

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	<ul style="list-style-type: none"> • Red cluster of pimples • Blisters • Itching • Red rash on the skin that usually occur on the neck, chest, breast and/or groin 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Swelling in the ankles, feet and hands • Body temperature normal or elevated core temperature up to 104° F 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • Hyperventilation • Respiratory alkalosis 	Remove the affected person from the heat and advise the person to breathe slowly.
Heat cramps	<ul style="list-style-type: none"> • Muscle spasms • Muscles usually affected include the abdomen, calf, thighs and shoulder muscles • Body temperature normal or elevated core temperature up to 104° F 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Dizziness • Fainting • Body temperature normal or elevated core temperature up to 104° F 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Profuse sweating • Weakness • Rapid breathing • Dizziness • Nausea/vomiting • Muscle cramps • Normal mentation • Body temperature normal or elevated core temperature up to 104° F 	<ul style="list-style-type: none"> • 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.

<p>Heat stroke</p> <p><i>This is a life threatening, adverse effect of exposure to extreme heat, usually occurring when the body temperature is greater than 104 °F.</i></p>	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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% 	<p>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.</p>
<p>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.</p> <p>² Platt, M. and Vicario, S. (2010). Heat Illness. In Rosen's Emergency Medicine: Concepts and Clinical Practice, 7th Ed. p1882-3.</p> <p>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.</p>			

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.