MINNESOTA EXTREME HEAT TOOLKIT




Minnesota Climate and Health Program
Minnesota Department of Health
Environmental Impacts Analysis Unit

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Overview of Extreme Heat Toolkit

The purpose of this toolkit is to provide information to local governments and public health professionals about preparing for and responding to extreme heat events. The toolkit is organized into six interdependent chapters. The first three chapters contain the body of the toolkit, while the last three chapters include definitions, references and appendices. The first chapter, "Introduction to Extreme Heat Events," describes the magnitude of health consequences from extreme heat, changing weather conditions in Minnesota, and the National Weather Service's definitions of extreme heat. The second chapter, "Extreme Heat Events and Public Health," discusses health illnesses caused by extreme heat and characteristics or risk factors that increase a person's risk for heat-related illnesses. The third chapter, "Preparing Minnesota for Extreme Heat Events," describes key steps in preparing for and responding to an extreme heat event, how to develop a heat response plan, and strategies for preventing heat-related illnesses and deaths.

The toolkit focuses on Minnesota examples and processes and describes practical, implementable steps and strategies to prevent morbidity and mortality from extreme heat at the local level. The toolkit provides several appendices, including a generic heat response plan that can be tailored to meet the needs of a specific location. The toolkit does not describe comprehensive surveillance systems for morbidity and mortality from extreme heat because this would most likely occur only in a few jurisdictions in Minnesota or at the state level.

The goal of the toolkit is to increase Minnesota's preparedness for extreme heat events, by providing information and resources to local governments and public health departments to create their own heat response plan.

Introduction to Extreme Heat Events

Extreme heat events can cause a number of health-related problems, including an increase in deaths (mortality) and nonfatal outcomes (morbidity). Yet, almost all of the negative health outcomes from extreme heat can be prevented by taking appropriate measures to ensure that the public stays cool and hydrated during an extreme heat event. As more counties and cities begin to prepare for extreme heat, it is hoped that Minnesota will experience fewer heat-related deaths and illnesses.

Why care about extreme heat events?

Although most heat-related deaths and illnesses are preventable, a significant number of people die and suffer from extreme heat events every year in the U.S. From 1979 to 2003, more people in the U.S. died from extreme heat than from hurricanes, lightning, tornadoes, floods, and earthquakes combined.[1] From 1999-2003, about 3,442 deaths resulted from exposure to extreme heat in the U.S.[2]

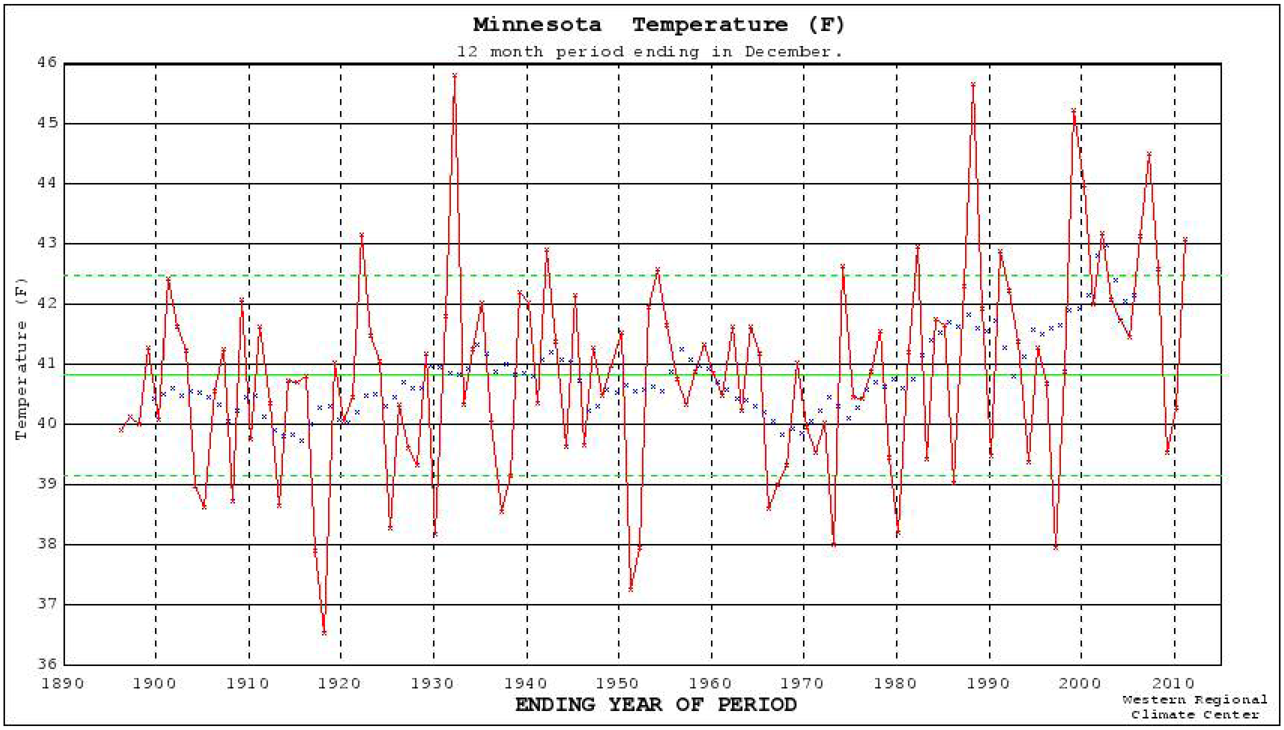
The magnitude of deaths and illnesses from extreme heat events is often underreported and little understood by the general public. Extreme heat events do not typically make the news headlines compared to other extreme weather events, such as tornadoes and floods, and they do not leave a lasting trail of infrastructural damage that continuously reminds people of their impact. Therefore, extreme heat events have been called the "silent killers."[3] However, in recent years there have been several notable heat waves that have caused a catastrophic number of deaths. In the historic 2003 European heat wave, about 14,800 people in France and about 50,000 people in Europe died from heat-related illnesses.[4] In 2010, Russia experienced a heat wave that caused an estimated 4,824 excess deaths in July in Moscow alone.[5] The United Nation News Centre reported that this Russian heat wave caused about 56,000 total fatalities across the country,[6] likely a result of the combination of extreme heat, smog, and smoke from wildfires.[7] Closer to home, more than 700 deaths have been attributed to the 1995 Chicago heat wave.[8]

Extreme heat events occur in Minnesota; however, it is difficult to know the exact number of deaths and illnesses due to extreme heat events because Minnesota does not have an official reporting system for deaths and illnesses attributable to extreme heat. A review of mortality records for deaths occurring in the months of May through September indicates that 35 deaths were directly attributable to extreme heat in Minnesota during the years 2000-2010.[9] This count likely underestimates the full burden of extreme heat on mortality, since it only captures deaths in which exposure to excess heat is explicitly listed as a cause of death on the death certificate. Because heat-related illnesses can cause various symptoms and exacerbate a wide variety of existing medical conditions, the cause of death can be difficult to establish if not witnessed by a physician.[10] Additionally, this count does not include data from summer 2011 when Minnesota experienced five separate extreme heat events, one of which broke several records for dew point temperature. Regarding morbidity, the number of people in Minnesota who have been afflicted with heat-related illnesses is unknown, but likely to be much higher than mortality numbers.

Minnesota is warming

Minnesota is getting hotter and more humid, which may increase the number of extreme heat events. Decadal trends assessed by the State Climatology Office, suggest that Minnesota's average temperature is increasing and the number of days with a dew point temperature greater than or equal to 70°F is increasing.

The chart below shows Minnesota's annual average temperature (red line), which demonstrates the wide fluctuation in temperature from year to year, and the 10-year running average temperature (blue stars) from the late 1890s to 2010. The 10-year running average temperature shows an upward trend in temperature starting in the 1980s.[11]



There are three significant trends in this overall warming:[12]

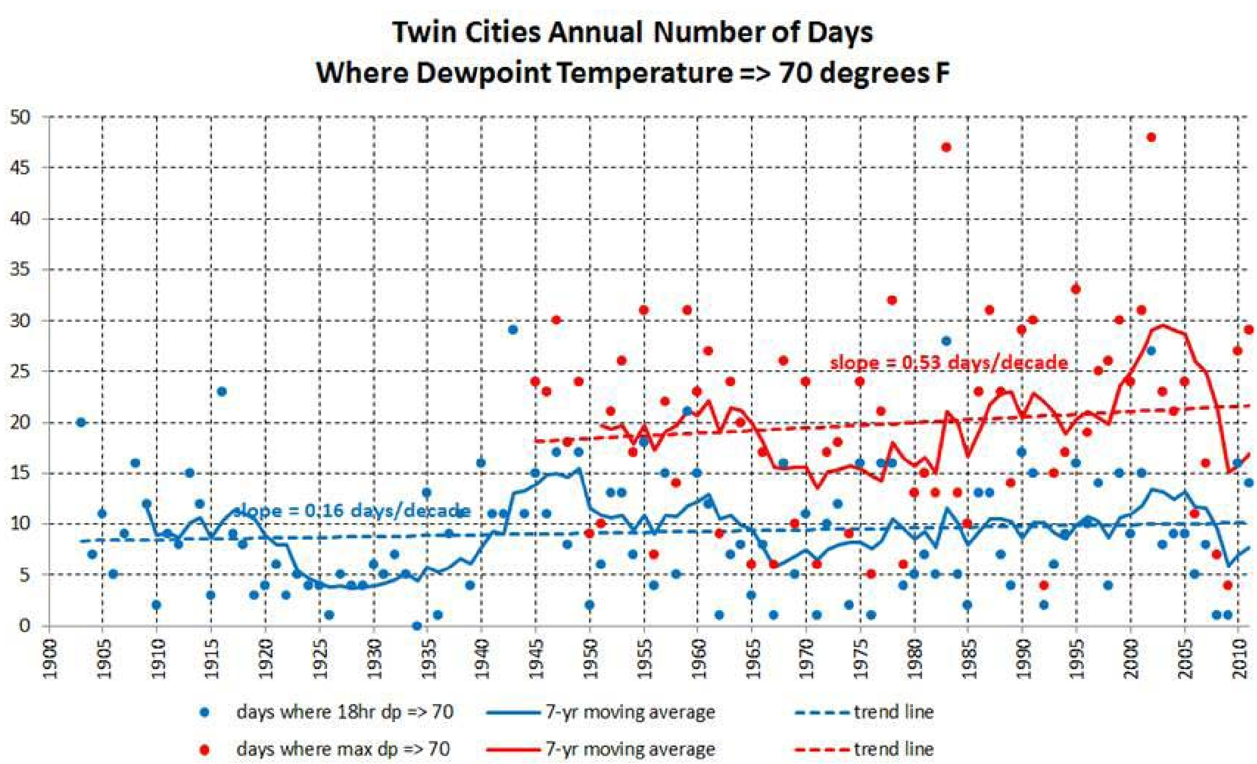
1. Temperature increases vary by season, with winters temperatures rising about twice as fast as annual average temperatures.
2. Minimum or 'overnight low' temperatures have been rising faster than the maximum temperature.
3. Temperature increases vary by geography. Since the early 1980s, the temperature has risen slightly over 1°F in the south of Minnesota to a little over 2°F in much of the north.

Climate change projections developed by various researchers concur with the observed trends. Climate models project that future temperatures in Minnesota will increase from 2-3°C (3.6-5.4°F) by 2069.[13,14] Exact predictions vary with the choice of climate model, assumptions about emission changes, and other model parameters. Regardless of these differences, climate model projections have consistently pointed to increased temperatures in Minnesota in the future.

Also, Minnesota has observed an increasing number of days with high dew point temperatures. The dew point temperature is the temperature to which the air must be cooled at constant pressure for it to become saturated.[15] The higher the dew point temperature, the greater the amount of moisture in the air. Some people may be more familiar with the term 'relative humidity' to describe the amount of moisture in the air. Relative humidity is the ratio of the amount of water vapor in the air at a specific temperature to the maximum amount that the air could hold at that temperature (e.g., dew point temperature), expressed as a percentage.[16] The same amount of water vapor in the air will yield a different percentage of relative humidity if the air temperature changes; whereas, the dew point temperature will stay the same for the same amount of water vapor. The dew point temperature is always lower than or equal to the air temperature. When the dew point temperature equals the air temperature, the relative humidity is 100% (i.e., the air is saturated). During the summer, the dew point temperature, not the relative humidity, is usually a better measure of how humid it feels outside.[18]

People accustom to continental climates (e.g., Minnesotans and Midwesterners generally) often begin to feel uncomfortable when the dew point temperature reaches between 65 and 69°F. Most inhabitants of these areas will consider dew points above 75 °F extremely uncomfortable or oppressive.[18] Higher dew point temperatures and humidity directly impact people's health by making it more difficult for people to cool themselves. The human body cools itself through four different mechanisms: radiation, evaporation, convection and conduction.[19] See Chapter 4, "Definitions," for a description of the four mechanisms. One of the main cooling mechanisms used during the summer is evaporation. The body perspires and the perspiration evaporates into the air, cooling the body. When evaporation is inhibited by additional humidity, perspiration does not evaporate easily off the skin, which reduces the ability of people to cool themselves.

High dew point and air temperatures combine to create dangerous conditions for human health. The heat index uses air temperature and relative humidity to determine how humans perceive ambient temperature. When humidity is high, the air temperature can be lower and still negatively affect human health. For a more detailed description of the heat index and combinations of temperature and humidity that are harmful to human health, see Appendix A.



Source: Dr. Mark Seeley, Climatologist, University of Minnesota

The chart "Twin Cities Annual Number of Days Where Dewpoint Temperatures => 70 degrees F" shows the trend line (dashed red line) of the number of days where the maximum dew point was greater than or equal to 70°F in the Twin Cities from 1945 to 2010. The slope of the line suggests that the number of days with a dew point temperature greater than or equal to 70°F may be increasing by 0.53 days per decade. The dashed blue line suggests that the numbers of days with a dew point at 1800 hours (i.e., 6PM) equal to or greater than 70°F may be increasing 0.16 days per decade. Dew point temperatures were historically collected only at 1800 hours because dew point temperature was collected manually and 1800 hours was often the time of day with the highest dew point.

Prior to 2011, the highest dew point temperature ever recorded in the Twin Cities was 81°F on July 30, 1999. On July 19, 2011, the dew point temperature reached 82°F in the Twin Cities.[20] On that same day, the state record dew point temperature was reached in Moorhead, Minnesota with a dew point temperature of 88°F.[21] The only other spot in the Western Hemisphere with a dew point temperature in the 80s that day was in the Amazon Jungle in South America.

Researchers of a report focusing on predicting climate changes in the Great Lake region ran a global climate model to estimate temperature extremes in the Great Lakes region through 2100. The climate model predicted that the number of hot days each summer would increase throughout the period, with many years during the last few decades of the century likely to experience 40 or more days exceeding 90°F (32°C).[22] The report surmised that the health impacts of increased days with hotter temperatures are likely to be greatest in urban areas, especially in cities such as such as Minneapolis/St. Paul, where extremely high temperatures have historically been rare.

Based on observed and predicted trends, extreme heat events have a high probability of occurring more frequently in Minnesota. Despite the likely increase in extreme heat events, many counties and cities in Minnesota are not prepared to deal with extreme heat events. Lessening the impact of extreme heat events requires improving the awareness of public health officials and the general public about the health risks of extreme heat events and developing and implementing effective extreme heat notification and response plans.

Defining extreme heat events

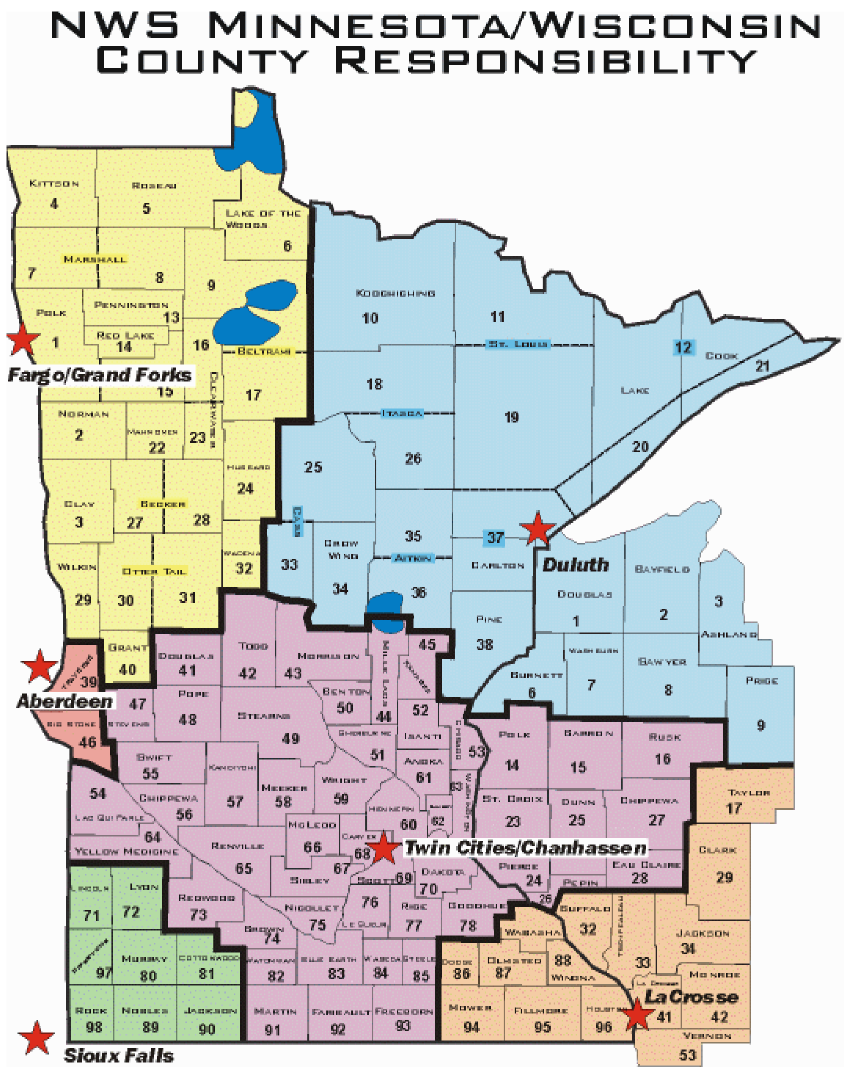
Extreme heat events are characterized by weather that is substantially hotter and/or more humid than average for a particular location at a particular time, especially in the spring and summer. Given the differences between average annual temperatures in St. Paul, Minnesota (45°F), for example, versus the average annual temperatures in Atlanta, Georgia (61°F), it is easy to see that an extreme heat event in Minnesota might not register as an extreme heat event in Georgia.

How hot it feels depends on location, time of year, and the interaction of multiple meteorological variables (e.g., temperature, humidity, cloud cover, wind). Hotter temperatures earlier in the spring are likely to have more detrimental health impacts than the same temperatures later in the summer because people have not had time to gradually adjust to the warmer temperatures.[23] Definitions of an extreme heat event can shift based on location and time of year. Thus, definitions of an extreme heat event need to be sensitive to the variables important for a particular location.

Defining an extreme heat event is important for two reasons. First, the National Weather Service (NWS) needs a definition of extreme heat in order to issue a heat advisory, watch or warning. Second, local jurisdictions need to define an extreme heat event locally to determine if and when a heat response plan should be implemented. The following section describes the NWS stations that cover Minnesota and how the NWS defines extreme heat events. Chapter 3, "Preparing Minnesota for Extreme Heat Events," describes how local jurisdictions define extreme heat events for the purposes of implementing their response plan. Timely forecasting of extreme heat events, transferring the forecast information to the agency responsible for the heat response plan and deciding when to implement the response plan are the first crucial steps in preventing heat-related morbidity and mortality.

There are six NWS stations serving Minnesota. Each NWS station releases heat advisories, watches, and warnings depending on the weather in its own service area. Below is a map of the stations.[24] Note that in some cases, the NWS station serving Minnesota communities may be located in another state.

The NWS defines extreme heat events differently depending on location. One way the NWS defines an extreme heat event is by using NWS's current and forecasted weather reports along with site-specific, weather-based mortality algorithms to identify extreme heat conditions. The NWS Chanhassen office uses the Synoptic Health Watch-Warning Network based on work by Dr. Laurence Kalkstein of the University of Miami and Dr. Scott Sheridan of Kent State University. The network is based on "evaluating the negative health impact of oppressive air masses, as expressed by excess mortality, in each locality. NWS forecast data are compared to historical meteorological conditions that have led to such mortality increases, and advisories, watches, and warnings are indicated accordingly."[25] The network was mainly composed for large cities, which are prone to holding onto heat through the nighttime hours, and thus do not experience a reprieve from the heat.



The NWS Chanhassen office issues watches and warnings for Hennepin and Ramsey Counties and will only issue a watch or warning if both meteorological conditions and the projected mortality data (derived from the Synoptic Health Watch-Warning Network) indicate an extreme heat event. For other areas of Minnesota, heat advisories, watches and warnings are issued based on a set of temperature thresholds over a certain period of time. See Table 1 below for definitions of heat advisories, watches and warnings for Hennepin and Ramsey Counties and all other counties in Minnesota.

Table 1: Definitions of heat watch, advisory, and warning[1]

	In Hennepin/Ramsey Counties	Outside Hennepin/ Ramsey Counties
Excessive Heat Watch		
Excessive Heat Watches are issued when conditions are favorable for an excessive heat event in the next 12 to 72 hours. A Watch is used when the risk of a heat wave has increased but its occurrence and timing is still uncertain. A watch provides enough lead time so that those who need to prepare can do so, such as city officials who have extreme heat response plans.	In Hennepin and Ramsey counties a heat watch is defined as: Maximum heat index at Minneapolis/St. Paul International Airport is expected to reach 100°F or greater for 1 day, or the maximum heat index is expected to reach 100°F or greater and an overnight low temperature no cooler than 75°F for 2 days in a row. In addition, the Heat Watch/Warning System must recommend a watch.	Outside Hennepin and Ramsey counties a heat watch is defined as: Maximum heat index reaches 105°F or greater and a minimum heat index of 75°F or greater for at least 48 hours.
Heat Advisory		
Heat Advisories are issued when an extreme heat event is expected in the next 48 hours. These statements are issued when an extreme heat event is occurring, is imminent, or has a very high probability of occurring. An advisory is for less serious conditions that cause significant discomfort or inconvenience and, if caution is not taken, could lead to a threat to life and/or property.	In Hennepin and Ramsey counties a heat advisory is defined as: Maximum heat index at Minneapolis/St. Paul International Airport is expected to reach 95°F or greater for 1 day, or the maximum heat index is expected to reach 95°F or greater and an overnight low temperature no cooler than 75°F for 2 days in a row.	Outside Hennepin and Ramsey counties a heat advisory is defined as: Maximum heat index reaches 100°F and/or the maximum temperature reaches 95°F or higher.
Excessive Heat Warning		
Excessive Heat Warnings are issued when an extreme heat event is expected in the next 48 hours. These statements are issued when an extreme heat event is occurring, is imminent, or has a very high probability of occurring. A warning is used for conditions posing a threat to life or property.	In Hennepin and Ramsey counties a heat warning is defined as: Maximum heat index at Minneapolis/St. Paul International Airport reaches 100°F or greater for at least 1 day. In addition, the Heat Watch/Warning System, a tool develop based on research, must recommend a warning. A warning may also be issued if advisory criteria are expected for 4 days in a row.	Outside Hennepin and Ramsey counties a heat warning is defined as: Maximum heat index reaches 105°F or greater and a minimum heat index of 75°F or greater for at least 48 hours. A warning may also be issued if advisory criteria are expected for 4 days in a row.

[1] National Weather Service (2012)

Definitions of extreme heat events should be reviewed regularly to ensure that they are and continue to be applicable to the locality and responsive to actual health impacts. As average temperatures in Minnesota continue to climb, Minnesotans may start to acclimate to warmer summers. The NWS may consider revising its heat advisory, watch and warning definitions every few years based on more current historical meteorological conditions and evidence of heat-attributable adverse health impacts.

Local government staff, public health professionals and other organizations that participate in planning and/or providing services for preventing heat-related illnesses should identify the NWS station for their jurisdiction and build relationships with the NWS staff to ensure receiving the most current information available on predicted extreme heat events.

Minnesota recently broke several heat-related records. During the summer of 2011, there were five heat episodes in Minnesota that were worthy of issuing heat advisories or warnings. The worst heat event occurred during the heat wave of July 16-20, 2011. On July 19, a record state dew point temperature was set in Moorhead at 88°F. The air temperature was 93°F, creating conditions that made it feel like almost 130°F. On that same day, the Twin Cities experienced an all-time high dew point of 82°F with an air temperature of 95°F. The combined hot air and high dew point temperatures created a heat index of almost 119°F.[26]

Extreme Heat Events and Public Health

Extreme heat events can cause a range of health problems from relatively minor health issues, such as a heat rash, to life-threatening conditions, such as heat stroke. Extreme heat can aggravate some chronic diseases and can increase formation of certain air pollutants that can affect people's health. Everyone is susceptible to heat-related illnesses, but some people may be more susceptible or 'at risk' for a heat-related illness because of factors that increase exposure to the extreme heat and/or affect their ability to stay cool. The following chapter reviews heat-related illnesses and the characteristics or risk factors that increase the risk of experiencing morbidity and/or mortality from extreme heat.

Health issues caused by extreme heat

The body needs to maintain an internal temperature of 98.6°F to function properly. When it is hot outside, the body becomes challenged to stay cool. When the internal temperature rises, the human body's ability to perform critical functions becomes impaired and a person becomes susceptible to serious adverse health effects.

Extreme heat events can cause a range of health problems from relatively minor health issues, such as a heat rash, to life-threatening conditions, such as heat stroke and ultimately death. Heat exhaustion is the most common heat-related illness.[27] Signs and symptoms of heat exhaustion include dizziness, thirst, fatigue, headache, nausea, visual disturbances, weakness, anxiety, confusion, and vomiting.[28] Treatment involves monitoring the person in a cool, shady environment and ensuring adequate hydration. Untreated heat exhaustion can progress to heatstroke, which can be fatal. See Table 2 on pages 2-3 and 2-4 for a list of some of the medical conditions directly attributable to excessive heat exposure along with recommended responses.

Exposure to extreme heat can aggravate already existing conditions.[29] An analysis of hospital admissions in Chicago during the July 1995 heat wave estimated that the heat wave was responsible for over 1,000 excess hospital admissions, particularly among people with pre-existing diabetes, respiratory illnesses, and nervous system disorders.[30] Another study found that elevated air temperatures were associated with short-term increases in cardiovascular-related hospital admissions for 12 US cities.[31] For a detailed description of pre-existing diseases/conditions that can increase the risk of heat-related illnesses and deaths, see the next section, "Characteristics that increase the risk of heat-related illnesses."

There is growing evidence that the effects of extreme heat events on mortality are larger during high ozone and high particulate matter (PM10) days. Ozone is formed by the reaction of volatile organic compounds (VOCs) and nitrogen oxide (NOx) in the presence of sunlight and is highly sensitive to temperature.[32] Research indicates a strong association between temperatures above 90°F and ground-level ozone formation.[33] Ground-level ozone and high air temperatures have been associated with increased mortality.[34] Ground-level ozone exposure can cause harmful cardiopulmonary health effects, including lung irritation, breathing difficulties, reduced lung capacity, aggravated asthma, and increased susceptibility to bronchitis.[35] Populations at risk to ozone exposure include outdoor workers in landscape and construction, and adults and children who are performing strenuous outdoor exercise and play.[36]

Similarly, during an extreme heat event, mortality is greater on high PM10 days. The interaction of heat days and PM10 seems to more significantly affect the elderly.[37] Exposure to PM can aggravate chronic respiratory and cardiovascular diseases, and several studies suggest that the elderly and children may be particularly affected by PM.[38]

Table 2: Heat illnesses and their symptoms[1,2,3]

Medical Condition	Symptom(s)	Causes	Safety Tips
Heat rash	• Red cluster of pimples • Blisters • Itching • Red rash on the skin that usually occur on the neck, chest, breast and/or groin	• Blockage of sweat ducts	Remove the affected person from heat. Minimize exposure of skin to sun. Keep the affected area dry. Seek medical attention if rash does not improve.
Heat edema	• Swelling in the ankles, feet and hands • Body temperature normal or elevated core temperature up to 104° F	• Occurs in persons who are not acclimatized to heat • Increased blood flow to the skin in limbs	Elevate and apply compressive stockings to the affected limbs.
Heat tetany	• Respiratory problems, such as breathing difficulty • Muscular problems, including spasms or numbness or tingling of muscles • Body temperature normal or elevated core temperature up to 104° F	• Hyperventilation • Respiratory alkalosis	Remove the affected person from the heat and advise the person to breathe slowly.
Heat cramps	• Muscle spasms • Muscles usually affected include the abdomen, calf, thighs and shoulder muscles • Body temperature normal or elevated core temperature up to 104° F	• Drinking liquid without electrolytes • Dehydration • Electrolyte deficiency	Stop all activities, relocate to a cool location, rest and drink electrolyte containing fluids. Seek medical attention if symptoms persist.
Heat syncope	• Dizziness • Fainting • Body temperature normal or elevated core temperature up to 104° F	• Increased blood flow to the skin resulting in decreased blood flow to the central nervous system	Lay the affected person gently on the floor and provide lots of fluid. Seek medical attention.
Heat exhaustion	• Profuse sweating • Weakness • Rapid breathing • Dizziness • Nausea/vomiting • Muscle cramps • Normal mentation • Body temperature normal or elevated core temperature up to 104° F	• Drinking liquid without electrolytes • Dehydration • Electrolyte deficiency	Stop all activities, relocate to a cool location, rest and drink electrolyte containing fluids. It can be difficult to determine if someone has heat stroke and not exhaustion. If symptoms do not quickly improve, or unable to oral rehydrate, seek medical attention.

Heat stroke *This is a life threatening, adverse effect of exposure to extreme heat, usually occuring when the body temperature is greater than 104˚F.*	• Oral body temperature of 104˚F and above • Often sudden onset of symptoms • Confusion or loss of consciousness • Rapid and strong pulse • Hot, red and dry skin • Headache • Dizziness • Nausea/vomiting	• Profound dehydration • Profound electrolyte deficiency • Body is unable to maintain heat diffusion through the skin • Normal regulation of body temperature is no longer intact • Mortality can be as high as 50%	Call 911 immediately if you see anyone with these symptoms and has a body temperature of 104˚F and above. While waiting for first responders, the affected person should be taken to a cool shady area. Cool the person with immersion in cool water, spraying the person with cool water while fanning the person vigorously, or placing ice packs on neck, axilla, and groin. The person is unlikely to be able tolerate oral fluids.

[1] Centers for Disease Control and Prevention. (2006). Frequently Asked Questions (FAQ) About Extreme Heat. Retrieved April 17, 2012, from http://www.bt.cdc.gov/disasters/extremeheat/faq.asp.

[2] Platt, M. and Vicario, S. (2010). Heat Illness. In Rosen's Emergency Medicine: Concepts and Clinical Practice, 7th Ed. p1882-3.

[3] Zimmerman JL, Hanania NA. (2005). Chapter 111. Hyperthermia. In: Hall JB, Schmidt GA, Wood LD, eds. Principles of Critical Care. 3rd ed. New York: McGraw-Hill.

In addition to direct health impacts, extreme heat events can result in increased use of energy, power outages, damage to highways and roads, and an increase strain on the provision of available essential services like emergency hospital services, ambulance services and security.[39] The heat wave that hit Minnesota in July of 2011 left 750 Excel energy customers without power in the seven-county metropolitan area and killed livestock throughout the state. "The stress on farm animals caused a die-off worse than some growers have seen in nearly 30 years," said Byron Hogberg, Farm Services Administration Director in Renville County in southwestern Minnesota.[40]

Characteristics that increase the risk of heat-related illnesses

Everyone is susceptible to illnesses due to extreme heat; however, certain characteristics can increase a person's risk. Demographic characteristics, social/behavioral factors, and geography/location may affect the ability of an individual to maintain normal body temperature and stay hydrated. Certain populations may have more than one characteristic/risk factor that could put them at increased risk. Below is a review of characteristics that increase the risk of experiencing morbidity and/or mortality from extreme heat. (For a quick reference of characteristics that increase the risk of heat-related illnesses, see Table 3 on page 2-5.) Identification of populations that are more vulnerable to extreme heat events is useful for targeting limited resources to people who need additional aid during an extreme heat event and an important strategy for preventing negative health outcomes from extreme heat. For more information on mapping vulnerable populations and risk factors for extreme heat events, see the Chapter 3, "Preparing Minnesota for Extreme Heat Events."

Demographic characteristics

Age-Older adults: Persons 65 years old or older are more vulnerable to negative health outcomes from extreme heat events than younger adults.[41,42] Additionally, the older the person is the greater the risk for a heat-related illness. A person 75 years old has a greater risk for heat-related illnesses than someone who is 65 years old. Certain physiological changes associated with aging, especially the body's decreased ability to thermoregulate, increase older adults' risk of experiencing heat-related illnesses.[43] Chronic disease conditions and the use of certain medications also may increase older adults' susceptibility to adverse health outcomes from heat.[44] Elderly persons who live alone and/or at or below the poverty line are particularly vulnerable to negative health outcomes from extreme heat because of a combination of factors associated with aging, social isolation, and economic constraints. Older adults are a growing segment of the population. Using the 2010 census data and estimates from the Minnesota State Demographers Officer, it is predicted that the number of people 65 years old and older will increase by 91% in Minnesota by 2030.[45]

Age-Children: Research identifies children, especially children ages five years and younger (including infants), as being at a greater risk for mortality during hot weather.[46,47] Children may be at increased risk due to dependency on other people for their care and/or physiological differences, including smaller body mass to surface area ratio than adults, blunted thirst response, production of more metabolic heat per pound of body weight and lower cardiac output.[48,49] In the US between 1998 and 2011, an average of 38 children (five days old to 14 years old) died per year from being left in a motor vehicle during warm weather. More than half of the deaths are children under two years of age.[50] Temperatures in parked cars

Table 3: Characteristics that increase the risk of heat-related illness
Demographic characteristics, social/behavioral factors, and geography/location may affect the ability of an individual to maintain normal body temperature and stay hydrated.
Demographic characteristics
• Age-Older adults: persons 65 years old or older • Age-Children: children ages five years and younger (including infants) • Economic constraints: persons living at or below poverty line • Persons with pre-existing diseases or mental health conditions • Persons on certain medications
Social/Behavioral factors
• Social isolation: persons living alone, especially the elderly • Prolonged exposure to the sun • Use of alcohol
Geographic/location factors
• Living in urban areas • Lack of air conditioners • Living in top floor apartments • Living in nursing homes/bedridden

can increase quickly even on relatively mild days (i.e., ~ 70°F), especially if the car is parked in the sun.[51,52] Leaving the windows slightly open does not significantly decrease the heating rate.[53] For a short video demonstrating how quickly temperatures can increase in a parked car, see the following website: http://www.nws.noaa.gov/os/heat/index.shtml. Never leave children, infants or pets unattended in a parked vehicle.

Economic constraints: Several studies have demonstrated increased risk of mortality among people with low socioeconomic factors.[54] Persons living at or below poverty line are less likely to have air conditioners in their homes,[55,56] live in deteriorating and substandard homes,[57] and may have difficulty paying for higher electricity bills from increased electricity usage during an extreme heat event. Persons living at or below the poverty line might be more concerned about safety and unwilling or unable to seek cooling centers or open doors and windows to increase circulation.[58] The homeless are at increased risk for illnesses and death due to extreme heat possibly because of limited access to air-conditioned places and underlying medical conditions.

Persons with pre-existing diseases or mental health conditions: Heat can exacerbate existing conditions, putting certain people at increased risk for heat-related illnesses and possibly death. Any condition that affects the body's ability to cool itself or puts additional stress on already compromised systems will make a person more susceptible to negative health effects from heat. Pre-existing conditions that make a person more vulnerable to extreme heat include obesity;[59] cardiovascular disease conditions (e.g., congestive heart failure, myocardial infarction);[60] respiratory disease conditions (e.g., COPD, bronchitis);[61,62] neurological diseases;[63] endocrine disorders (e.g., diabetes mellitus);[64] renal failure; and liver diseases (e.g., liver cirrhosis). Additionally persons with mental illness or intellectual disabilities are at increased risk for negative health outcomes due to extreme heat.[65,66] They may be unable to make rational decisions that would help them recognize symptoms of or limit their exposure to excessive heat.

Persons on certain medications: Persons on certain medications are vulnerable to negative health consequences from extreme heat events. Drugs, such as diuretics, anticholinergics, beta blockers and calcium channel blockers and antipsychotic drugs, make it difficult for the body to dissipate excess heat by interfering with normal thermoregulatory systems. For a complete list of categories of medicines that may increase a person's risk of heat-related illness, see Appendix B.

Social/Behavioral factors

Social isolation: Persons living alone, especially the elderly, are more vulnerable to extreme heat events.[67,68] Socially isolated people may be less likely to recognize the symptoms of excessive heat exposure, less likely to leave their homes if hot, and/or less willing or able to reach out for help from others.

Prolonged exposure to sun: People who are involved in sporting activities or work in outdoor occupations, like farming, landscaping, roofing, and construction, are at an increased risk for heat-related illnesses. These people may be exposed to the sun and extreme heat for longer periods of time and need to take extra precautions to stay cool and hydrated.

Use of alcohol: The consumption of alcoholic beverages during extreme heat events increases the risk of heat-related illnesses. Alcoholic beverages can cause dehydration and depress the thermoregulatory system. In addition, alcohol impairs judgment, influencing a person's ability to make decisions to limit exposure to and recognize symptoms of extreme heat exposure.

Geographic/location factors

Living in urban areas: The urban heat island effect is a measurable increase in ambient urban air temperature and results primarily from the replacement of vegetated land with buildings, roads, and other heat-absorbing and reflecting infrastructure. Urban dwellers are more at risk for heat-related illnesses than rural dwellers because of the urban heat island effect. Urban areas are usually hotter and cool off less at night than rural areas. The annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F warmer than its surroundings. In the evening, the difference can be as high as 22°F.[69] The urban heat island effect is proportional to the size of the city, but all cities, large and small experience the effect. Urban heat islands can increase health risks from extreme heat by increasing the potential maximum temperatures residents are exposed to and the length of time that they are exposed to elevated temperatures.[70] According to the 2000 Census, more than half of Minnesota's population (55%) lives in urban areas.[71] For a map illustrating developed places in Minnesota, see Appendix C of Minnesota's land cover.

Lack of air conditioners: Living in houses without air conditioning and/or not having access to air-conditioned spaces increases the risk of experiencing heat-related illnesses. During periods of extreme heat, air conditioners regulate and cool indoor air temperatures, putting less strain on the body's thermoregulatory system.

Living in top floor apartments: Persons living in top floor apartments are at increased risk of suffering from heat-related illnesses. Hot air rises and is trapped by the roof, so that people who live on the top floors of a building are exposed to higher temperatures.

Living in nursing homes/bedridden: Persons living in long-term care facilities (e.g., nursing homes, assisted living, group homes) and/or are bedridden are at increased risk of suffering from heat-related illnesses. These persons may be at increased risk due to dependency on others for care, and they frequently have underlying medical conditions and take medications that affect their ability to regulate their body temperature.

Preparing Minnesota for Extreme Heat Events

Minnesotan's are more equipped to deal with snowstorms and the extreme cold than extreme heat. Extreme heat notification and response plans are critical to preparing Minnesotans for extreme heat events. Notification systems and plans reflect local conditions and draw upon available local expertise and resources. As a result, local notification and response plans vary. This chapter discusses the key steps in responding to an extreme heat event and how to develop a heat response plan. The chapter also summarizes a range of strategies that can be included in the response plan and used to prevent morbidity and mortality from extreme heat events.

Key Steps for Planning for and Responding to an Extreme Heat Event

The key steps for planning for and responding to an extreme heat event have been summarized in Figure 1 on page 3-3. Below is a detailed description of each step.

Step 1: Create a heat response plan

The first step in preparing to respond to an extreme heat event is to develop a heat response plan. A heat response plan is essential for describing and coordinating activities to prevent heat-related morbidity and mortality. The next section, "Developing a heat response plan," describes the minimum elements of an effective response plan. The response plan should define the lead agency responsible for the plan, criteria for activating the plan, and the roles of agencies and organizations involved with the plan. The plan also should contain a communications plan, identify high-risk and vulnerable persons, describe strategies to prevent heat-related illnesses and deaths, and establish an evaluation process.

Step 2: Predict extreme heat event and transfer information to lead agency

For successful notification of an upcoming heat event, it is critical for the lead agency of the response plan (see the next section for a description of the lead agency) to develop partnerships with the NWS to ensure early weather forecasts capable of predicting extreme heat conditions a few days in advance of an extreme heat event. In Minnesota, the NWS provides weather forecasts and determines the issuance of heat advisories, watches or warnings. Definitions and processes used by the NWS to determine extreme heat events are described in the section, "Defining extreme heat events." All Minnesota jurisdictions involved in planning and implementing heat response plans should develop relationships with their local NWS station to ensure daily monitoring of weather conditions and early detection and transfer of information regarding the characteristics of the upcoming event to the lead agency of the response plan.

Step 3: Assess risk and determine activation of response plan

Once the lead agency is informed of a possible extreme heat event, the agency, in collaboration with its partners, needs to determine if the characteristics are indicative of an extreme heat event that could trigger activation of the heat response plan. Generally, the lead agency reviews the NWS forecast data and health-impact information to determine whether location-specific criteria for an extreme heat event are satisfied, and then, if the conditions are met, the agency activates the plan. Activation of the heat response plan should happen before the extreme heat event occurs to ensure that preventive measures and strategies are implemented at the most opportune time for preventing illnesses and deaths from extreme heat.

Figure 1: Key Steps for Responding to an Extreme Heat Event*

* Although this diagram presents key steps in responding to an extreme heat event as discrete steps, actual details and timing of each step will vary locally. For example, determining the activation of the response plan may happen simultaneously with notifying the public of an impending extreme heat event. The response plan should reflect local conditions and resources and should clearly articulate each step in responding to an extreme heat event, along with the agencies and organizations that are responsible for implementing each step of the process.

Step 4: Activate response plan and notify the public

Assuming the impending heat event meets location-specific criteria for an extreme heat event, the lead agency activates the response plan. Immediately after a decision has been made to activate the extreme heat response plan, the public needs to be informed of the timing, severity and duration of the forecasted extreme heat event. Effective public notification of an upcoming extreme heat event helps eliminate the risk of the heat event taking a population by surprise. Notifying the public of anticipated conditions, strategies to stay cool and hydrated, and places to go to cool off will enable residents to prepare themselves and will enable the organizations involved in the response to concentrate on known high-risk individuals and locations. Advance public notification about the cooling centers (if used as a strategy) will increase the likelihood that at-risk individuals can take advantage of these services. All messages regarding an upcoming extreme heat event should be coordinated with media outlets to ensure the public receives consistent and accurate information. The communications strategy should be described in detail within the heat response plan.

Step 5: Implement response plan

The fifth step in responding to an extreme heat event is to implement the strategies in the response plan. The strategies should reflect the demographics and vulnerabilities of the community. See the next two sections for detailed descriptions of several strategies that can be inserted into the response plan. The response plan should clearly delineate which participating agencies and organizations are responsible for implementing each strategy.

Step 6: Evaluate response plan

Each step of responding to an extreme heat event should be reviewed and evaluated after an extreme heat event. Evaluation is critical for improving the plan and making it more effective for preventing heat-related illnesses and deaths in the future.

Developing a heat response plan

Heat response plans have been shown to be effective in reducing heat-related mortality.[72] Heat response plans describe in detail the roles and actions of government agencies and nongovernmental organizations for preventing morbidity and mortality from an extreme heat event. Each city or county in Minnesota should have a heat response plan. The level of detail and the number of strategies in the plan will vary based on available resources, geographic location, agencies and organizations involved in planning and responding, and the types and distribution of vulnerable populations. For a draft heat response plan that can be modified and adapted to a local jurisdiction, see Appendix D.

All Response Plans Should Contain the following Elements:[73]

<u>Lead agency</u>: A lead agency for implementing the extreme heat response plan should be identified. Typically, a health department or emergency management is the lead agency in charge of responding to extreme heat events, but this can vary at the local level. The lead agency will activate the plan and help coordinate the efforts of organizations involved in the response.

Criteria for activating and deactivating the plan: Criteria for activating and deactivating an extreme heat response plan vary and should be based on location-specific factors that affect the relationship between weather and mortality. These factors may include air temperatures, dew point temperatures, wind, daytime highs and overnight lows, and how long the hot weather is expected to last. Some public health departments have their own thresholds and calculations that include health-related criteria for extreme heat events. Others use the NWS criteria for activation. See the box below for how the City of Minneapolis determines activation of their heat response plan.

Minneapolis Department of Health and Family Support Activation of Heat Response Plan
The Minneapolis Department of Health and Family Support reviews information from the Synoptic Health Watch-Warning Network to assess the health risks for an upcoming heat event. The integrated heat health watch/warning system uses meteorological forecast data as inputs into a health impact model. The program identifies when forecast conditions may result in excess mortality and estimates the potential number of heat-attributable deaths. This information is used by Minneapolis to determine activation of the heat response plan and the type and scope of response activities that will be implemented.

Roles and activities of agencies and organization involved with the plan: Implementation of a heat response plan requires close collaboration between government agencies (e.g., local public health department, city/county emergency management, NWS, tribal health departments) and non-governmental organizations, especially organizations that serve the community and vulnerable populations (e.g., the American Red Cross, Meals on Wheels, Salvation Army). Engaging local organizations that work with vulnerable populations in planning and implementing the response plan will make it easier to identify appropriate strategies for the vulnerable populations in the community. Additionally, these organizations are most likely to perform successful outreach and strategies targeted to specific populations. The plan must clearly articulate the roles and responsibilities of all the organizations involved in the plan.

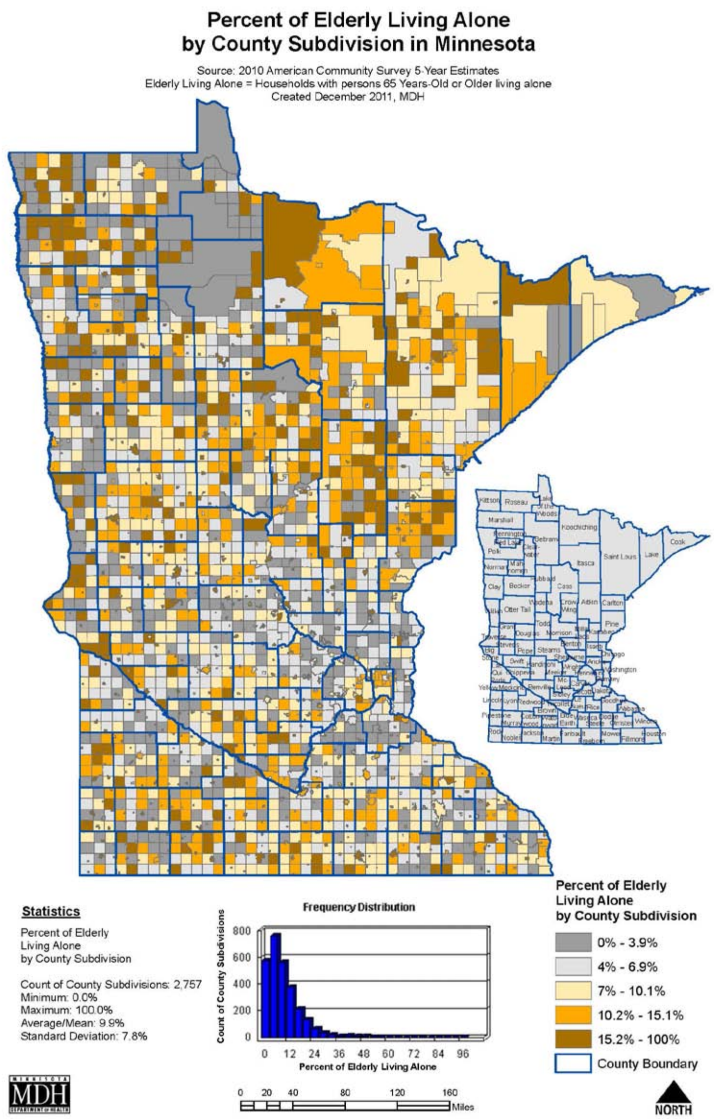
Communications plan: The communications plan needs to articulate communication strategies both between partners involved in the response plan and with the public. There should be frequent communication between the NWS, the lead agency in charge of the response plan and other collaborating agencies and organizations. Additionally, the plan should identify communication strategies for communicating heat-related information before and during an extreme heat event. For example, the lead response agency, in coordination with other partner organizations, should coordinate extreme heat education/awareness campaigns in their communities in the spring before a heat event to help prepare and educate residents of the dangers of extreme heat.

In addition to messages to the public, information should be provided to organizations/companies that have at-risk populations (e.g., young children, outdoor workers, elderly) and may include the following: schools, daycares, landscape/construction businesses, sports teams/camps, and senior living facilities. Messages should include information on what to do (e.g., how to prevent illnesses from extreme heat) (see Appendix E for a tip sheet), symptoms of heat-related illnesses (see Table 2 on page 2-3), characteristics of persons more vulnerable to extreme heat (see Table 3 on page 2-5), and where to go for more information. Messages may be transmitted through a variety of media outlets, including television, radio, internet, and distribution of fliers and posters. Messages should be tailored, translated and sensitive to the demographics and population of the area. For example, translations of tip sheets for individuals could be translated into the top five languages spoken in Minnesota, in addition to English, which are Spanish, Hmong, Somali, German and Vietnamese.[74] The communications plan should be developed before the heat event and updated after the event using lessons learned from implementing the plan.

Identification of vulnerable persons: Quantifying and mapping vulnerable populations and other risk factors provide important information for planning and implementing appropriate strategies that reach the most vulnerable members of a community. The lead response agency or another entity should create data summaries and/or maps to identify the most vulnerable populations in their community and where the populations reside, so that appropriate preventative actions and strategies for these populations can be determined before an extreme heat event. See the section, "Characteristics that increase the risk of heat-related illnesses," for more information on characteristics to map.

MDH created a suite of resources to aid local public health departments in locating their community's vulnerable populations. The suite includes the following resources:

1. Statewide maps of five vulnerability characteristics:
    a. Percent of population 65 years old and older
    b. Percent of population less than 5 years old
    c. Percent of population 65 years old and older living alone (see image on the right)
    d. Percent of population living below the poverty level
    e. Percent of population living below 200% of the poverty level.



These maps can be found online with an Excel spreadsheet that contains tabulated data at: http://www.health.state.mn.us/divs/climatechange/extremeheat.html. The data described in the state maps are at the county subdivision level (e.g., city, township, or unorganized territory).

2. A list of data sources for vulnerable populations and risk factors identified in the section "Characteristics that increase the risk of heat-related illnesses." The list links the characteristics

to appropriate data sources. Two types of data sources are referenced in the list: a source that contains summarized/tabulated data at the county level, and another source that contains raw data for lead agencies that may want to create maps or summaries at smaller geographic levels, such as cities or census tracts. The list of data sources can be found in Appendix F.

3. A GIS primer that describes how to use GIS to create maps of vulnerable populations and risk factors. This resource has been developed for local public health professionals and planners who already have some knowledge of ArcGIS software. It walks users through the process of joining data to shapefiles and how to display the joined data using quintiles. The primer on mapping vulnerable populations and certain risk factors can be found in Appendix G.

In 2011, MDH worked with the Minneapolis Department of Health and Family Support to develop a set of maps to help identify vulnerable populations and environmental characteristics that could aid with implementing strategies to prevent heat-related morbidity and mortality. The set of maps can be found in Appendix H. The partnership helped identify additional factors that are important for planning for extreme heat events, including mapping the locations of public air-conditioned buildings, the percentage of residential units with central air-conditioning, special residential buildings such as nursing homes and group homes, and impervious surfaces within the community. In one instance, by geographically identifying where cooling centers/cool buildings are located and comparing those locations with where vulnerable populations reside, public health staff were able to identify places that needed additional resources and were able to site cooling centers or other resources in places that were easily accessible to the at risk populations. The Minneapolis maps are meant to provide an example of some of the additional types of characteristics that may be helpful to review when planning for an extreme heat event. Local jurisdictions may discover other important characteristics to map as they develop the best strategies for their community.

Evaluation: Response plans should be reviewed and evaluated after an extreme heat event. Modifications to the plan should address lessons learned and changes in local conditions. This ensures continuous quality improvement and rectifies any challenges or mistakes observed from implementing the plan during previous events. The agencies and organizations involved in responding to the extreme heat events should partake in the evaluation process. Records on heat-related morbidity and mortality that occurred during the extreme heat event also should be collected, analyzed and used to adjust strategies and/or criteria for activating the heat response plan.

Additional strategies to prevent heat-related illnesses

In addition to those essential elements described above, there are more strategies that may be included in a local heat response plan. Not all of the following strategies will be feasible or appropriate for every location. The best strategies for any given jurisdiction utilize local resources and are tailored to the at-risk populations within the community. For a listing of some of the strategies that have been implemented in Minnesota, see Table 4 on page 3-10, which provides a checklist of response plan elements and strategies and demonstrates activities performed by Olmsted County Public Health Services and the Minneapolis Department of Health and Family Support to prevent morbidity and mortality from extreme heat. For a detailed case study of strategies and lessons learned by Olmsted County Public Health Services, see Appendix I.

Coordinate distribution of information on heat exposure symptoms and tips on how to stay cool for public broadcasts: Educating the public and communicating prevention information to them before and during an extreme heat event is critical to reducing illnesses and deaths due to extreme heat exposure. Publicly broadcasting cooling tips and symptoms of excessive heat exposure should complement broadcasts about the extreme heat conditions and help residents respond to the heat appropriately (e.g., stay well-hydrated, seek air-conditioned locations, minimize direct sun exposure). See Appendix J for a sample press release. A tip sheet for staying cool can be found in Appendix E.

Disseminate information related to preventing heat-related illnesses to community organizations and facilities with concentrations of high-risk individuals: Developing a database/list of facilities (e.g., those with mobility/health impaired residents) and organizations that serve vulnerable populations and their locations aids prioritization of prevention efforts to populations vulnerable to extreme heat and facilitates dissemination of extreme heat information to the organizations that serve these populations through faxes, emails, and/or telephone contact trees. For example, nursing homes and senior living centers that might not have air conditioning should be contacted and provided information to ensure that their populations are staying cool and are being assessed for symptoms of overexposure to heat.

Activate a heat line: An emergency heat line provides real-time advice and information during extreme heat events that can help prevent heat-related illnesses. A heat line can be activated when the response plan is activated or heat-related messages can be incorporated into more general, full-time systems (e.g., 211 line). In much of Minnesota, the United Way supports a 211 line that provides information to people during an extreme heat event. The Minneapolis Department of Health and Family Support utilizes the city's 311 information line to disseminate heat event information and track the number of calls coming in related to extreme heat issues. Monitoring heat line calls and 911 calls made during an extreme heat event can provide information about how well the community is adapting to the heat. A reverse 911 call system can be activated, so that numbers that call 911 during an extreme heat event can be dialed and notified of current information on weather forecasts and safety measures.

Identity and designate buildings with air conditioning as public cooling centers and extend hours of operation: Spending time in an air-conditioned building during an extreme heat event is one of the most effective means of reducing a person's risk of developing a heat-related illness. Work with partners to identify and designate specific public or private buildings with air conditioning as official cooling centers. If possible choose buildings with back-up generators for cooling centers. Cooling centers should be ADA accessible and monitored by appropriate staff. Information on providing full access to a cooling center can be found in Chapter 7 of the *ADA Best Practices Tool Kit for State and Local Governments*, available online at: http://www.ada.gov/pcatoolkit/toolkitmain.htm. Extending the hours of operation of the cooling centers increases the opportunity for high-risk individuals to spend time in an air-conditioned environment. Providing free public transportation to cooling centers helps individuals who may have limited access to transportation and financial resources to reach the center.

Work with the public and private sector to allow public gathering at buildings with air conditioning and extend hours of operation: Minnesota has had varying degrees of success with opening public cooling centers. See Appendix I for a description of Olmsted County Public Health Services experience with providing cooling centers. Allowing the public to congregate freely at air-conditioned places where they already frequent, such as shopping malls, libraries and movie theaters, can increase the use of air-conditioned buildings and minimize negative health impacts. Agreements should be made with the owners of these buildings before announcements are made to the public about visiting the facilities. Many of the people who are at greatest risk for negative health effects from an extreme heat event may regularly visit specific air-conditioned locations and may be more likely to go to these places versus a cooling center. Hours of operation of public spaces, such as libraries and public swimming pool, may be extended to increase accessibility for working families. Providing free public transportation to cool places during an extreme heat event helps individuals who may have limited access to transportation and financial resources to reach a cool destination.

Outreach to vulnerable populations: Some high-risk individuals (e.g., elderly living alone, homeless persons) need to be contacted directly, and, preferably, observed several times a day during an extreme heat event to ensure that cooling tips are being followed (e.g., fluids are being consumed, appropriate clothing is being worn) and that any symptoms of overexposure are recognized and alleviated as early as possible. Depending on local resources, persons involved in the outreach process can include the following: social and health workers, volunteers, church organizations, other nongovernmental agencies, and the police. Additional efforts must be made to outreach and evaluate the homeless. Increased outreach efforts should be supported by authorizing officials to move individuals believed to be experiencing medical difficulties or at extreme risk to cooling shelters for observation and treatment.[75]

Arrange for extra staffing of emergency support services: Extreme heat events place additional burdens on emergency medical and social support services through increased use of these services. Increasing staffing helps avert any crises that may arise from the systems becoming overwhelmed. Hospital administrators should be encouraged to prepare for increased patient loads during extreme heat events.

Suspend utility shutoffs and provide transportation and financial assistance: Local governments should develop partnerships and/or policies to prevent power and water companies from shutting off services to their customers due to nonpayment of bills during extreme heat events. Drinking water, taking cool baths/showers and using air conditioners are some of the most effective ways of preventing heat-related morbidity and mortality. Free bus passes and/or other subsidized means of transportation to cooling centers also should be provided to low-income people. Vouchers for buying air conditioners and financial aid for electricity bills are other ways of providing assistance to low-income people.

Provide water at public places: Providing sources of clean potable drinking water at strategic locations in public places (e.g., parks, malls and cooling centers) enhances people's ability to stay hydrated.

Reschedule outdoor public events when possible: Developing and implementing policies that identify when large outdoor events or activities (e.g., sports games, outdoor camps, concerts) should be canceled or rescheduled due to extreme heat can help prevent heat-related illnesses. To the extent that local officials can control these events (e.g., through permits or use of facilities), efforts should be taken to reschedule an event or, when rescheduling is not feasible, require water stations, medical staff and/or "cool zones" for attendees.

Provide information to pet owners on protecting their pets from extreme heat: Some pet owners are reluctant to leave their homes to go to a cool place if they cannot bring their pets with them. Providing messages to pet owners on tips for keeping their pet cool and hydrated can help to alleviate their anxiety. Also, pet owners can be encouraged to call their veterinarian if they have any specific concerns. If possible, identify a local cool place that may be willing to accept people and their pets.

Table 4: Checklist of response plan elements and strategies implemented by Olmsted County and the City of Minneapolis

Strategies	Olmsted County	City of Minneapolis
Response Plan Elements[1]		
Lead agency responsible for the response plan	✓	✓
Criteria for activating and deactivating the plan	✓	✓
Assigned roles and activities of agencies and organization involved with the plan	✓	✓
Communications plan for communicating heat-related information to partners and the public before and during an extreme heat event		✓
Identification of vulnerable persons	✓	✓
Strategies for preventing morbidity and mortality from extreme heat (see below)	✓	✓
Evaluation of the response plan	✓	✓
Response Plan Strategies		
Prediction		
Establish partnership with local National Weather Service (NWS) station to ensure access to weather forecasts capable of predicting extreme heat conditions a few days in advance of an event	✓	✓
Ensure timely transfer of weather forecasts to lead agency	✓	✓
Assessment, Activation and Notification		
Review activation criteria based on predicted meteorological characteristics and health impacts and determine activation of the response plan	✓	✓
Coordinate distribution of information about the anticipated timing, severity, and duration of extreme heat event; heat exposure symptoms; and tips on how to stay cool during an extreme heat event for public broadcasts	✓	✓
Implementation		
Disseminate information related to preventing heat-related illnesses to community organizations and facilities with concentrations of high-risk individuals	✓	✓
Activate a heat line		✓
Identify and designate buildings with air conditioning as public cooling centers and extend hours of operation	✓	✓
Work with the public and private sector to allow public gathering at buildings with air conditioning and extend hours of operation		✓
Outreach to vulnerable populations	✓	✓
Arrange for extra staffing of emergency support services		✓

[1] Table and strategies adapted from U.S. Environmental Protection Agency. 2006. Excessive heat events guidebook. www.epa.gov/heatisland/about/heatguidebook.html.

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Response Plan Strategies (cont.)		
Suspend utility shutoffs and provide transportation and financial assistance	✓	✓
Provide water at public places		
Reschedule outdoor public events when possible	✓	✓
Provide information to pet owners on protecting their pets from extreme heat		
Prepare strategies for a power outage		
Evaluation		
Evaluate heat response plan after implementation	✓	✓
Mitigation		
Support and promote programs and policies to reduce effects of urban heat islands		

Chapter 3

Prepare strategies for a power outage: If a wide-spread power outage occurs during an extreme heat event, air conditioning may be unavailable. Ideally, messages regarding tips on how to stay cool and hydrated have already been provided to the public and vulnerable populations. People who do not want to leave their homes and are without air conditioning should be encouraged to drink plenty of water and take cold baths or showers to cool off. Buildings where vulnerable populations reside, such as hospitals, nursing homes, etc. may want to consider buying a back-up generator to ensure that their building will stay cool if there is a power outage.

Mitigation/adaptation to extreme heat

It is important to support and promote programs and policies to reduce effects of urban heat islands. Although strategies to reduce the urban heat island effect typically are not included within a response plan, they are important for long-term adaptation to climate changes and to help reduce the severity and duration of urban residents' exposure to high-heat conditions.[76] Programs and policies that increase urban vegetation, especially shade trees, and encourage the use of cool building materials can help reduce the urban heat island effect. Some strategies that help reduce the urban heat island effect can provide multiple health benefits. For example, green roofs can help reduce the urban heat island effect, can help capture and clean stormwater, and can provide a green space for mental health benefits for people in the city.

Training and resources for extreme heat

MDH created a training module on extreme heat and public health for local government staff and public health practitioners. The training module provides a basic overview of extreme heat and its impacts on public health and contains some of the information within this document. The training was created as a PowerPoint presentation with detailed notes so that professionals could use the presentation to train others on extreme heat and public health. A copy of the presentation with detailed notes can be found on the MDH website at: http://www.health.state.mn.us/divs/climatechange/extremeheat.html.

MDH developed a list of links to additional online resources. Appendix K provides a listing and brief description of several websites that contain additional information on extreme heat events.

Definitions

Below are definitions of words, phrases and terminology used within the Minnesota Extreme Heat Toolkit. It is important to note that some of the below definitions may differ outside the context of this toolkit. The definitions below clarify the usage of these words within the toolkit.

At risk

People who are "at risk" are people who are at an increased risk for heat-related illnesses because they have certain risk factors, e.g., young children, people with pre-existing conditions or diseases.

Extreme heat event

An extreme heat event is a period of time with abnormally high air temperatures and/or high dew point temperatures that affect human health. An exact definition of an extreme heat event varies by geographic location.

Extreme heat response plan/excessive heat annex

A plan/annex for states, communities, governments, etc. to use in the event of an extreme heat event and contains information on strategies for preventing heat-related illnesses and identifies who will perform the strategies.

Modified from: http://www.getreadyforflu.org/pg_glossary.htm

Risk factor

A risk factor is a characteristic that is statistically associated with, although not necessarily causally related to, an increased risk of morbidity (i.e., illness, disease, or condition) or mortality (i.e., death). For example, age is a risk factor for heat-related illnesses.

Modified from: http://dictionary.webmd.com/terms/risk-factor

Vulnerable population

Subpopulations who are at increased risk of heat-related illnesses because they have certain risk factors.

Modified from: http://www.hc-sc.gc.ca/dhp-mps/homologation-licensing/gloss/index-eng.php

Ways the human body loses heat

The human body loses heat in four different ways:[1]

1. Radiation – transfer of heat through electromagnetic waves (i.e., the body releases heat simply by being in an environment cooler than the body temperature). This is similar to heat leaving a woodstove. Radiation is a normal process of heat moving away from the body when air temperatures are lower than 68°F. [2]

[1] Platt M and Vicario S. (2010). Heat Illness in Rosen's Emergency Medicine: Concepts and Clinical Practice, 7th Ed. p1882-3.

2. Evaporation – conversion of liquid into a gas, which transfers heat energy to the gas and away from the skin (i.e., the body sweats and the evaporation of the sweat from the skin cools the body). During intense exercise, the body loses 85% of its heat through sweating.[2]

3. Convection – direct transfer of heat to water vapor molecules surrounding the skin. Heat is carried and dispersed from the body due to fluid motion. This is similar to sitting in front of a fan.[2]

4. Conduction – transfer of heat to air or water surrounding our bodies. Heat is lost when temperatures are lower than 68°F. This is heat lost from sleeping on the cold ground or when the body is submerged in water. Water causes more heat loss than air, so heat can be lost from the body very quickly when it is placed in cold water.[2]

As air temperature and humidity increases, the ability to cool the body through radiation is dramatically reduced. Under direct sunlight, heat is actually transferred back to the skin, reversing the process of heat transfer and warming the body. As air temperature rises, evaporation becomes the dominant mechanism of heat transfer through sweating; however as humidity increases, the ability to transfer heat and cool the body through evaporation is dramatically reduced. Convection is minimal when there is little movement in the air around the skin but can become more important as wind speed increases. Convection does not cool the body when air temperatures are high. Only 2% of our body heat is lost through conduction when surrounded by air; however, heat loss through conduction in water can be 25 times greater.

[2] Healthwise. (2011). WebMD: First Aid & Emergencies: Ways in Which the Body Loses Heat. Available online: http://firstaid.webmd.com/ways-in-which-the-body-loses-heat. Accessed April 16, 2012.

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