.C. in Summer 2021

Report to the Chief Coroner of British Columbia

Release Date: June 7, 2022

This report is dedicated to the families, friends and communities of those who lost their lives from the impact of the extreme heat event. May their memories endure in our actions to prevent similar deaths in the future.

The BC Coroners Service acknowledges with gratitude that this death review panel was convened on the territory of the Musqueam, Tsleil-Waututh and Squamish peoples.

Preface

On April 20, 2022, the British Columbia Coroners Service (BCCS) convened a panel to review the deaths of 619 persons who died following an extreme heat event that occurred June 25–July 1, 2021. During this period, an unprecedented heat dome resulted in record high temperatures across many parts of the province that persisted over several days.

Panel support was provided by BCCS staff Andrew Tu, Carla Springinotic, Dean Campbell, Quiana Foster and Ryan Panton.

I would like to thank the panel members for sharing their expertise, bringing the support of their respective organizations and participating in a collaborative discussion. I believe the panel has generated actionable recommendations that I am confident will contribute to reducing heat related deaths in British Columbia.

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Dr. Jatinder Baidwan – Chief Medical Officer, BC Coroners Service
Alex Boston – Executive Director, Simon Fraser University, Renewable Cities
Dr. Sam Bugis – VP Physician Affairs and Specialist Practice, Doctors of BC
Rowan Burdge – Provincial Director, BC Poverty Reduction Coalition
Gerry Delorme – Director, Health Emergency Management BC (HEMBC)
Dr. Michael Christian – Chief Medical Officer, BC Emergency Health Services (BCEHS)
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Dr. Sarah Henderson – Scientific Director, Environmental Health Services, BC Centre for Disease Control (BCCDC)
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Jim Ogloff – Fire Chief, Coquitlam Fire Department
Norm Peters – Vice President, Fraser Health Authority
Dr. Michael Schwandt – Medical Health Officer, Vancouver Coastal Health
Daniel Stevens – Director, Vancouver Emergency Management Agency, City of Vancouver
Magdalena Szpala – Director, Sustainability and Resiliency, BC Housing
Fiona Wilson – Deputy Chief, Vancouver Police Department
Amina Yasin – City and Regional Planner and Commissionaire, Vancouver City Planning Commission

On behalf of the panel, I submit this report and recommendations to the chief coroner of B.C.

Michael Egilson
Chair, Death Review Panel

Executive Summary

Extreme heat events (EHE) are also described in the literature as “heat waves” or “heat domes”. A heat dome occurs when an area of high pressure stays over the same area for days or even weeks, trapping very warm air underneath - rather like a lid on a pot*. The definition of an extreme heat event varies based on many factors, including geographic location and weather conditions such as temperature, humidity, and cloud cover as well as the duration of the event. During this type of event, the temperature is much hotter than average for a particular time and place.

In late June 2021, British Columbia (BC) experienced an unprecedented heat dome which resulted in record temperatures across many parts of the province over several days. Temperatures started to rise on June 24 and continued increasing to a peak on June 28-29. At the peak, temperatures reached over 40ºC in many parts of the province. Overnight temperatures were also uncharacteristically high.

During the week of the EHE (June 25–July 1, 2021), the BC Coroners Service (BCCS) responded to a sudden and significant increase in deaths. More than 800 deaths were investigated by BCCS during that week, with 619 of these deaths later identified as being heat-related.

The Chief Coroner convened a death review panel to review the circumstances around these deaths to identify actions to improve public safety and prevent future deaths. This multi-disciplinary panel was comprised of experts in emergency management, medicine, public health, First Nations health, seniors, city and municipal planning, health administration, poverty reduction, patient safety, policy, research, housing, police, fire and ambulance services.

Most of the deceased were older adults with compromised health due to multiple chronic diseases and who lived alone.

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*-What is a heat dome? | Royal Meteorological Society (rmets.org)

Major Findings

- 98% of deaths occurred indoors;
- There was a lag between the heat alerts issued by Environment and Climate Change Canada (ECCC) and public agencies and the public response;
- Heat-related deaths were higher among persons on specific chronic disease registries (schizophrenia, substance use disorder, epilepsy, chronic obstructive pulmonary disease, depression, asthma, mood and anxiety disorders, and diabetes) compared to the B.C. population;
- More than 60% of decedents had seen a medical professional within the month prior to their death;
- 67% (415) of decedents were 70 years of age or older;
- More than half of all decedents (56%) lived alone;
- More decedents lived in socially or materially deprived neighbourhoods than the general population;
- Most decedents were in homes without adequate cooling systems such as air conditioners or fans;
- 74% (457) of deaths occurred in Fraser and Vancouver Coastal Health Authorities;
- Fraser North, Fraser East, and Vancouver had the highest rates of deaths by Health Services Delivery Area (HSDA);
- 911 calls doubled during the peak of the heat dome;
- Paramedics attended 54% (332) of deaths with a median time of 10 minutes and 25 seconds;
- In 50 instances, paramedics took 30 minutes or longer from time of call to scene attendance; and
  - In 17 instances, 911 callers were placed on hold for an extended period of time; and
  - In 6 instances, callers were told that there was no ambulance available at the time of call.

The Panel identified three key areas to reduce heat-related deaths:

A coordinated provincial heat alert response system	Ensuring vulnerable populations are identified and supported during extreme heat events	Implementing prevention and longer-term risk mitigation strategies

These findings are the basis for the following recommendations made to the chief coroner by the Panel.

RECOMMENDATION 1:
Implement a coordinated provincial heat alert and response system (HARS)

Priority actions identified by the Panel are:

(A) By June 30, 2022, the Ministry of Health will be assigned as the lead ministry to coordinate the response to public health impacts from an extreme heat event and the Ministry of Public Safety and Solicitor General will assign Emergency Management BC (EMBC) as the lead agency to coordinate the government provincial response to the non-health related impacts of extreme heat emergencies.

(B) By June 30, 2022, the Ministry of Health, provincial health authorities and EMBC will adopt and implement the HARS pilot, developed by the BC Health Effects of Anomalous Temperatures (BC HEAT) Committee, province-wide.

(C) By June 30, 2022, the Ministry of Health will forward the HARS pilot to local governments for review and adoption of recommended actions as appropriate based on community needs and identified vulnerabilities, including actions specific to vulnerable populations (ie. wellness checks, cooling centres [including mobile cooling centres], water distribution, greening areas, cooling parks).

(D) By June 30, 2022, on the advice of the BC HEAT Coordinating Committee (Ministry of Health), EMBC will issue a Broadcast Intrusive alert for an Extreme Heat Emergency.

(E) By summer 2023 the Ministry of Health will coordinate a gap analysis/evaluation of the HARS pilot.

RECOMMENDATION 2:
Identify and support populations most at risk of dying during extreme heat emergencies

Priority actions identified by the Panel are:
(A) By June 30, 2022, provincial health authorities will ensure that Home and Community Care Services identify and prioritize clients who: are listed on chronic disease registries (schizophrenia, substance use disorder, epilepsy, chronic obstructive pulmonary disease, depression, asthma, mood and anxiety disorders, and diabetes registries); persons with limited mobility; persons with cognitive impairment; and/or live alone, for home visits and contact during an extreme heat emergency.

(B) At their next meeting, the Union of BC Municipalities (UBCM) will review and consider the adoption of community wellness checks, as referenced in the BC HEAT Committee's Pilot HARS plan, as a strategy to identify and support vulnerable persons during an extreme heat emergency.

(C) By summer 2022, the Ministry of Health, in conjunction with the health authorities and the First Nations Health Authority, will develop and distribute public messaging on self-care and caring for vulnerable persons during a heat event, that is culturally appropriate and available in multiple languages.

(D) By December 1, 2022, the Ministry of Health, in collaboration with the Ministry of Social Development and Poverty Reduction, and in consultation with vulnerable populations, will conduct a review into issuing cooling devices as medical equipment accessible to persons most at risk of dying during an extreme heat event, and make public the findings of the review.

(E) By June 30, 2023, the Ministry of Health, provincial health authorities and the First Nations Health Authority will engage and consult with vulnerable populations (elderly, persons with chronic health conditions including mental illness, persons with mobility challenges, and persons living in neighbourhoods and geographic areas most likely to be impacted by an extreme heat event) and local government emergency planners regarding HARS planning, review and evaluation at provincial, regional and local levels.

RECOMMENDATION 3:
Implement extreme heat prevention and long-term risk mitigation strategies

Priority actions identified by the Panel are:

(A) By summer 2022, EMBC, in partnership with the Ministry of Health, provincial health authorities and the First Nations Health Authority, will distribute the Prepared BC Extreme Heat Preparedness Guide to British Columbians and provide public service announcements on extreme heat preparedness in multiple languages and formats.

(B) By summer 2023, the Ministry of Environment and Climate Change Strategy will ensure the CleanBC Better Homes and Home Renovation Rebate Program includes both passive and active cooling measures as eligible for rebates. Rebate priorities should be focused on census areas identified in the lower quintiles of material deprivation index and targeted to low income households and the least energy efficient residential building stock.

(C) The Ministry of Attorney General and Responsible for Housing will ensure that the 2024 release of the BC Building Code incorporates both passive and active cooling requirements in new housing construction, and that the release of the Alterations Code for Energy Efficient, Resilient Buildings explicitly identifies both passive and active cooling standards for existing home renovation.

(D) As the *Local Government Act*, *Community Charter* and the *Vancouver Charter* are reviewed and "Climate Lenses" are crafted for *Official Community Plans and Regional Growth Strategies*, the Ministry of Environment and Climate Change Strategy will ensure that updates and revisions are consistent with the *Climate Preparedness and Adaptation Strategy* and require the protection and restoration of the urban tree canopy and permeable surface areas to absorb water.

Death Review Panel

The *Coroners Act* provides the chief coroner with the discretion to establish death review panels to review the facts and circumstances of deaths to provide the chief coroner with advice on medical, legal, social welfare and other matters that may impact public health and safety and prevention of deaths. A death review panel may review one or more deaths before, during or after a coroner's investigation, or inquest.

Members of the Panel were appointed by the chief coroner under Section 49 of the *Coroners Act* and included professionals with expertise in emergency management, medicine, public health, First Nations health, seniors, city and municipal planning, health administration, poverty reduction, patient safety, policy, research, housing, police, fire and ambulance services.

Regardless of their employment or other affiliations, individual panel members were asked to exercise their mandate under the *Coroners Act* and express their personal knowledge and professional expertise. The findings and recommendations contained in this report need not reflect, or be consistent with, the policies or official position of any organization.

In the course of reviewing heat-involved deaths that occurred in 2021, the panel reviewed:

- Coroners' aggregated investigative findings;
- Information provided by panel members;
- Environmental, social and medical factors associated with the deaths;
- Possible trends or themes;
- The current state of related public policy and strategies; and
- Existing challenges.

Data Limitations and Confidentiality

The BCCS operates in a live database environment. Decedent information, investigative notes, case details and findings are regularly updated during a death investigation. The data presented within this case review is based on open and closed BCCS case files. It includes analysis of BCCS investigative notes, police reports, medical records and other documents collected or protocols completed during the course of the investigation. Some cases are still under investigation and information may be incomplete. Linkages were made to other data sources; however, due to incomplete or incorrect information, not all cases were linked successfully.

Where possible, the best available data was used for analysis; however, discrepancies can still occur. For example, weather data were mapped to the nearest weather station which may have been a large distance away or at a different altitude. Additionally, chronic disease information was obtained from the Chronic Disease Registries which do not include clinical diagnosis. Instead, each registry has its own defined inclusion criteria from administrative data.

Consistent with the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10), deaths resulting from environmental heat are considered to be externally caused and are thus deemed accidental deaths. On July 2, 2021, a notice was distributed to medical clinicians to remind them of the requirement to report heat-related deaths to the Coroners Service. Reports of deaths due to exposure to excessive natural heat were received by the Coroners Service for a number of days after the deaths themselves, thus not all deaths were reported in real time, which impacted data collection.

Provisions under the *Coroners Act* and *Freedom of Information and Protection of Privacy Act* allow for the BCCS to disclose information to meet its legislative mandate and support the findings and recommendations generated by the review process. For the purposes of this report, information is presented in aggregate. The BCCS is sensitive to the privacy of individuals and families that it serves and proceeds with caution when reporting findings. Details that could identify the individuals have been omitted to respect the privacy of the person who died and their families.

All **bolded** terms in this report are defined in the glossary.

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Introduction

Extreme Heat Events (EHEs), also referred to as "heat waves" or "heat domes" impact health and result in a significant number of preventable deaths (Government of Canada, 2020; Health Canada, 2011). The number and intensity of extreme heat events is projected to increase as a result of climate change (IPCC, 2021, 2022).

The human body maintains a core temperature of approximately 36.6°C, and significant changes in core temperature are hazardous to our health. The mechanisms and rates of heat gain and loss are impacted by many factors, including age, cardiovascular fitness, chronic conditions, medications, clothing and humidity. Health impacts can include dehydration, heat rashes, cramps, heat exhaustion and, most threatening, heat stroke. Heat stroke refers to when core body temperature reaches at least 40°C, resulting in severe impacts to the central nervous system. Heat stroke can result in confusion or loss of consciousness and is a medical emergency that needs to be treated quickly. If untreated it can lead to death.

In Canada, extreme heat events are the leading weather-related cause of death, with health effects related to several variables:

- The number of days and maximum temperatures of the event;
- When it occurs in the season;
- How accustomed people of the area are to extreme heat;
- The ability of the community to respond; and
- Actions taken, particularly for the most vulnerable, to manage risks.

In late June 2021, British Columbia (B.C.) experienced an unprecedented extreme heat event that resulted in record temperatures across many parts of the province and lasted for several days. Overnight temperatures were also uncharacteristically high.

During the week of the extreme heat event, the BC Coroners Service (BCCS) responded to a sudden and significant increase in deaths. More than 800 deaths were investigated by BCCS during the week of the heat dome compared to an average of approximately 200 deaths during the same week in previous years. At the time of this report, 619 deaths have been identified as being caused by extreme heat.

The BCCS is mandated to investigate and review all unnatural and unexpected deaths in the province. This includes attending the location of the death when possible, completing a physical assessment of the decedent, conducting interviews with family, friends and persons or service providers involved in the decedent's life, arranging necessary post-mortem testing, obtaining medical records, and documenting the investigation's findings in a coroner's report. These investigative findings provide insight into the circumstances of a decedent's life and may also identify issues or challenges, opportunities for preventing similar deaths, and areas for program or policy improvement.

A BCCS investigative protocol for heat-related deaths was implemented during the extreme heat event and is currently being refined and updated. The protocol includes scene, environment and additional data to support a better understanding of heat-related mortality.

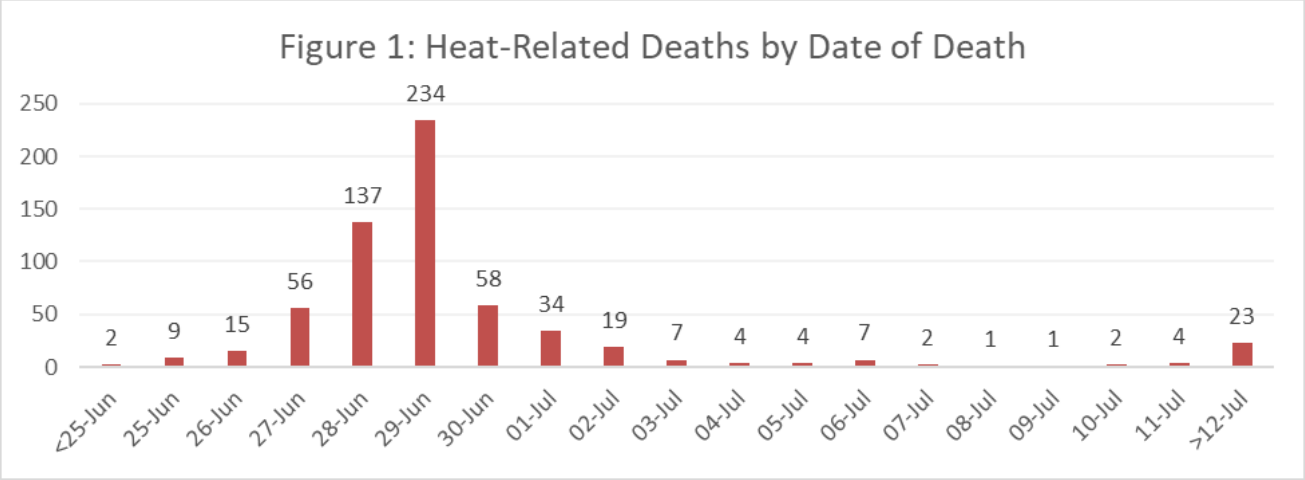
On April 20, 2022, the chief coroner convened a death review panel to review the circumstances around the 619 deaths that occurred in the summer of 2021. The purpose of the Panel is to identify actions to improve public safety and prevent future deaths; it is prohibited from making findings of legal responsibility or expressing any conclusions of law.

Although this report lists many statistics, each data point is an individual life. The people who died were people who, for myriad reasons, were overcome by the effects of extreme heat. Most lacked access to cooler buildings or air-conditioned spaces. Many were older adults who had chronic health conditions. Many communicated that they were feeling unwell and were having difficulty managing in the hot temperatures. Many were also connected to health services and other resources prior to their death.

Part One: BC Coroners Service Review Findings

This review summarizes investigative findings about the deaths of people who died as a result of an extreme heat event that occurred during the summer of 2021 (see Figure 1).

Coroner investigations found that those who died were predominantly older adults with chronic health conditions and relatively compromised overall health. These conditions may have impacted their ability to seek assistance or cooler environments. The majority of those who died lacked access to cooling or ventilation, and were often living in areas of higher material and social deprivation. Although deaths occurred over a seven-month period, in the majority of deaths, the injury event that contributed to the death was sustained during the extreme heat event.



Of the 619 heat-related deaths, 576 (93%) were injured during the week of June 25-July 1. The majority of injuries occurred on June 28 and June 29 which corresponds with the highest temperatures during the extreme heat event. In certain parts of the province, temperatures above 40ºC were observed from June 27–June 30.

Extreme heat can cause a range of health effects from mild to life threatening. These effects include: dehydration, heat rashes, cramps, heat exhaustion, and heat stroke. Heat stroke may result in confusion or loss of consciousness. If heat stroke is untreated it can lead to death (Health Canada, 2012).

Age and Sex

More older adults died during the extreme heat event than younger persons.

- 67% of decedents were 70 years of age or older, and 90% were over age 60 (see Appendix 2, Figure 2).
- Males and females were equally affected, however males who died tended to be younger compared to females who died (see Appendix 2, Figure 3).
- There were no deaths among infants or children, or persons younger than age 30.

Indigenous Peoples

Nine (1.5%) of the decedents were identified by coroners as being Indigenous. Indigeneity may not have been identified in many cases where deaths were initially identified as natural or expected, and therefore not under the jurisdiction of the BCCS. Accurate data collection regarding Indigenous morbidity and mortality is understood to be critically important to addressing health inequities experienced by Indigenous peoples. Having heat-related deaths reported as they occur will assist more accurate Indigenous health data collection.

Health Conditions

Chronic conditions, including cardiovascular disease, hypertension, lung disease and diabetes interfere with the body's thermoregulation process increasing susceptibility to extreme heat. Some conditions including schizophrenia can affect a person's ability to recognize overheating and to take protective action (Ebi et al., 2021).

Data matched with the Ministry of Health's Chronic Disease Registry found that 91% of decedents were assigned to at least one chronic disease registry. The most common registry that decedents belonged to was hypertension (71%), mood and anxiety disorders (60%), depression (54%), diabetes (37%), and osteoarthritis (33%) (see Appendix 2, Figure 4). Compared with the B.C. population 65 years and over, a higher percentage of decedents were on schizophrenia, substance use disorder, epilepsy, chronic obstructive pulmonary disease, depression, asthma, mood and anxiety disorders, and diabetes registries.

- More than 80% of decedents were on three or more chronic disease registries (see Appendix 2, Table 1).

Many chronic conditions impact mobility and cognition. Reduced mobility and cognitive decline may potentially impact a person's ability to understand or to respond to extreme heat, or to self-rescue by hydrating, attending a cooling centre, or finding other relief.

- More than two-thirds (69%) of decedents were identified as having chronic illnesses that potentially could impact mobility, including conditions such as heart failure, arthritis or Parkinson's disease.
- Just under two-thirds (64%) of decedents were identified with chronic illnesses that potentially could impact cognition, including mood and anxiety disorders, dementia, or schizophrenia.

This review could not determine how many of the decedents had mobility or cognitive challenges that actually played a role in their death.

Health Care Utilization

According to Medical Services Plan (MSP) billings, just over 60% of decedents had at least one visit with a health professional in the past month while 12% had no visits within the 12 months prior to their death (see Table 2). 62% of decedents had 10 or more visits to a health professional within the 12 months prior to their death.

Table 2: Heat-related deaths by Last Visit to Health Professional

Last Visit	Count	Percent
No visits past year	75	12.1%
Within 7 days	191	30.9%
Between 8-30 days	184	29.7%
Between 31-90 days	114	18.4%
Between 91-180 days	26	4.2%
Between 181-365 days	5	0.8%
Unknown	5	0.8%
Total	619	

Location of Death

During the extreme heat event, heat-related deaths occurred across the province (see Figure 5). However, almost three-quarters of decedents (74%) lived within the Vancouver Coastal or Fraser Health Authorities.

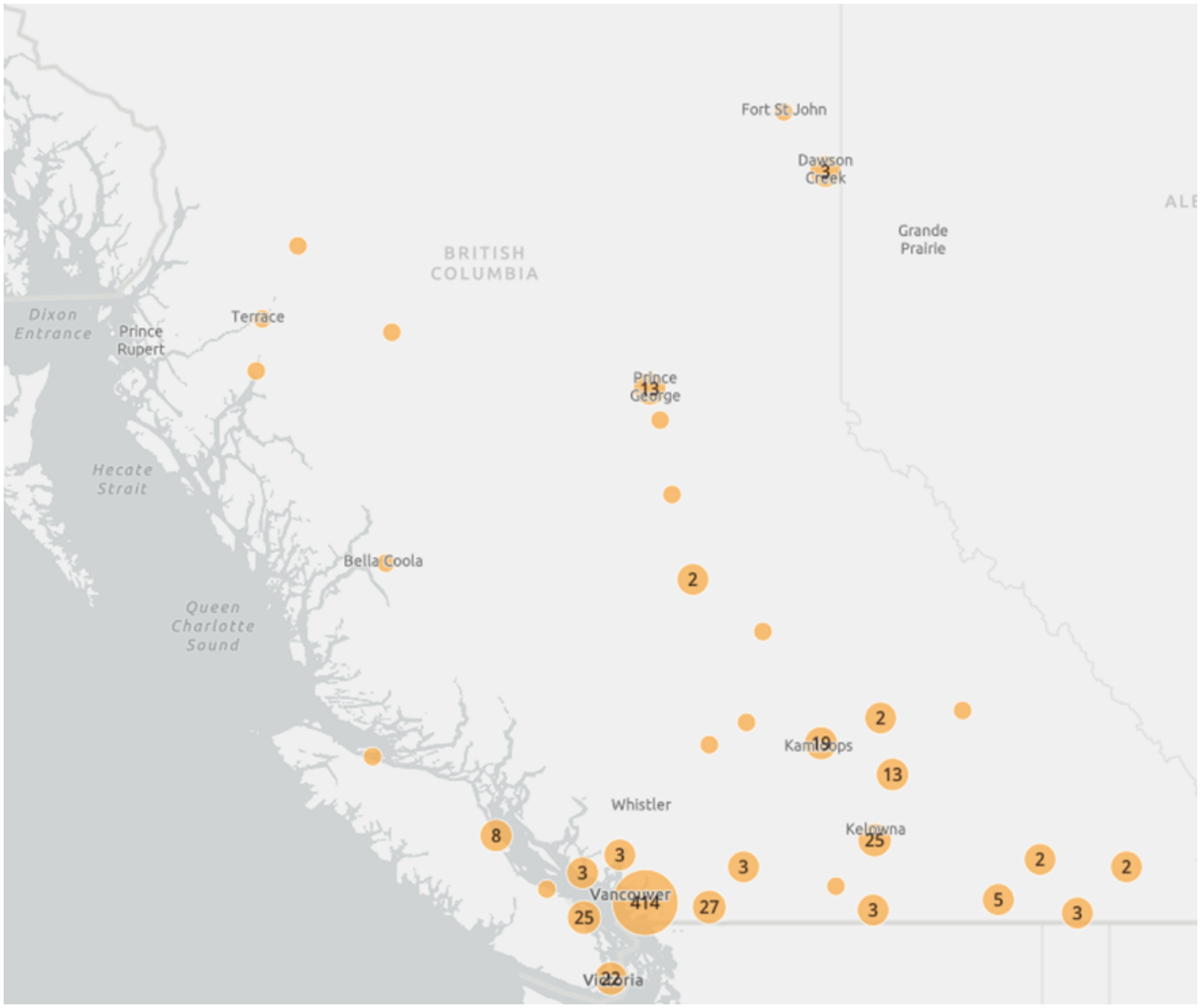
- 51% of deaths were recorded in Fraser Health, and 23% were recorded in Vancouver Coastal Health (see Appendix 2, Table 3).
- By Health Service Delivery Area (HSDA), the highest rates of death were in Fraser North, Fraser East, and Vancouver.
- By township, Vancouver (117) had the highest number of heat-related deaths, followed by Surrey (75), Burnaby (73), New Westminster (33), Chilliwack (27), Abbotsford (23), Langley (23) and Victoria (20) (see Appendix 2, Table 4).

City centers may be hotter than surrounding rural areas because of their design and construction, including:

- *pavement and asphalt roads and walkways which absorb heat,*
- *multi-storied glass buildings which reflect sunlight and block wind, and*
- *the absence of tree canopy and other green space to provide protective cooling.*

Wang et al., 2016

Figure 5: Heat-related deaths mapped by injury location



Note: Locations are mapped to the nearest bubble.

Community and Neighbourhood

This review identified that a number of the deaths were in urban areas with low greenness (fewer trees) surrounded by large roads, large buildings, and high density.

Residential addresses of the decedents were linked to the corresponding material and social deprivation quintile of the area.

- 28% of decedents lived in neighbourhoods that were most materially deprived and 33% lived in neighbourhoods that were most socially deprived (see Appendix 2, Tables 5 and 6), both over-representations of deprivation.

Poor quality housing, homelessness, and overall deprivation are risk factors for increased mortality during extreme heat events (Kenny et al 2019; Kovats and Hajat, 2008).

Urban tree canopy reduces surface temperatures by as much as 12°C (Schwaab et al, 2021). *The urban heat island effect increases heat related mortality and morbity* (Santamouris, 2020).

Housing

In almost all (98%) of the deaths, the heat injury occurred indoors in a residence.

- 73% occurred in private residences (39% in multi-unit buildings and 34% in detached buildings);
- 10% occurred in social housing, single room occupancy (SRO), or supportive housing;
- 7% occurred in trailer homes, mobile homes, RVs, or campers; and
- 7% occurred in senior or long-term care homes (see Appendix 2, Table 7).

Living Situation

More than half (56%) of decedents lived alone, 30% lived with spouse or family members; 8% lived in community or assisted living situations (i.e. group home, senior homes, long-term care homes); and 5% lived with unrelated friends or roommates (see Appendix 2, Table 8).

Recent Activity

Very few deaths were linked to physical activity in the heat. BCCS investigative notes found that 20 (3.2%) decedents were known to be recently active prior to their death. Activities included gardening, outdoor home maintenance/repairs, walking outdoors, hiking, or playing a sport.

Reason Found

Place of injury, living situations and social connectedness influenced why and when the deceased was found (see Appendix 2, Table 9).

Half of those who died were found during a wellness check. Wellness checks were completed by family or friends, support workers or health workers who attended the deceased specifically out of concern for their well-being, or were conducted by police due to reported well-being concerns.

32% of those who died were found by someone during regular or routine contact such as a family member returning home or during a scheduled routine visit.

External Environment

Environment and Climate Change Canada is responsible for issuing timely weather forecasts, warnings and alerts across Canada including heat alerts. Heat warnings issued in the days prior to a heat event are intended to allow enough time for the impacted areas to mobilize, activate plans and protocols (Government of Canada, 2022).

Outdoor Temperature

Outdoor temperatures on the day of and the day prior to injury were collected from the nearest weather station to each injury location. The maximum temperature on either day was then calculated. The average maximum temperature on the day of or day prior to injury was 36ºC, and for 61% of deaths the max temperature was 35ºC or greater (see Appendix 2, Table 10).

Within urban areas, landscape and building design can result in significant temperature differences between neighborhoods (Hong et al. 2019).

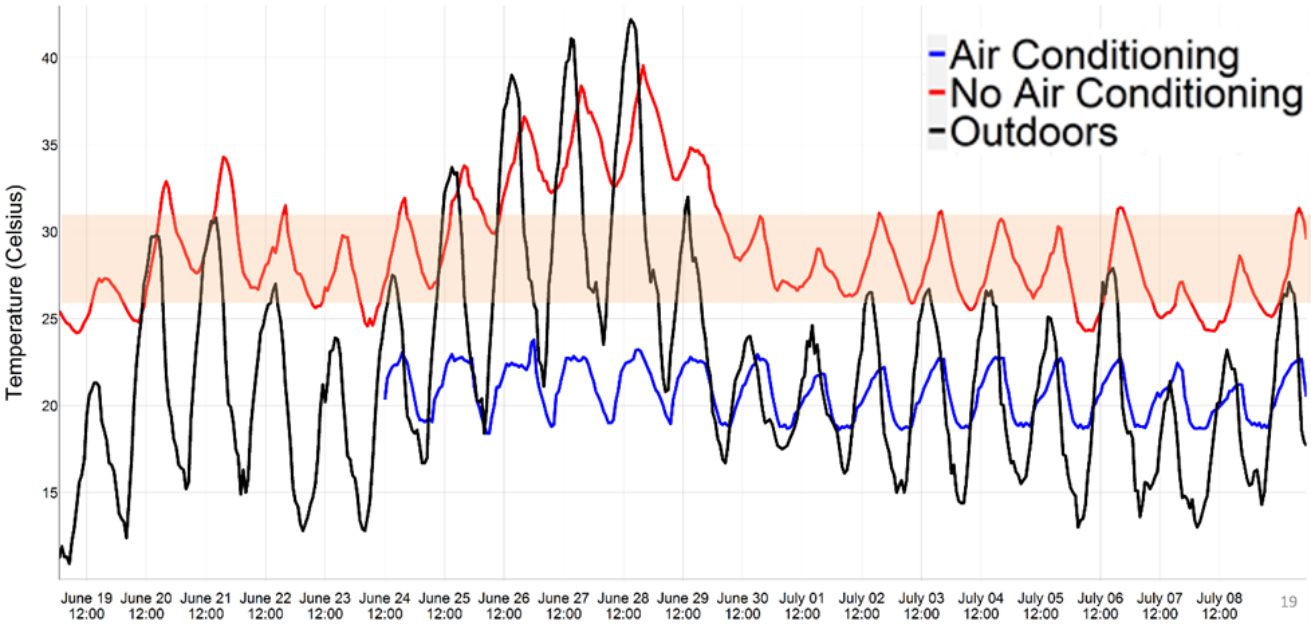
Home Environment

Indoor temperatures are strongly influenced by the building design, construction, cardinal orientation, and size. Indoor air temperature is generally higher when the buildings have greater solar radiation indoors, southward facing, poor insulation, dark materials, low ventilation. Upper floors can be hotter because of cumulative heat transfer from lower floors upwards and downwards through the roof. (Kenny et al., 2018).

Indoor temperature readings were not available at all death locations. Instead, investigative notes indicated temperatures using terminology like “warm,” “hot,” or “extremely hot,” or were described using an estimated temperature range (>25ºC to 30ºC, 30ºC to 35ºC, etc.).The presence of air cooling, fan use and/or ventilation was obtained through a review of investigative notes. Information about building size, condition, windows or building orientation was not collected or available.

Figure 6 shows that outdoor temperatures cooled at night but that indoor temperatures remained high, consistently exceeding 26ºC during the extreme heat event. Without air conditioning, indoor temperatures remained hazardous throughout this period.

Figure 6 (Abbotsford)



Air Conditioning

Based on information collected by coroners during their investigations, 46 (7%) decedents had air conditioning present in their residence (see Appendix 2, Table 11). Of those, 7 (15%) were on at the time of death but may have been in a different room or improperly used (i.e. blowing hot air).

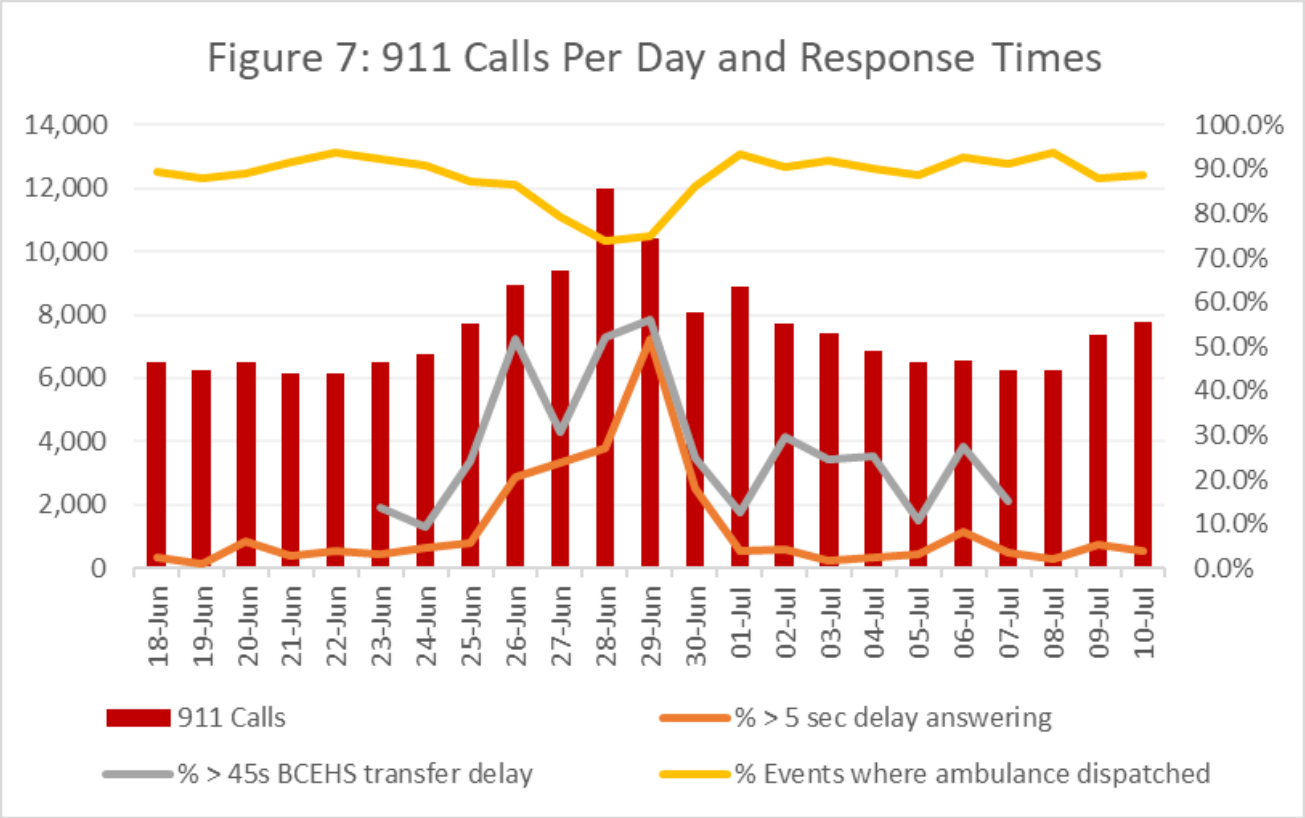
Fans

Fans were used in 24% of residences; however, for 44% of decedents it was unknown if fans were in use (see Appendix 2, Table 12). Of those with fans in use, 70% had them on in the room where the deceased was found.

Provincial Emergency Response

During the extreme heat event, emergency services were significantly impacted, with an increase in calls for ambulance, police and fire (as first responders). First responders reported that lack of other agency availability (including coroner response) resulted in personnel remaining on scene for extended periods until transport of the patient or decedent could occur.

Data from E-Comm 911 found that 911 call volumes increased from between 6,000-7,000 calls in the days prior to and following the extreme heat event, to as high as 11,970 calls on June 28 (see Appendix 2, Table 13). Call delays also increased during the extreme heat event. E-Comm 911's service level target is for 95% of 911 calls to be answered in five seconds or less. Between June 26-June 30, 29% of calls took more than 5 seconds to be answered and on June 29, 52% of calls took more than 5 seconds to answer. Call transfers to BC Emergency Health Services (BCEHS) were also delayed during this time period, with 44% of transfers between June 26-June 30, taking more than 45 seconds compared to 16% just prior to the heat dome (see Figure 7).



BCEHS also experienced a corresponding increase in the number of calls accepted and the number of events created during the heat dome (see Table 13, Appendix 2). The increase volume seems to have affected the number of ambulances that were dispatched. Between June 26-30, BCEHS dispatched an ambulance to an average of 80% of events, down from over 90% on the days prior and following the extreme heat event.

Data from BCEHS and BCCS investigative notes found that a 911 call for an ambulance was made in 72% of heat-related deaths (Appendix 2, Table 14). Of those calls, paramedics were dispatched to and attended 332 (74%) events (Appendix 2, Table 15). The most common reason that BCEHS was not dispatched was because the patient was determined to be already deceased at the time of the call.

Where BCEHS attended, 83% of patients were dead or died at the scene and 17% were transported to hospital (see Appendix 2, Table 16).

Part 2: Discussion

The Panel considered the investigative findings, a review of the literature and the experiences of the panel members and represented agencies in its discussions.

Extreme heat events (EHE) are also described in the literature as “heat waves” or “heat domes.” A heat dome occurs when an area of high pressure stays over the same area for days or even weeks, trapping very warm air underneath - rather like a lid on a pot. The definition of an extreme heat event varies based on many factors, including geographic location and weather conditions such as temperature, humidity, and cloud cover as well as the duration of the event. The temperature is much hotter than average for a particular time and place.

The Intergovernmental Panel on Climate Change (IPCC) concluded that the climate will continue to warm despite efforts to reduce global emissions, which will result in more frequent heat events (IPCC, 2021).

As identified in the introduction, the human body has a core body temperature of approximately 36.6 degrees Celsius. When the body is unable to maintain this core temperature due to excessive external heat, various life threatening conditions can occur; including dehydration, heat rashes, cramps, heat exhaustion and, most serious, heat stroke. Health problems become more pronounced during a heat event for people who are unable to avoid the heat. The mechanisms and rates of heat gain and loss are impacted by many factors including age, cardiovascular fitness, chronic conditions, medications, clothing, and humidity.

High indoor temperature was the primary cause of injury and death during the extreme heat event. During this time, hot air became trapped indoors and continued to rise over time. Although outdoor temperatures decreased overnight, residences did not cool off, exposing people to harmful high temperatures for extended periods of time. The BC Centre for Disease Control (BCCDC) identified that people were most in danger when indoor temperatures remained above 26 degrees throughout the heat event.

Environment and Climate Change Canada (ECCC) is responsible for issuing timely weather forecasts, warnings, and alerts across Canada, including heat alerts. Heat warnings issued by ECCC in the days prior to a heat event are intended to allow enough time for the impacted areas to mobilize, activate plans and protocol response (Government of Canada, 2022; Health Canada, 2012). ECCC delivers public alerts through several sources including the ECCC Weather Office, the Weather APP, Alert Me APP, subscriber email and through the Weather Network* (ECCC communication, 2022; Government of Canada, 2020). Additionally, ECCC also delivers extreme heat warnings to the B.C. emergency partners and Ministries responsible for heat related coordination and response planning (ECCC communication, 2022).

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*-The Weather Network (TWN) is a Canadian weather information specialty channel that delivers weather information on television, digital platforms (responsive websites, mobile and tablet applications) and TV apps.

Heat Alert and Response Systems

In 2012 Health Canada published a best practices guidebook: *Heat Alert and Response Systems (HARS) to Protect Health*. The guide stated:

The effects of heat on the health of Canadians will depend upon actions taken by public health and emergency management officials, community health and social service providers, and by individuals to prepare for and respond to the impacts. Research suggests that the health effects of extreme heat are a function of:

- *the duration and severity of an extreme heat event*
- *when an extreme heat event occurs in the season*
- *the sensitivity of the population*
- *the ability of a community to respond during extreme heat events*
- *actions taken by officials and individuals, particularly the most vulnerable, to manage the risks*

To prepare for extreme heat events, some communities in Canada and internationally have developed Heat Alert and Response System(s) (HARS). These systems have the following core elements:

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.*

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.*

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.*

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.*

Evaluation Plan—*Assesses HARS activities and facilitates improvements. Aims to evaluate the extent to which implemented measures are timely, relevant, effective, meet local priorities, and contribute to the reduction of health impacts.*

A HARS is most effective when it is delivered in conjunction with preventative actions that provide long-term and sustainable protection from extreme heat events (Health Canada 2012).

HARS planning is also applicable when dealing with other types of severe weather events such as extreme cold events and flooding.

A jurisdictional scan completed by the BCCDC in 2017 found most municipal governments and health authorities did not have comprehensive HARS plans. At that time, planning for extreme heat was considered a lower priority because the risk seemed low, there were other competing priorities with fixed resources, or heat response planning was not considered their responsibility. Both the City of Vancouver and subsequently, the Village of Ashcroft were acknowledged by the Panel for their HARS planning.

Table 7: Heat Alert Levels

Alert Level	Level 1	Level 2
Proposed Name	**Heat Warning**	**Extreme Heat Emergency**
Public Health Risk	Moderate (5% increase in mortality)	Very high (20% or more increase in mortality)
Descriptor	Very hot	Dangerously hot
Historic Frequency	1-3 per summer season	1-2 per decade
Criteria	Southwest = 29-16-29 Fraser = 33-17-33 Southeast = 35-18-35 Northeast = 29-14-29 Northwest = 28-13-28	Level 1 criteria have been met and forecast indicates that daily highs will substantively increase day-over-day for 3 or more consecutive days

In response to the extreme heat event in 2021, the BC Health Effects of Anomalous Temperatures (BC HEAT) Coordinating Committee was established in January 2022 to support planning and public health response efforts to significant heat events in B.C. The primary goals of the Committee are focused on public health actions and messaging for the heat alert system.

The Committee has established a pilot for a two-tiered heat alert response system in B.C. that would identify Heat Warning and Extreme Heat Emergency (Table 17) thresholds and procedures based on regional criteria. The pilot framework outlines recommended actions to be taken prior to the heat season and during a heat warning, as well as extreme alert and post-heat season actions.

Additionally, EMBC is finalizing an Extreme Heat Preparedness Guide for Provincial Ministries and Agencies that will address Heat Alert and Response Systems (consistent with the work done by the BC HEAT Committee) and will identify government roles and responsibilities regarding extreme heat.

Panel discussions identified that other circumstances may impact personal and community response to a public health emergency. The province's response to COVID-19 likely further exacerbated the impact of the extreme heat event, as people may have been reluctant to congregate in public areas and as a result may have avoided cooling centres. Additionally, deployment of staff to public areas was also problematic at times with concerns about COVID-19 exposure.

Coordinated Strategy

The 2012 Health Canada HARS best practice guidebook identified very similar findings to this death review panel in terms of who was at risk in terms of age, health conditions and living arrangements.

Panel discussions identified the need to establish clear provincial protocols that outline actions to be initiated when either a heat warning or an extreme heat emergency alert is issued by ECCC. The Panel recognized the need for overall provincial coordination as, like other natural disasters, an extreme heat emergency event is a provincial emergency and may require access to provincial emergency resources.

The Panel also identified the importance of regional and local decision-making in response to an extreme heat emergency as this is where understanding of local communities resides. Extreme heat emergency alerts also need to trigger regional and local level action plans. The BC HEAT coordinating committee has been working on many of the coordinated strategy issues discussed at the death review panel.

The Panel identified that clarity is needed on who should act as the lead agency in coordinating planning and action. Coordinated planning should ensure that agencies are aware of impending heat events which would trigger agency action to address needs such as surge planning around staff and resources to adequately respond to an extreme heat emergency.

Extreme heat emergency alerts need to be paired with clear protocols to ensure no time is lost in responding to a heat emergency. The protocols need to recognize the seriousness of an extreme heat emergency and the potential of a mass casualty event.

In May 2022, the provincial government announced that Alert Ready (a national alert system) had been expanded to include wild fires, floods and extreme heat events in B.C. The alert system was developed to target imminent threats. There was discussion during the panel around the use of the alert system to warn of impending extreme heat events. The discussion identified that the alert system was warranted given the significant number of people who died over a short period and the emergency nature of an extreme heat event.

Provincial coordination is required to ensure that:

- Response to heat events occurs rapidly;
- All ministries, agencies and municipalities clearly understand their roles;
- No ministries/agencies are working at cross purposes with other ministries/agencies;
- Provincial emergency funds can be accessed in a timely manner as for other natural disasters such as windstorms and floods; and
- Robust evaluation and continuous quality improvement occur to assess the adequacy of extreme heat emergency response.

Planning for extreme heat events must also anticipate the possibility of other provincial or public health emergencies as was experienced in 2021 with the province also responding to the COVID-19 pandemic and wildfires during the heat dome.

Vulnerable Populations

Not all people experienced the same degree of heat health risks during the extreme heat event. The elderly, persons with chronic health conditions, persons living alone, those with no access to cooling, and those in particular geographic areas were more impacted by the heat. Wider public awareness about heat, and targeting community training on how to recognize heat concerns is needed.

Universal safety measures and warnings are required for all British Columbians when an extreme heat event is occurring, but vulnerable populations will require additional interventions, support and assistance. One of the challenges is identifying who is most vulnerable and how to adequately meet their needs during an extreme heat event.

Two of the most impactful interventions during a heat event deal with:

1. Ensuring people have a way of staying cool either inside their residence or elsewhere (i.e. a cooling centre, air conditioned lobby, etc.); and
2. Conducting heat-informed checks on older adults, persons with health conditions, those living alone and those with mobility issues to consult them on their on their well-being and support needs.

When issuing extreme weather alerts, recognition will need to be paid to the fact that not everyone accesses social media, has a phone, can read signage or speaks English as their primary language. Alerts and warnings must be multilingual and delivered via a variety of mediums. It is also essential that people working in any type of care facility or who provide housing, are aware of heat dangers and measures required to alleviate those dangers.

Any successful strategy must include the voices and needs of those most at risk of injury or death from extreme heat to find out what would be most helpful during a heat event. In some areas with higher material deprivation, the number of deaths was lower than may have been expected. It is important to learn from the people living in those areas, such as those living in the downtown east side of Vancouver, what communities did to support their members – a journey mapping exercise could be very instructive in understanding the experiences of vulnerable people who lived through the 2021 extreme heat event. Lived experience must inform community strategies for prevention from planning through implementation.

Taking the needs of people with mobility issues into account will also be key in ensuring access to cooling areas. Establishing cooling centres during an extreme heat event is important, but people with mobility issues may not be able to access them and distance could be a further impediment for people lacking funds for transit. Solutions that bring cooling to those who cannot easily leave their residence for health or mobility reasons will be required. Measures such as temporary free transit, mobile cooling centres, or cooling shuttles should be considered.

Many decedents had recent contact with medical professionals, likely due to their age and/or health needs as identified by the number of deceased on multiple chronic disease registries. Leveraging these contact encounters approaching the summer months could provide an opportunity for education on the impacts of heat and assessing any additional health conditions that may place patients at greater risk of heat-related injury.

Mapping geographic areas through census data and the social and material deprivation indexes could also help identify neighbourhoods where access to cooling areas in parks is limited and/or little green space or tree canopy exists. This could help communities prioritize where green space is needed and where parks should be developed with shade and accessibility in mind.

Often when an extreme heat event occurs, air quality due to smoke from wildfires and pollution trapped by the high-pressure systems associated with heat domes can exacerbate the challenges, particularly for vulnerable communities, and people with additional health challenges such as asthma and other respiratory issues.

Indigenous Peoples

Indigenous individuals and communities are identified as vulnerable to and disproportionately affected by climate change and extreme climate events in Canada and globally (Norton-Smith et. al., 2016; Ford, J., 2012). Many Indigenous populations face unique exposures and sensitivities to climate change, as a function of their traditional relationship with and dependence on the land, sea, and natural resources. These differences present risk factors that are different from nonindigenous populations, and among and between Indigenous groups (Ford, J., 2012).

Canada's Indigenous populations, whether living in rural communities or in urban centres are at significantly higher risk of developing chronic disease than non-Indigenous people (Indigenous Services Canada, 2018). For example, First Nations people experience higher rates of heart disease, diabetes and rheumatoid arthritis, all of which potentially increase vulnerability to extreme heat events (Indigenous Services Canada, 2018; Hitchon et al., 2020; Government of Canada, 2010).

Researchers including Deen et al. (2021) find a lack of literature on the impact of temperature and extreme event trends in Canadian Indigenous communities. They identify how climate data can provide a resource for First Nations community resilience planning and resource allocation strategies. The BCCS investigations found that a disproportionately low number of Indigenous people died during the extreme heat event. As previously noted, this may have been the result of under reporting due to data collection processes but consultation with Indigenous peoples will be important to ensure their voices are heard and their needs around heat planning understood.

Risk Mitigation

Governments and other organizations should recognize extreme-heat events as "natural disasters" and include extreme heat in their messaging, in the same way that flooding and wildfire are seen as natural disasters (Eyquem & Feltmate 2022).

In addition to the need to meaningfully respond in real time to an extreme heat emergency, the Panel also discussed the need for, and the importance of, prevention and risk mitigation strategies to reduce the likelihood of another mass casualty event. Adaption and risk mitigation become more urgent with the increasing likelihood of more frequent extreme heat events due to the impacts of climate change.

Eyquem & Feltmate (2022) identify three categories of action to reduce risks in relation to extreme heat: changing behaviour (non-structural); working with nature (green infrastructure); and improving buildings and public infrastructure (grey infrastructure).

EMBC is finalizing public information regarding heat preparedness in a guide titled *PreparedBC: Extreme Heat Preparedness Guide*. The guide will address how British Columbians can plan and prepare for extreme heat events.

Urban areas can be significantly warmer than surrounding rural areas because of their design and construction, known as the "urban heat island effect." The increase in heat is attributed to areas with extensive surfaces like asphalt and concrete that absorb solar radiation, have less vegetation to provide a cooling effect, and have heavier concentrations of traffic that generate additional heat. Significant heat differences can be found across and between neighbourhoods due to variations in landscape and building characteristics. Declining tree canopy and permeable surfaces in urban areas will increase vulnerability to extreme heat.

Canadian Census data identifies an ageing population and an increase in one person households. This trend will increase the proportion of B.C.'s population vulnerable to heat-related mortality and morbidity. The BCCS investigative findings showed that elderly, socially-isolated people were at a higher risk of heat-related mortality. Many of the deceased lived in single family dwellings. Building practices such as adding suites to homes could potentially reduce social isolation.

A number of deaths occurred in neighbourhoods with large roads, large buildings, high density, and low greenness. Discussions focused on the importance of increasing shading, heat reflectivity (**albedo**) and reducing evaporation (through increasing the tree canopy and surface permeability to absorb water) as natural cooling measures to help mitigate the impact of a future extreme heat event. Increasing green space and shading, especially in neighourhoods high on the material deprivation index, would provide naturally cooler areas where people can find respite from extreme heat events.

Indoor temperatures are strongly affected by a building's design, construction, **cardinal orientation** and size. Buildings constructed of materials that conduct solar energy inwards; that have larger windows and/or single pane windows; that have poor insulation and/or low ventilation; that face south or southwest; and that have dark exteriors promote higher indoor temperatures. Larger buildings also tend to get hotter on higher floors and especially floors under the structure's roof. By covering windows during the day, promoting ventilation when it is cooler outside and avoiding the use of ovens and stoves, individuals can help decrease indoor temperatures.

Building codes that require passive and active cooling (heat pumps, building materials, insulation, ventilation, greening, tree canopy, landscape permeability, solar reflectivity, etc.) can mitigate the effects of extreme heat events. Retrofitting codes and rebate programs that encourage active and passive cooling in current housing stock, especially in materially and socially deprived index areas, would further mitigate the impact of extreme heat. Current building codes in British Columbia do not consider cooling in the same manner as heating requirements. As building codes are revised they will need to reflect the latest climate science and consider cooling needs.

Data collection on (health, social and infrastructure) circumstances surrounding heat related mortality and morbidity is important to help communities identify the most at risk populations and neighbourhoods to support evidence-based decision making for community planning.

Although the Panel was specifically reviewing the impact of the 2021 extreme heat event and the mortality that resulted, discussions also recognized the importance that any actions taken to mitigate and adapt to the effects of an extreme heat event need to support and be consistent with the latest climate science.

Part Three: Recommendations

This death review panel has developed a set of recommendations considering the BCCS investigative findings, current research and applying subject matter expert opinion to heat-related deaths. The recommendations arising from the death review panel were developed in a manner that was:

- Cognizant of the scale of the emergency;
- Collaborative;
- Attributable to the deaths being reviewed;
- Focused on identifying opportunities for improving public safety and prevention of future deaths;
- Targeted to specific parties;
- Realistically and reasonably implementable; and
- Measurable.

The Panel identified three key areas to reduce heat-related deaths:

A coordinated provincial heat alert response system	Ensuring vulnerable populations are identified and supported during extreme heat events	Implementing prevention and longer-term risk mitigation strategies

Panel Recommendations

A COORDINATED HEAT ALERT RESPONSE SYSTEM (HARS)

Rationale

To respond effectively to an extreme heat event three elements are necessary:

1. A formal determination that an extreme heat event is likely or emerging. An alert system for heat warnings and extreme heat emergencies has been established with Environment and Climate Change Canada (ECCC). These alerts allow the province to distinguish when weather is predicted to be unseasonably hot and when the weather is predicted to create an extreme heat emergency (conditions that endanger human health).
2. A coordinated plan with protocols to identify roles, responsibilities and actions to be taken once an extreme heat emergency is declared.
3. Affected community, municipalities, health authorities must implement the actions identified in their HARS plan.

RECOMMENDATION 1:
Implement a coordinated provincial heat alert and response system (HARS)

Priority actions identified by the Panel are:

(A) By June 30, 2022, the Ministry of Health will be assigned as the lead ministry to coordinate the response to public health impacts from an extreme heat event and the Ministry of Public Safety and Solicitor General will assign Emergency Management BC (EMBC) as the lead agency to coordinate the government provincial response to the non-health related impacts of extreme heat emergencies.

(B) By June 30, 2022, the Ministry of Health, provincial health authorities and EMBC will adopt and implement the HARS pilot, developed by the BC Health Effects of Anomalous Temperatures (BC HEAT) Committee, province-wide.

(C) By June 30, 2022, the Ministry of Health will forward the HARS pilot to local governments for review and adoption of recommended actions as appropriate based on community needs and identified vulnerabilities, including actions specific to vulnerable populations (ie. wellness checks, cooling centres [including mobile cooling centres], water distribution, greening areas, cooling parks).

(D) By June 30, 2022, on the advice of the BC HEAT Coordinating Committee (Ministry of Health), EMBC will issue a Broadcast Intrusive alert for an Extreme Heat Emergency.

(E) By summer 2023 the Ministry of Health will coordinate a gap analysis/evaluation of the HARS pilot.

ENSURING VULNERABLE POPULATIONS ARE IDENTIFIED AND SUPPORTED DURING EXTREME HEAT EVENTS

Rationale

As identified by the BCCS investigative findings, the effects of the 2021 extreme heat event were not felt equally amongst the population. The elderly, those with chronic health conditions and materially and socially disadvantaged people were disproportionately impacted. Most of the deceased had recent contact with medical professionals prior to their deaths. Mobility or cognitive issues, poverty and discrimination, may prevent some people from accessing cooling areas during an extreme heat event and they will require services coming to them rather than be expected to access services outside of their living area.

To ensure the needs of vulnerable populations are adequately addressed, policy, planning, service development and implementation must all be considered through an equity lens.

RECOMMENDATION 2:
Identify and support populations most at risk of dying during extreme heat emergencies

Priority actions identified by the Panel are:

(A) By June 30, 2022, provincial health authorities will ensure that Home and Community Care Services identify and prioritize clients who: are listed on chronic disease registries (schizophrenia, substance use disorder, epilepsy, chronic obstructive pulmonary disease, depression, asthma, mood and anxiety disorders, and diabetes registries); persons with limited mobility; persons with cognitive impairment; and/or live alone, for home visits and contact during an extreme heat emergency.

(B) At their next meeting, the Union of BC Municipalities (UBCM) will review and consider the adoption of community wellness checks, as referenced in the BC HEAT Committee's Pilot HARS plan, as a strategy to identify and support vulnerable persons during an extreme heat emergency.

(C) By summer 2022, the Ministry of Health, in conjunction with the health authorities and the First Nations Health Authority, will develop and distribute public messaging on self-care and caring for vulnerable persons during a heat event, that is culturally appropriate and available in multiple languages.

(D) By December 1, 2022, the Ministry of Health, in collaboration with the Ministry of Social Development and Poverty Reduction, and in consultation with vulnerable populations, will conduct a review into issuing cooling devices as medical equipment accessible to persons most at risk of dying during an extreme heat event, and make public the findings of the review.

(E) By June 30, 2023, the Ministry of Health, provincial health authorities and the First Nations Health Authority will engage and consult with vulnerable populations (elderly, persons with chronic health conditions including mental illness, persons with mobility challenges, and persons living in neighbourhoods and geographic areas most likely to be impacted by an extreme heat event) and local government emergency planners regarding HARS planning, review and evaluation at provincial, regional and local levels.

IMPLEMENTING PREVENTION AND LONGER-TERM RISK MITIGATION STRATEGIES

Rationale

Due to climate change, extreme weather events are likely to occur more frequently in the future. The number of people vulnerable to an extreme heat event is expected to grow as census predictions show a steadily rising elderly population and an increasing share of one person households.

A number of heat mitigation actions have been considered, and some have been implemented, but current efforts have been insufficient and this work needs to prioritized and accelerated by all levels of government and the private sector.

Focusing on prevention opportunities, adaptation strategies and longer-term risk mitigation initiatives is necessary if future mass casualty incidents due to natural disaster extreme heat events are to be avoided. In addition to personal risk mitigation, policy and planning related to the built environment and demographic changes are key.

RECOMMENDATION 3:
Implement extreme heat prevention and long-term risk mitigation strategies

Priority actions identified by the Panel are:

(A) By summer 2022, EMBC, in partnership with the Ministry of Health, provincial health authorities and the First Nations Health Authority, will distribute the *Prepared BC Extreme Heat Preparedness Guide* to British Columbians and provide public service announcements on extreme heat preparedness in multiple languages and formats.

(B) By summer 2023, the Ministry of Environment and Climate Change Strategy will ensure the CleanBC Better Homes and Home Renovation Rebate Program includes both passive and active cooling measures as eligible for rebates. Rebate priorities should be focused on census areas identified in the lower quintiles of material deprivation index and targeted to low income households and the least energy efficient residential building stock.

(C) The Ministry of Attorney General and Responsible for Housing will ensure that the 2024 release of the BC Building Code incorporates both passive and active cooling requirements in new housing construction, and that the release of the Alterations Code for Energy Efficient, Resilient Buildings explicitly identifies both passive and active cooling standards for existing home renovation.

(D) As the *Local Government Act*, *Community Charter* and the *Vancouver Charter* are reviewed and "Climate Lenses" are crafted for Official Community Plans and Regional Growth Strategies, the Ministry of Environment and Climate Change Strategy will ensure that updates and revisions are consistent with the *Climate Preparedness and Adaptation Strategy* and require the protection and restoration of the urban tree canopy and permeable surface areas to absorb water.

Appendix 1: Glossary

The following terms are used within this report to mean:

Albedo: A non-dimensional, unitless quantity that indicates how well a surface reflects solar energy. Albedo varies between 0 and 1. Albedo commonly refers to the "whiteness" of a surface, with 0 meaning black and 1 meaning white.

Cardinal orientation: One of the four principal directional indicators (north, east, south and west).

Materially deprived: Includes poorer housing locations and construction, less green space and less recreation areas than in other parts of the community. Materially deprived neighbourhoods are associated with lower education and income levels*.

Socially deprived: Where people are more likely to live alone, be a single parent, separated, divorced or widowed*.

Wellness check: When someone (ie. police, support workers, health care workers, family or friends) specifically contacts an individual(s) who has been unreachable for a period of time. The purpose of the contact is to ensure the individual(s) is safe and to consult with them regarding their well-being and support needs.

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*-Material and Social Deprivation Index. INSPQ Public health expertise and reference centre. https://www.inspq.qc.ca/en/deprivation/material-and-social-deprivation-index

Appendix 2: Data Tables and Figures

Figure 2

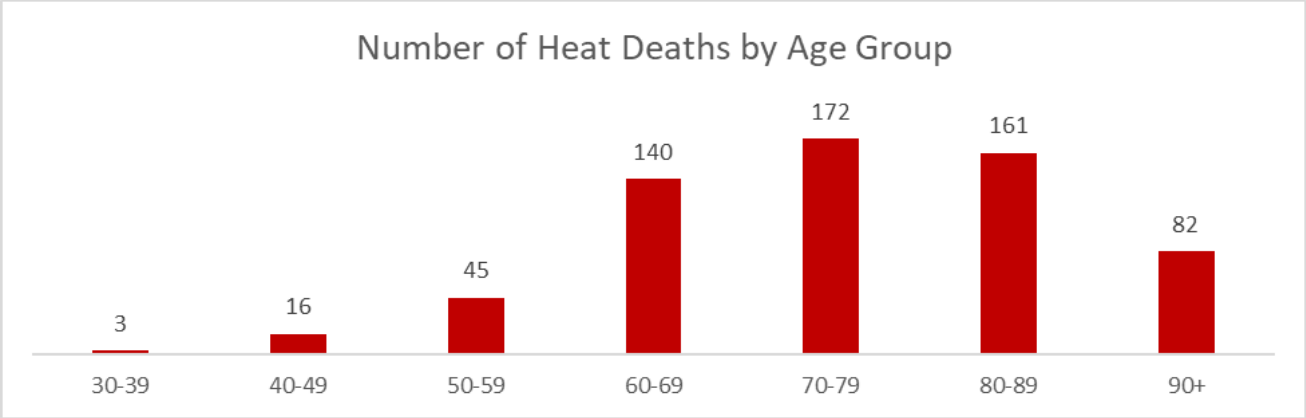


Figure 3

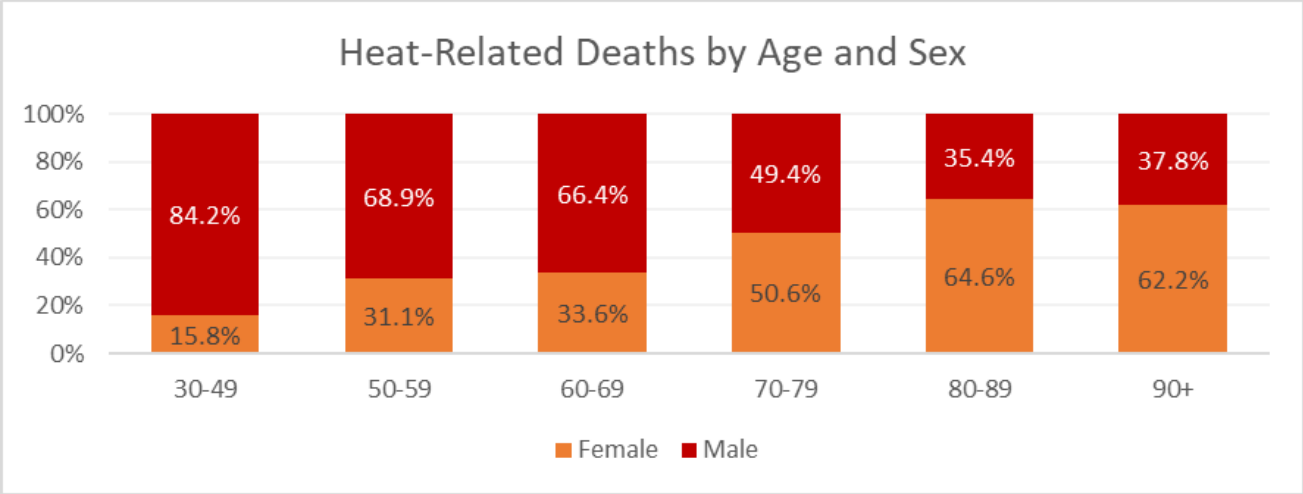
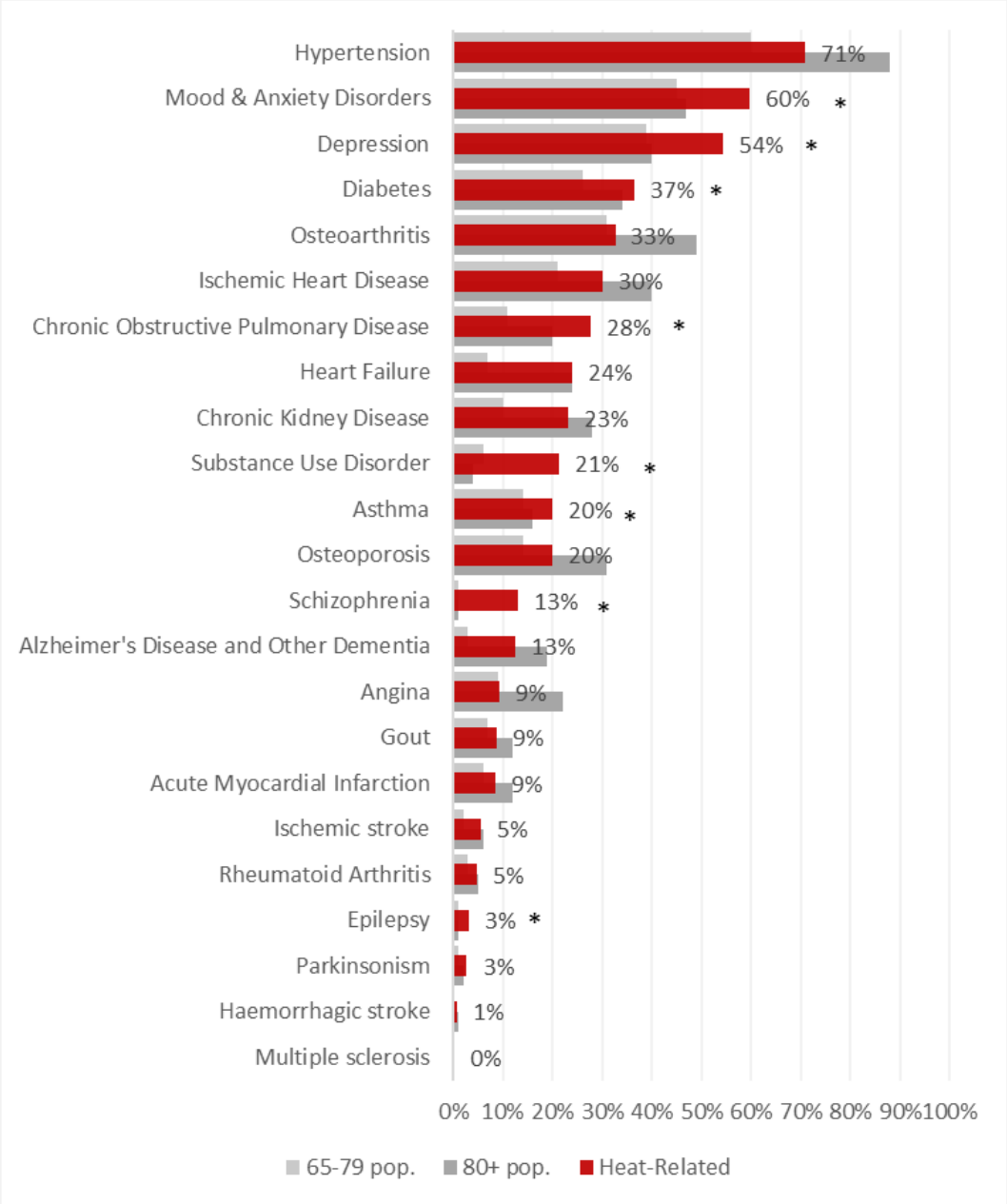


Figure 4: BC Centre for Disease Control Chronic Disease Dashboard



*-The proportion of heat-related deaths with the condition is greater than the prevalence of the condition in the 65-79 and 80+ population.

Source: BC Centre for Disease Control. Chronic Disease Dashboard. http://www.bccdc.ca/health-professionals/data-reports/chronic-disease-dashboard#Dashboard

Table 1: Heat-related deaths by Number of Chronic Disease Registries

Number of Registries	Count	Percent
None	27	4.4%
1	30	4.8%
2	51	8.2%
3-5	257	41.5%
6-9	209	33.8%
10+	34	5.5%
Unknown	11	1.8%
Total	619	

Table 3: Heat-Related Deaths by Health Authority of Injury

Health Authority	Count	Percent	Rate (per 100,000)
Fraser	312	50%	15.9
Interior	84	14%	10.2
Island	55	9%	6.3
Northern	23	4%	7.6
Vancouver Coastal	145	23%	11.6
Provincial	619		

Table 4: Heat-Related Deaths by Township of Injury

Township	Count	Percent	Rate (per 100,000)
Vancouver	117	18.9%	17.7
Surrey	75	12.1%	13.2
Burnaby	73	11.8%	29.3
New Westminster	33	5.3%	41.8
Chilliwack	27	4.4%	29.0
Greater Victoria	24	3.9%	6.0
Abbotsford	23	3.7%	15.0
Langley	23	3.7%	17.3
Kamloops	17	2.8%	17.4
Kelowna	15	2.4%	10.4
Coquitlam	14	2.3%	9.4
Prince George	14	2.3%	18.3
Other Townships	168	27.1%	N/A
Provincial	619		

Notes: Deaths are reported to the nearest township of injury; Rates were calculated using census 2021 population counts (https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/index.cfm?Lang=E)

Table 5: Heat-Related Deaths by Material Deprivation

Material Deprivation	Count	Percent
Quintile 1 - Least deprived	38	6.1%
Quintile 2 - Less deprived	68	11.0%
Quintile 3 - Average	101	16.3%
Quintile 4 - More deprived	116	18.7%
Quintile 5 - Most deprived	170	27.5%
Unknown	126	20.4%
Total	619	

Table 6: Heat-Related Deaths by Social Deprivation

Social Deprivation	Count	Percent
Quintile 1 - Least deprived	45	7.3%
Quintile 2 - Less deprived	75	12.1%
Quintile 3 - Average	69	11.2%
Quintile 4 - More deprived	100	16.2%
Quintile 5 - Most deprived	204	33.0%
Unknown	126	20.4%
Total	619	

Table 7: Heat-Related Deaths by Place of Injury

Place of Injury	Count	Percent
Private Residence - Multi-unit	242	39.1%
Private Residence - Detached	210	33.9%
SRO/Social Housing/Supportive Housing	62	10.0%
Trailer Home/Mobile Home/RV/Camper	40	6.5%
Senior/Long-Term Care Home	40	6.5%
Outside	13	2.1%
Other Residential	12	1.9%
Total	619	

Table 8: Heat-related deaths by Living Situation

Living Situation	Count	Percent
Lived Alone	347	56.1%
Lived with Family	187	30.2%
Lived with Unrelated Friends or Roommates	28	4.5%
Community or Assisted Living	47	7.6%
Death Related to Outdoor Activity not near Home	7	1.1%
Homeless	3	0.5%
Total	619	

Table 9: Heat-related deaths by Reason Found

Reason	Count	Percent
Wellness check	308	50%
Routine contact	200	32%
Witnessed event	72	12%
Passerby	16	3%
Other	19	3%
Unknown	4	1%
Total	619	

Table 10: Heat-related deaths by Max Outdoor Temperature on Day of Injury or Day Prior

Temperature (ºC)	Count	Percent
<30	63	10.2%
30-34	177	28.6%
35-39	207	33.4%
40+	172	17.8%
Total	619	

Table 11: Heat-related deaths by Air Conditioning Present

Air Conditioning Present	Count	Percent
Yes	46	7.4%
No	414	66.9%
Unknown	270	43.6%
Decedent outdoors and not near home	10	1.6%
Total	619	

Table 12: Heat-related deaths by Fans In Use in Residence

Fans in Use	Count	Percent
Yes	149	24.1%
No	190	30.7%
Unknown	270	43.6%
Decedent outdoors and not near home	10	1.6%
Total	619	

Table 13: 911 Calls during the period of the heat dome event

	E-Comm 911			BC Emergency Health Services (BCEHS)		
Date	911 calls	% > 5 sec delay	% > 45 sec delay transfer to BCEHS	Calls Accepted	Events Created	% Events where Ambulance Dispatched
Jun 23, 2021	6,510	3.2%	13.8%	2,162	1,887	92%
Jun 24, 2021	6,771	4.6%	9.2%	2,228	1,974	91%
Jun 25, 2021	7,722	5.9%	24.2%	2,458	2,105	87%
Jun 26, 2021	8,945	20.6%	51.9%	2,748	2,149	87%
Jun 27, 2021	9,387	23.9%	30.7%	2,889	2,279	79%
Jun 28, 2021	11,970	27.2%	51.9%	3,554	2,694	74%
Jun 29, 2021	10,387	51.7%	56.2%	3,373	2,629	75%
Jun 30, 2021	8,081	18.1%	25.0%	2,763	2,200	86%
Jul 1, 2021	8,914	4.0%	12.6%	2,280	1,990	93%
Jul 2, 2021	7,708	4.3%	29.8%	2,504	2,008	90%
Jul 3, 2021	7,437	1.6%	24.4%	2,280	1,950	92%
Jul 4, 2021	6,869	2.5%	25.2%	2,199	1,864	90%

Table 14: Heat-related deaths by BCEHS Calls

Calls	Count	Percent
No 911 call for ambulance	172	27.8%
911 call for ambulance	447	72.2%
Total	619	

Table 15: Heat-related deaths by Ambulance dispatched

Dispatched	Count	Percent
Ambulance dispatched	332	74.3%
No ambulance dispatched	115	25.7%
Total	447	

Table 16: Heat-related deaths by BCEHS Attended Disposition

Disposition	Count	Percent
Dead or died at scene	277	83.4%
Transported to hospital	55	16.6%
Total	332	

Appendix 3: Data Sources

Multiple data sources were used for this review. A full description of each data source can be found below.

BCCS Data: Includes all suspected and confirmed heat-related deaths in B.C. where the injury occurred over the summer of 2021 (Jun-Aug). Data includes dates of injury and death, age, sex, and Indigeneity of the decedent, and the place of injury and death.

BCCS Protocol Data: In response to the significant number of heat-related deaths, BCCS developed a set of questions, called protocol data, to be completed by the investigating coroner, to provide more insight into the decedent and the circumstances surrounding the death. These questions included the decedent's living situation, any recent activities, their mobility, and information about their home environment. The set of questions were developed after the heat dome event so coroners relied on investigation notes to complete the questions.

Chronic Disease Registry: Chronic disease registries are derived from administrative data sources maintained by the B.C. Ministry of Health. There are 26 conditions with registries and registries include date up to 2020/21 fiscal year. People on the registries are not identified by clinical diagnoses but through their healthcare service utilization matching specific case definitions for each condition. Case definitions for each registry can be found at: http://www.bccdc.ca/health-professionals/data-reports/chronic-disease-dashboard. Heat-related deaths were linked to the chronic disease registry by the B.C. Ministry of Health.

Medical Services Plan (MSP): MSP data includes all medically necessary services provided by fee-for-service practitioners, including laboratory and diagnostic procedures, to individuals covered by the MSP, B.C.'s universal insurance program. Practitioners include physicians, supplementary benefit practitioners, and out-of-province practitioners. Heat-related deaths were linked to MSP data by the BC Ministry of Health.

BC Housing: BC Housing develops, manages, and administers a range of subsidized housing options and programs across B.C. A list of all BC Housing-funded affordable housing buildings, shelters and supportive housing addresses was obtained from BC Housing. This list was then matched to the injury location of each heat-related death.

BC Emergency Health Services (BCEHS): BCEHS provides pre-hospital emergency services and inter-facility patient transfers throughout the province and oversees the BC Ambulance Service and BC Patient Transfer Services. Information on heat-related deaths were provided to BCEHS to link to an ambulance event. Each ambulance event was then provided back to BCCS.

Weather Data: Each injury location was matched spatially to the nearest Environment and Climate Change Canada (ECCC) weather station. For each case, hourly temperature and humidex values from the nearest station were extracted for the date of injury and the day prior. Daily values were calculated from hourly values by taking the maximum for temperature and the mean for humidex.

Deprivation Index: The Material and Social Deprivation Index (MSDI) was created with the aim of characterizing and highlighting the deprivation at the small area level*. The material deprivation reflects the deprivation of goods and conveniences. The social deprivation reflects the deprivation of relationships among individuals in the family, the workplace, and the community. The residential address of the decedent was linked to the material and social deprivation index quintile of the corresponding dissemination area.

E-COMM 911: E-Comm is responsible for 99% of the province's 911 call volume. Call volume data including the number of calls transferred to police, ambulance, and fire and call response and transfer times were provided by E-Comm for June 18 – July 10, 2021.

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*-Institut National de Santé Publique du Québec. Material and social deprivation index. https://www.inspq.qc.ca/en/deprivation/material-and-social-deprivation-index

Appendix 4: References and Bibliography

Abbinett, Jessica, Paul Schramm, Stasia Widerynski, Shubhayu Saha, Suzanne Beavers, Margaret Eaglin, Uei Lei, Seema Nayak, Matthew Roach, Matt Wolff, Kathryn Conlon and Lauren Thie. 2020. "Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation." Climate and Health Technical Report Series Climate and Health Program, Centers for Disease Control and Prevention. Retrieved from https://www.cdc.gov/climateandhealth/docs/HeatResponsePlans_508.pdf.

Aflaki, Ardalan, Norhayati Mahyuddin, Golnoosh Manteghi and Mohamad Rizal Baharum. 2017. "Building Height Effects on Indoor Air Temperature and Velocity in High Rise Residential Buildings in Tropical Climate." *OIDA International Journal of Sustainable Development*, 7(7), 39–48.

Aminipouri, Mehdi, Anders Jensen Knudby, E. Scott Krayenhoff, Kirsten Zickfeld and Ariane Middel. 2019. "Modelling the Impact of Increased Street Tree Cover on Mean Radiant Temperature Across Vancouver's Local Climate Zones." *Urban Forestry & Urban Greening*, 39, 9–17. Retrieved from https://doi.org/10.1016/j.ufug.2019.01.016.

Anderson, Vidya and William A. Gough. 2022. "Nature-Based Cooling Potential: A Multi-type Green Infrastructure Evaluation in Toronto, Ontario, Canada." *International Journal of Biometeorology*, 66(2), 397–410. Retrieved from https://doi.org/10.1007/s00484-021-02100-5.

Åström, Daniel Oudin, Forsberg Bertil and Rocklov Joacim. 2011. "Heat Wave Impact on Morbidity and Mortality in the Elderly Population: A Review of Recent Studies." *Maturitas*, 69(2), 99–105. Retrieved from https://doi.org/10.1016/j.maturitas.2011.03.008.

Auger, Nathalie, Marianne Bilodeau-Bertrand, Maud Emmanuelle Labesse and Tom Kosatsky. 2017. "Association of Elevated Ambient Temperature with Death from Cocaine Overdose." *Drug and Alcohol Dependence*, 178, 101–105. Retrieved from https://doi.org/10.1016/j.drugalcdep.2017.04.019.

Auger, Nathalie, William D. Fraser, Audrey Smargiassi and Tom Kosatsky. 2015. "Ambient Heat and Sudden Infant Death: A Case-crossover Study Spanning 30 Years in Montreal, Canada." *Environmental Health Perspectives*, 123(7), 712–716. Retrieved from https://doi.org/10.1289/ehp.1307960.

Barriopedro, David, Erich M. Fischer, Jurg Luterbacher, Ricardo M. Trigo and Ricardo García-Herrera. 2011. "The Hot Summer of 2010: Redrawing the Temperature Record Map of Europe." *Science*, 332(6026), 220–224. Retrieved from https://doi.org/10.1126/science.1201224.

BC Coroners Service. 2021. "Heat-Related Deaths in B.C. - Knowledge Update." Retrieved from https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/statistical/heat_related_deaths_in_bc_knowledge_update.pdf.

BC Hydro. 2018. "Cold Comfort: The Rising Use (and Cost) of Air Conditioning in B.C." Retrieved from https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/news-and-features/air-conditioning-report-july-2018.pdf.

Beaudoin, Melanie and Pierre Gosselin. 2016. "An Effective Public Health Program to Reduce Urban Heat Islands in Québec, Canada." *Revista Panamericana de Salud Publica = Pan American Journal of Public Health*, 40(3), 160–166. Retrieved from https://pubmed.ncbi.nlm.nih.gov/27991973.

Bekkar, Bruce, Susan Pacheco, Rupa Basu et al. 2020. "Association of Air Pollution and Heat Exposure With Preterm Birth, Low Birth Weight, and Stillbirth in the US." *JAMA Network Open*, 3(6), e208243. Retrieved from https://doi.org/10.1001/jamanetworkopen.2020.8243.

Berry, Peter, Anna Yusa, Toni Morris-Oswald and Anastasia Rogaeva. 2014. "Heat Alert and Response Systems in Urban and Rural Communities in Canada." *Change and Adaptation in Socio-Ecological Ecosystems*, 1(1), 84-97. DOI: 10.2478/cass-2014-0009.

Bohnert, Amy S. B., Marta R. Prescott, David Vlahov, Kenneth J. Tardiff, and Sandro Galea. 2010. "Ambient Temperature and Risk of Death from Accidental Drug Overdose in New York City, 1990–2006." *Addiction*, 105(6), 1049–1054. Retrieved from https://doi.org/10.1111/j.1360-0443.2009.02887.x.

Booth, John N., Gregory G. Davis, John Waterbor and Gerald McGwin. 2010. "Hyperthermia Deaths Among Children in Parked Vehicles: An Analysis of 231 Fatalities in the United States, 1999–2007." \ *Forensic Science, Medicine, and Pathology*, 6(2), 99–105. Retrieved from https://doi.org/10.1007/s12024-010-9149-x.

Brady, Kathleen T. and Rajita Sinha. 2005. "Co-Occurring Mental and Substance Use Disorders: The Neurobiological Effects of Chronic Stress." *American Journal of Psychiatry*, 162(8), 1483–1493. Retrieved from https://doi.org/10.1176/appi.ajp.162.8.1483.

Bunker, Aditi, Jan Wildenhain, Alina Vandenbergh, Nicholas Henschke, Joacim Rocklöv, Shakoor Hajat and Rainer Sauerborn. 2016. "Effects of Air Temperature on Climate-Sensitive Mortality and Morbidity Outcomes in the Elderly; A Systematic Review and Meta-analysis of Epidemiological Evidence." *EBioMedicine*, 6, 258–268. Retrieved from https://doi.org/10.1016/j.ebiom.2016.02.034.

Bustinza, Ray, Germain Lebel, Pierre Gosselin, Diane Bélanger and Fateh Chebana. 2013. "Health Impacts of the July 2010 Heat Wave in Québec, Canada." *BMC Public Health*, 13(1), 56–56. Retrieved from https://doi.org/10.1186/1471-2458-13-56.

Calkins, Miriam M., Tania Busch Isaksen, Benjamin A. Stubbs, Michael G. Yost and Richard A. Fenske. 2016. "Impacts of Extreme Heat on Emergency Medical Service Calls in King County, Washington, 2007– 2012: Relative Risk and Time Series Analyses of Basic and Advanced Life Support." *Environmental Health*, 15(1):13. DOI:10.1186/s12940-016-0109-0.

City of Vancouver. 2020. "Extreme Heat Initial Response Guideline (IRG)." Retrieved from https://vancouver.ca/files/cov/07-26-2021-heat-response-review.pdf.

Centers for Disease Control and Prevention (CDC). 1994. "Heat-Related Deaths--Philadelphia and United States, 1993-1994." *Mortality and Morbidity Weekly Report,* 43(25), 453-5. Retrieved from https://pubmed.ncbi.nlm.nih.gov/8208234.

Dahlblom, Mats and Lars Jensen. 2014. "Vertical Temperature Increase in Multi-Storey Buildings." In *NSB 2014: 10th Nordic Symposium on Building Physics, 15-19 June 2014 Lund Sweden*, 814-821. Retrieved from https://lup.lub.lu.se/search/ws/files/6367003/8309669.pdf.

Deegan, Heather E., Jenny Green, Sylvia El Kurdi, Michelle Allen and Sue L. Pollock. 2022. "Development and Implementation of a Heat Alert and Response System in Rural British Columbia." *Canadian Journal of Public Health*, 113, 446-454. Retrieved from https://doi.org/10.17269/s41997-022-00611-1.

Deen, Tariq A., M. Altaf Arain, Olivier Champagne, Patricia Chow-Fraser, Nidhi Nagabhatla and Dawn Martin-Hill. 2021. "Evaluation of Observed and Projected Extreme Climate Trends for Decision Making in Six Nations of the Grand River, Canada." *Climate Services*, Volume 24, 100263. Retrieved from https://doi.org/10.1016/j.cliser.2021.100263.

Ebi, Kristie L., Anthony Capon, Peter Berry, Carolyn Broderick, Richard de Dear, George Havenith, Yasushi Honda, R. Sari Kovats, Wei Ma, Arunima Malik, Nathan B. Morris, Lars Nybo, Sonia I. Seneviratne, Jennifer Vanos and Ollie Jay. 2021. "Hot Weather and Heat Extremes: Health Risks." *The Lancet*, 398(10301), 698–708. Retrieved from https://doi.org/10.1016/s0140-6736(21)01208-3.

Ebi, Kristie L. and Jordana K. Schmier. 2005. "A Stitch in Time: Improving Public Health Early Warning Systems for Extreme Weather Events." *Epidemiologic Reviews*, 27, 115-121. Retrieved from https://doi.org/10.1093/epirev/mxi006.

E-Comm 9-1-1. n.d. "About E-Comm: History & Facilities." Retrieved from https://www.ecomm911.ca/about-e-comm/history-facility.

Emergency Management BC. 2016. "Policy 2.07. Road and Medical Policy." Retrieved from https://www2.gov.bc.ca/gov/content/safety/emergency-management/emergency-management/policies.

Eyquem, Joanna and Blair Feltmate. 2022. "Irreversible Extreme Heat: Protecting Canadians and Communities from a Lethal Future." Retrieved from https://www.intactcentreclimateadaptation.ca/irreversible-extreme-heat-protecting-canadians-and-communities-from-a-lethal-future.

Ford, James D. 2012. "Indigenous Health and Climate Change." *American Journal of Public Health,* 102(7), 1260-1266. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3477984.

Fouillet, A., G. Rey, F. Laurent, G. Pavillon, S. Bellec, C. Guihenneuc-Jouyaux, J. Clavel, E. Jougla and D. Hémon. 2006. "Excess Mortality Related to the August 2003 Heat Wave in France." *International Archives of Occupational and Environmental Health*, 80(1), 16–24. Retrieved from https://doi.org/10.1007/s00420-006-0089-4.

Giguère, Melissa. 2012. "Literature Review of Urban Heat Island Mitigation Strategies." National Institute of Public Health of Quebec." Retrieved from https://www.inspq.qc.ca/node/3063.

Goedel, William C., Brandon D. L. Marshall, Keith R. Spangler, Nicole Alexander-Scott, Traci C. Green, Gregory A. Wellenius and Kate R. Weinberger. 2019. "Increased Risk of Opioid Overdose Death Following Cold Weather: A Case–Crossover Study." *Epidemiology*, 30(5), 637–641. Retrieved from https://doi.org/10.1097/ede.0000000000001041.

Government of Canada. 2010. "Chapter 4: Life with Arthritis in Canada: A Personal and Public Health Challenge – Arthritis Among First Nations, Métis and Inuit." Retrieved from https://www.canada.ca/en/public-health/services/chronic-diseases/arthritis/life-arthritis-canada-a-personal-public-health-challenge/chapter-four-arthritis-among-first-nations-metis-and-inuit.html.

Government of Canada. 2017. "First Responders. 2017-09-26." Retrieved from https://www.canada.ca/en/department-national-defence/services/uxo/first-responders.html.

Government of Canada. 2020. "Criteria for Public Weather Alerts. 2020-10-29." Retrieved from https://www.canada.ca/en/environment-climate-change/services/types-weather-forecasts-use/public/criteria-alerts.html.

Government of Canada. 2020. "Communicating the Health Risks of Extreme Heat Events. 2020-12-14." Retrieved from https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/climate-change-health/communicating-health-risks-extreme-heat-events-toolkit-public-health-emergency-management-officials-health-canada-2011.html.

Government of Canada. 2022. "Extreme Heat Events: Overview. Climate Change and Innovation Bureau. Jan 24, 2022." Retrieved from https://www.canada.ca/en/health-canada/services/climate-change-health/extreme-heat.html.

Government of Canada. 2022. "Heat Alert and Response Systems (HARS) Across Canada. Climate Change and Innovation Bureau. Jan 24, 2022." Retrieved from https://www.canada.ca/en/health-canada/services/climate-change-health/heat-alert-reponse-systems.html.

Graham, Drew A., Jennifer K. Vanos, Natasha A. Kenny, and Robert D. Brown. 2016. The Relationship Between Neighbourhood Tree Canopy Cover and Heat-Related Ambulance Calls During Extreme Heat Events in Toronto, Canada." *Urban Forestry & Urban Greening*, 20, 180–186. Retrieved from https://doi.org/10.1016/j.ufug.2016.08.005.

Grigorieva, Elena and Artem Lukyanets. 2021. "Combined Effect of Hot Weather and Outdoor Air Pollution on Respiratory Health: Literature Review." *Atmosphere*, 12(6), 790. Retrieved from https://doi.org/10.3390/atmos12060790.

Gronlund, Carina J. 2014. "Racial and Socioeconomic Disparities in Heat-Related Health Effects and Their Mechanisms: A Review." *Current Epidemiology Reports*, 1(3), 165–173. Retrieved from https://doi.org/10.1007/s40471-014-0014-4.

Guergova, Slava and Andre Dufour. 2011. "Thermal Sensitivity in the Elderly: A Review. *Ageing Research Reviews*, 10(1), 80–92. Retrieved from https://doi.org/10.1016/j.arr.2010.04.009.

Hajat, Shakoor, Madeline O'Connor and Tom Kosatsky. 2010. Health Effects of Hot Weather: From Awareness of Risk Factors to Effective Health Protection." *The Lancet*, 375(9717), 856–863. Retrieved from https://doi.org/10.1016/s0140-6736(09)61711-6.

Health Canada. 2011. "Communicating the Health risks of Extreme Heat Events: Toolkit for Public Health and Emergency Management Officials." Retrieved from https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/climat/heat-chaleur/heat-chaleur-eng.pdf.

Health Canada. 2012. "Heat Alert and Response Systems to Protect Health: Best Practice Guidebook." Retrieved from https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/climate-change-health/heat-alert-response-systems-protect-health-best-practices-guidebook.html.

Health Canada. 2018. "Ventilation and the Indoor Environment." Retrieved from https://www.canada.ca/content/dam/hc-sc/documents/services/publications/healthy-living/ventilation-indoor-environment/ventilation-indoor-environment.pdf.

Health Canada. 2021. "Extreme Heat and Human Health: Information for Pharmacists and Pharmacist Technicians." Retrieved from https://www.canada.ca/content/dam/hc-sc/documents/services/publications/healthy-living/extreme-heat-human-health-pharmacists-technicians/extreme-heat-human-health-pharmacists-technicians-eng.pdf.

Henderson, Sarah B. 2021. "Mortality During the Catastrophic 2021 Heat Dome: What we Know and Where We Need to Go. BCCDC Grand Rounds." Retrieved from https://nexuswebcast.mediasite.com/mediasite/Showcase/bc-cdc-showcase/Presentation/896ca6fb39e246ab801c0526867b73741d

Henderson, S. B., Y. Ding, J. Yao, N. SahaTurna, D. McVea and T. Kosatsky. 2022. "Hot Weather and Mortality Related to Acute Cocaine, Opioid, and Amphetamine Toxicity in British Columbia, Canada: A Time-Stratified Case-Crossover Study." In Review. *Canadian Medical Association Journal*.

Henderson, Sarah B., Kathleen E. McLean, Michael J. Lee, and Tom Kosatsky. 2022. "Analysis of Community Deaths During the Catastrophic 2021 Heat Dome." *Environmental Epidemiology*, 6(1), e189. Retrieved from https://doi.org/10.1097/ee9.0000000000000189.

Henderson, Sarah B., Kathleen E. McLean, Michael Lee and Tom Kosatsky. 2021. "Extreme Heat Events are Public Health Emergencies." *BC Medical Journal*, 63(9), 366-367. Retrieved from https://bcmj.org/bccdc/extreme-heat-events-are-public-health-emergencies#:~:text=The%20average%20number%20of%20deaths,across%20the%20province%20%5BFigure%5D.

Henderson, Sarah B., Victoria Wan and Tom Kosatsky. 2013. "Differences in Heat-Related Mortality Across Four Ecological Regions with Diverse Urban, Rural, and Remote Populations in British Columbia, Canada." *Health Place*, 23, 48–53. Retrieved from https://doi.org/10.1016/j.healthplace.2013.04.005.

Hitchon, Carol A., Sazzadul Khan, Brenda Elias, Lisa M. Lix, and Christine A. Peschken. 2020. "Prevalence and Incidence of Rheumatoid Arthritis in Canadian First Nations and Non–First Nations People." *Journal of Clinical Rheumatology,* 26(5), 169-175. DOI: 10.1097/RHU.0000000000001006.

Holmén, Johan, Johan Herlitz, Sven-Erik Ricksten, Anneli Strömsöe, Eva Hagberg, Christer Axelsson and Araz Rawshani. 2020. "Shortening Ambulance Response Time Increases Survival in Out-of-Hospital Cardiac Arrest." *Journal of the American Heart Association*. Retrieved from https://doi.org/10.1161/JAHA.120.017048.

Hong, Kris Y., Pak Keung Tsin, Matilda van den Bosch, Michael Brauer and Sarah B. Henderson. 2019. "Urban Greenness Extracted From Pedestrian Video and its Relationship with Surrounding Air Temperatures." *Urban Forestry & Urban Greening*, 38, 280–285. Retrieved from https://doi.org/10.1016/j.ufug.2019.01.008.

Hsu, Angel, Glenn Sheriff, Tirthankar Chakraborty and Diego Manya. 2021. "Disproportionate Exposure to Urban Heat Island Intensity Across Major US Cities." *Nature Communications*, 12(1), 2721. Retrieved from https://doi.org/10.1038/s41467-021-22799-5.

Indigenous Services Canada. 2018. "Preventing and Managing Chronic Disease in First Nations Communities: A Guidance Framework. February 2018." Retrieved from https://publications.gc.ca/collections/collection_2018/aanc-inac/H34-313-1-2017-eng.pdf.

IPCC. 2021. "Climate Change 2021: The Physical Science Basis Summary for Policymakers." Retrieved from https://www.ipcc.ch/report/ar6/wg1/#SPM.

IPCC. 2022. "Climate Change 2022: Impacts, Adaptation and Vulnerability Summary for Policymakers." Retrieved from https://www.ipcc.ch/report/ar6/wg2.

Isaksen, Tania Busch, Richard A. Fenske, Elizabeth K. Hom, You Ren, Hilary Lyons and Michael G. Yost. 2016. "Increased Mortality Associated with Extreme-Heat Exposure in King County, Washington, 1980–2010." *International Journal of Biometeorology*, 60(1), 85–98. Retrieved from https://doi.org/10.1007/s00484-015-1007-9.

Jandaghian, Zahra and Hashem Akbari. 2018. "The Effects of Increasing Surface Reflectivity on Heat-Related Mortality in Greater Montreal Area, Canada." *Urban Climate*, 25, 135–151. Retrieved from https://doi.org/10.1016/j.uclim.2018.06.002.

Jandaghian, Zahra, & Hashem Akbari. 2021. "Increasing Urban Albedo to Reduce Heat-Related Mortality in Toronto and Montreal, Canada." *Energy and Buildings*, 237, 110697. Retrieved from https://doi.org/10.1016/j.enbuild.2020.110697

Johnson, Lisa. 2021, July 7. "Alberta Saw Spike in Reported Deaths During Heatwave, Causes Still Under Investigation." Edmonton Journal. Retrieved from https://edmontonjournal.com/news/local-news/alberta-saw-spike-in-reported-deaths-during-heatwave-causes-still-under-investigation.

Kenny, Glen P., Andreas D. Flouris, Abderrahmane Yagouti and Sean R. Notley. 2018. "Towards Establishing Evidence-based Guidelines on Maximum Indoor Temperatures During Hot Weather in Temperate Continental Climates." *Temperature: Multidisciplinary Biomedical Journal*, 6(1), 11–36. Retrieved from https://doi.org/10.1080/23328940.2018.1456257.

Kenny, Glen P., Sean R. Notley, Andreas D. Flouris and Andrew Grundstein. 2019. "Climate Change and Heat Exposure: Impact on Health in Occupational and General Populations." *Exertional Heat Illness*, 225-261. Retrieved from https://doi.org/10.1007/978-3-030-27805-2_12.

Kinney, Patrick L. 2018. "Temporal Trends in Heat-Related Mortality: Implications for Future Projections." *Atmosphere*, 9(10), 409. Retrieved from https://doi.org/10.3390/atmos9100409.

Kosatsky, Tom, Sarah B. Henderson and Sue L. Pollock. 2012. "Shifts in Mortality During a Hot Weather Event in Vancouver, British Columbia: Rapid Assessment with Case-Only Analysis." *American Journal of Public Health*, 102(12), 2367–2371. Retrieved from https://doi.org/10.2105/ajph.2012.300670.

Kovats, R. Sari and Shakoor Hajat. 2008. "Heat Stress and Public Health: A Critical Review." *Annual Review of Public Health*, 29(1), 41–55. Retrieved from https://doi.org/10.1146/annurev.publhealth.29.020907.090843.

Kownacki, Karin Lundgren, Chuansi Gao, Kalev Kuklane and Aneta Wierzbicka. 2019. "Heat Stress in Indoor Environments of Scandinavian Urban Areas: A Literature Review." *International Journal of Environmental Research and Public Health*, 16(4), 560. Retrieved from https://doi.org/10.3390/ijerph16040560.

Kuehn, Leeann and Sabrina McCormick. 2017. "Heat Exposure and Maternal Health in the Face of Climate Change." *International Journal of Environmental Research and Public Health*, 14(8), 853. Retrieved from https://doi.org/10.3390/ijerph14080853.

Lamothe, F., M. Roy and S-H Racine-Hamel. 2019. "Epidemiological Investigation - Heat Wave in the Summer of 2018 in Montreal." Regional Public Health Department of the CIUSSS du Centre-Sud-de-l'Île-de-Montréal. Retrieved from https://santemontreal.qc.ca/fileadmin/fichiers/professionnels/DRSP/Directeur/Rapports/Resume_EnqueteChaleurMtl_2018_Anglais.pdf.

Li, Zhong, Guohe Huang, Wendy Huang, Qianguo Lin, Renfei Liao and Yurui Fan. 2018. "Future Changes of Temperature and Heat Waves in Ontario, Canada." *Theoretical and Applied Climatology*, 132(3–4), 1029–1038. Retrieved from https://doi.org/10.1007/s00704-017-2123-8.

Liang, Kevin E. and Tom Kosatsky. 2020. "Protecting Rural Canadians From Extreme Heat." *CMAJ*, 192(24), E657–E658. Retrieved from https://doi.org/10.1503/cmaj.200004.

Liu, Jingwen, Blesson M. Varghese, Alana Hansen, Jianjun Xiang,, Ying Zhang, Keith Dear, Michelle Gourley, Timothy Driscoll, Geoffrey Morgan, Anthony Capon and Peng Bia. 2021. "Is There an Association Between Hot Weather and Poor Mental Health Outcomes? A Systematic Review and Meta-Analysis." *Environment International*, 153. Retrieved from https://doi.org/10.1016/j.envint.2021.106533.

Lõhmus, Mare. 2018. "Possible Biological Mechanisms Linking Mental Health and Heat—A Contemplative Review." *International Journal of Environmental Research and Public Health*, 15(7), 1515. Retrieved from https://doi.org/10.3390/ijerph15071515.

Lubik, Amy, and Tom Kosatsky. 2017. "Developing a Municipal Heat Response Plan: A Guide for Medium sized Municipalities." BC Centre for Disease Control. Retrieved from http://www.bccdc.ca/health-professionals/professional-resources/heat-event-response-planning.

Lubik, Amy, Geoff McKee, Tina Chen and Tom Kosatsky. 2017. "Municipal Heat Response Planning in British Columbia, Canada." BC Centre for Disease Control. Retrieved from http://www.bccdc.ca/health-professionals/professional-resources/heat-event-response-planning.

Ludwig, Jens, Greg J. Duncan, Lisa A. Gennetian, Lawrence F. Katz, Ronald C. Kessler, Jeffrey R. Kling and Lisa Sanbonmatsu. 2012. "Neighborhood Effects on the Long-Term Well-Being of Low-Income Adults." *Science*, 337(6101), 1505–1510. Retrieved from https://doi.org/10.1126/science.1224648.

Maisch, B. 2016. "Alcoholic Cardiomyopathy." *Herz*, 41(6), 484–493. Retrieved from https://doi.org/10.1007/s00059-016-4469-6.

McKeown, David. 2015. "Reducing Health Risk from Extreme Heat in Apartment Buildings." City of Toronto. Retrieved from https://www.toronto.ca/legdocs/mmis/2015/hl/bgrd/backgroundfile-81510.pdf.

McLean, Kathleen E., Rebecca Stranberg, Melissa MacDonald, Gregory R. A. Richardson, Tom Kosatsky and Sarah B. Henderson. 2018. "Establishing Heat Alert Thresholds for the Varied Climatic Regions of British Columbia, Canada." *International Journal of Environmental Research and Public Health*, 15(9), 2048. DOI: 10.3390/ijerph15092048.

Meade, Robert D., Ashley P. Akerman, Sean R. Notley, Ryan McGinn, Paul Poirier, Pierre Gosselin and Glen P. Kenny. 2020. "Physiological Factors Characterizing Heat-Vulnerable Older Adults: A Narrative Review." *Environment International*, 144, 105909. Retrieved from https://doi.org/10.1016/j.envint.2020.105909.

Meade, Robert D., Sean R. Notley and Glen P. Kenny. 2019. "Aging and Human Heat Dissipation During Exercise-Heat Stress: An Update and Future Directions." *Current Opinion in Physiology*, 10, 219–225. Retrieved from https://doi.org/10.1016/j.cophys.2019.07.003.

Nebia, Bachir and Kheira Tabet Aoul. 2017. "Overheating and Daylighting; Assessment Tool in Early Design of London's High-Rise Residential Buildings." *Sustainability*, 9(9), 1544. Retrieved from https://doi.org/10.3390/su9091544.

Nitschke, Monika, Graeme R. Tucker, Alana L. Hansen et al. "Impact of Two Recent Extreme Heat Episodes on Morbidity and Mortality in Adelaide, South Australia: A Case-Series Analysis." *Environmental Health*, 10, 42. Retrieved from https://doi.org/10.1186/1476-069X-10-42.

Norton-Smith, Kathryn, Kathy Lynn, Karletta Chief, Karen Cozzetto, Jamie Donatuto, Margaret Hiza Redsteer, Linda E. Kruger, Julie Maldonado, Carson Viles and Kyle P. Whyte. 2016. "Climate Change and Indigenous Peoples: A Synthesis of Current Impacts and Experiences." General Technical Report. PNWGTR-944. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 136 p. Retrieved from https://doi.org/10.2737/PNW-GTR-944.

Page, Lisa A., Shakoor Hajat, R. Sari Kovats and Louise M. Howard. 2012. "Temperature-Related Deaths in People with Psychosis, Dementia and Substance Misuse." *British Journal of Psychiatry*, 200(6), 485–490. https://doi.org/10.1192/bjp.bp.111.100404.

Philip, Sjoukje Y., Sarah F. Kew, Geert Jan van Oldenborgh, Wenchang Yang, Gabriel A. Vecchi, Faron S. Anslow, Sihan Li, Sonia I. Seneviratne, Linh N. Luu, Julie Arrighi, Roop Singh, Maarten van Aalst, Mathias Hauser, Dominik L. Schumacher, Carolina Pereira Marghidan, Kristie L. Ebi, Remy Bonnet, Robert Vautard, Jordis Tradowsky, Dim Coumou, Flavio Lehner, Michael Wehner, Chris Rodell, Roland Stull, Rosie Howard, Nathan Gillett and Friederike E. L. Otto. 2021. "Rapid Attribution Analysis of the Extraordinary Heatwave on the Pacific Coast of the US and Canada June 2021." Retrieved from https://www.worldweatherattribution.org/wp-content/uploads/NW-US-extreme-heat-2021-scientific-report-WWA.pdf.

Phillips, David. 2006. "Heat Wave. The Canadian Encyclopedia." Retrieved from https://www.thecanadian encyclopedia.ca/en/article/heat-wave.

Poumadère, Marc, Claire Mays, Sophie Le Mer and Russell Blong. 2005. "The 2003 Heat Wave in France: Dangerous Climate Change Here and Now." *Risk Analysis*, 25(6), 1483–1494. Retrieved from https://doi.org/10.1111/j.1539-6924.2005.00694.x.

Price, Karine, Stephane Perron and Norman King. 2013. "Implementation of the Montreal Heat Response Plan During the 2010 Heat Wave." *Canadian Journal of Public Health*, 104(2), e96–e100. Retrieved from https://doi.org/10.1007/bf03405667.

Ramgopal, Sriram, Jennifer Dunnick, Sylvia Owusu-Ansah, Nalyn Sirpong, David D. Salcido and Christian Martin-Gill. 2019. "Weather and Temporal Factors Associated with Use of Emergency Medical Services." *Prehospital Emergency Care,* 23(6), 802–810. DOI: 10.1080/10903127.2019.1593563.

Regier, Darrel A., Mary E. Farmer, Donald S. Rae et al. 1990. "Comorbidity of Mental Disorders with Alcohol and Other Drug Abuse: Results From the Epidemiologic Catchment Area (ECA) Study." *JAMA*, 264(19), 2511–2518. Retrieved from https://doi.org/10.1001/jama.1990.03450190043026.

Robine, Jean-Marie, Siu Lan K. Cheung, Sophie Le Roy, Herman Van Oyen, Clare Griffiths, Jean-Pierre Michel and Francois Richard Herrmann. 2008. "Death Toll Exceeded 70,000 in Europe During the Summer of 2003." *Comptes Rendus Biologies*, 331(2), 171–178. Retrieved from https://doi.org/10.1016/j.crvi.2007.12.001.

Rowland, Thomas. 2008. "Thermoregulation During Exercise in the Heat in Children: Old Concepts Revisited. *Journal of Applied Physiology*, 105(2), 718–724. Retrieved from https://doi.org/10.1152/japplphysiol.01196.2007.

Salamanca, F., M. Georgescu, A. Mahalov, M. Moustaoui, and M. Wang. 2014. "Anthropogenic Heating of the Urban Environment Due to Air Conditioning." *Journal of Geophysical Research: Atmospheres*, 119(10), 5949–5965. Retrieved from https://doi.org/10.1002/2013jd021225.

Santamouris, M. 2020. "Recent Progress on Urban Overheating and Heat Island Research. Integrated Assessment of the Energy, Environmental, Vulnerability and Health Impact. Synergies with the Global Climate Change. *Energy and Buildings*, 207. Retrieved from https://doi.org/10.1016/j.enbuild.2019.109482.

Santé Montréal. 2022. "Extreme Heat: 66 Deaths in Montreal in 2018." Retrieved from https://santemontreal.qc.ca/en/public/fh/news/news/extreme-heat-66-deaths-in-montreal-in-2018/#:~:text=Investigation%20of%20deaths%20due%20to%20extreme%20heat%20in%202018&text=Among%20those%20who%20died%2C%2072,from%20alcohol%20or%20drug%20addiction.

Schwaab, Jonas, Ronny Meier, Gianluca Mussetti, Sonia Seneviratne, Christine Burgi and Edouard L. Davin. 2021. "The Role of Urban Trees in Reducing Land Surface Temperatures in European Cities." *Nature Communications*, 12, 67632021. Retrieved from https://doi.org/10.1038/s41467-021-26768-w.

Semenza, Jan C., Carol H. Rubin, Kenneth H. Falter, Joel D. Selanikio, W. Dana Flanders, Holly H. Howe and John L. Wilhelm. 1996. "Heat-Related Deaths During the July 1995 Heat Wave in Chicago. *New England Journal of Medicine*, 335(2), 84-90. Retrieved from https://www.nejm.org/doi/full/10.1056/nejm199607113350203.

Stapleton, Jill M., Martin P. Poirier, Andreas D. Flouris, Pierre Boulay, Ronald J. Sigal, Janine Malcolm and Glen P. Kenny. 2015. "Aging Impairs Heat Loss, But When Does it Matter?" *Journal of Applied Physiology*, 118(3), 299–309. Retrieved from https://doi.org/10.1152/japplphysiol.00722.2014.

Statistics Canada. 2015. "Health at a Glance. November 27, 2015." Retrieved from https://www150.statcan.gc.ca/n1/pub/82-624-x/2013001/article/11763-eng.htm.

Statistics Canada. 2021. "Mortality among First Nations people, 2006 to 2016. October 20, 2021." Retrieved from https://www.doi.org/10.25318/82-003-x202101000001-eng.

Steen, Yvette van, Anna-Maria Ntarladima, Rick Grobbee, Derek Karssenberg and Ilonca Vaartjes. 2019. "Sex Differences in Mortality After Heat Waves: Are Elderly Women at Higher Risk?" *International Archives of Occupational and Environmental Health*, 92(1), 37–48. Retrieved from https://doi.org/10.1007/s00420-018-1360-1.

Substance Abuse and Mental Health Services Administration. 2018. "First Responders: Behavioral Health Concerns, Emergency Response, and Trauma." Retrieved from https://www.samhsa.gov/dtac/disaster-behavioral-health-resources/supplemental-research-bulletin.

Tallon, John M., Lu Zheng, Julie Wei, William Dick, George Papadopoulos and Ognjenka Djurdjev. 2020. "Population-Based Analysis of the Effect of a Comprehensive, Systematic Change in an Emergency Medical Services Resource Allocation Plan on 24-hour Mortality." *CJEM*, 22(1), 86-94. DOI:10.1017/cem.2019.429.

Thompson, R., R. Hornigold, L. Page and T. Waite. 2018. "Associations Between High Ambient Temperatures and Heat Waves with Mental Health Outcomes: A Systematic Review." *Public Health*, 161, 171–191. Retrieved from https://doi.org/10.1016/j.puhe.2018.06.008.

Touchaei, A. G. and Y. Wang. 2015. "Characterizing Urban Heat Island in Montreal (Canada)—Effect of Urban Morphology. *Sustainable Cities and Society*, 19, 395–402. Retrieved from https://doi.org/10.1016/j.scs.2015.03.005.

Touchaei, Ali G., Hashem Akbari and Christopher W. Tessum. 2016. "Effect of Increasing Urban Albedo on Meteorology and Air Quality of Montreal (Canada) – Episodic Simulation of Heat Wave in 2005." *Atmospheric Environment*, 132, 188–206. Retrieved from https://doi.org/10.1016/j.atmosenv.2016.02.033.

Touchaei, Ali G., Mirata Hosseini and Hashem Akbari. 2016. "Energy Savings Potentials of Commercial Buildings by Urban Heat Island Reduction Strategies in Montreal (Canada)." *Energy and Buildings*, 110, 41–48. Retrieved from https://doi.org/10.1016/j.enbuild.2015.10.018.

Tsin, Pak Keung, Anders Knudby, E. Scott Krayenhoff, Hung Chak Ho, Michael Brauer and Sarah B. Henderson. 2016. "Microscale Mobile Monitoring of Urban Air Temperature." *Urban Climate*, 18, 58–72. Retrieved from https://doi.org/10.1016/j.uclim.2016.10.001.

United Nations Environment Program. 2004. "Impacts of Summer 2003 Heat Wave in Europe." Retrieved from https://www.unisdr.org/files/1145_ewheatwave.en.pdf.

US FEMA. 2018. "National Fire Incident Reporting System. Washington, D.C.: US Fire Administration, FEMA." Retrieved from https://www.usfa.fema.gov/data/statistics.

Wang, Yupeng, Umberto Berardi and Hashem Akbari. 2016. "Comparing the Effects of Urban Heat Island Mitigation Strategies for Toronto, Canada." *Energy and Buildings*, 114, 2–19. Retrieved from https://doi.org/10.1016/j.enbuild.2015.06.046.

Wheeler, Katherine, Kathryn Lane, Sarah Walters and Thomas Matte. 2013. "Heat Illness and Deaths - New York City, 2000-2011." *Morbidity and Mortality Weekly Report*, 62(31). Retrieved from https://pubmed.ncbi.nlm.nih.gov/23925170.

Williams, Augusta A., Joseph G. Allen, Paul J. Catalano, Jonathan J. Buonocore and John D. Spengler. 2020. "The Influence of Heat on Daily Police, Medical, and Fire Dispatches in Boston, Massachusetts: Relative Risk and Time-Series Analyses." *American Journal of Public Health*, 110(5), 662–668. Retrieved from https://doi.org/10.2105/AJPH.2019.305563.

Williams, Augusta, Larissa McDonogh-Wong and John D. Spengler. 2020. "The Influence of Extreme Heat on Police and Fire Department Services in 23 U.S. Cities." *GeoHealth*, 4, e2020GH000282. Retrieved from https://doi.org/10.1029/2020GH000282.

Wogen, Jenifer and Maria Teresa Restrepo. 2020. "Human Rights, Stigma, and Substance Use." *Health and Human Rights*, 22(1), 51–60. Retrieved from https://pubmed.ncbi.nlm.nih.gov/32669788.

Xu, Zhiwei, Perry E. Sheffield, Hong Su, Xiaoyu Wang, Yan Bi and Shilu Tong. 2014. "The Impact of Heat Waves on Children's Health: A Systematic Review." *International Journal of Biometeorology*, 58(2), 239–247. Retrieved from https://doi.org/10.1007/s00484-013-0655-x.

Zhang, Yunquan, Chuanhua Yu and Lu Wang. 2017. "Temperature Exposure During Pregnancy and Birth Outcomes: An Updated Systematic Review of Epidemiological Evidence." *Environmental Pollution*, 225, 700–712. Retrieved from https://doi.org/10.1016/j.envpol.2017.02.066.

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