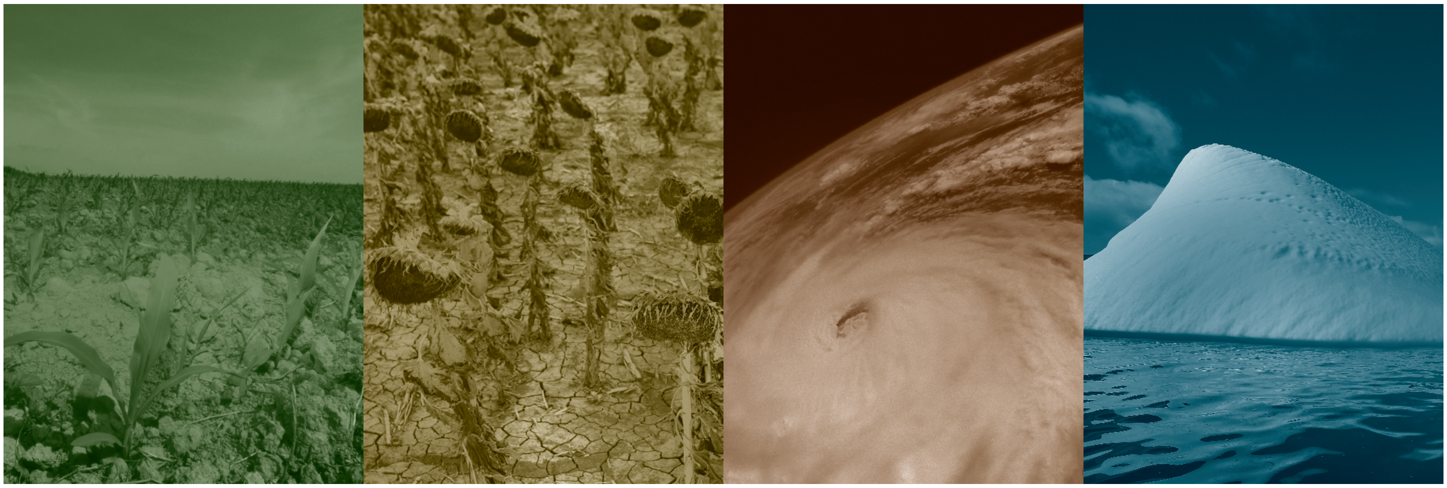
Heat Response Plans:

Summary of Evidence and Strategies for Collaboration and Implementation



Climate and Health Technical Report Series

Climate and Health Program, Centers for Disease Control and Prevention

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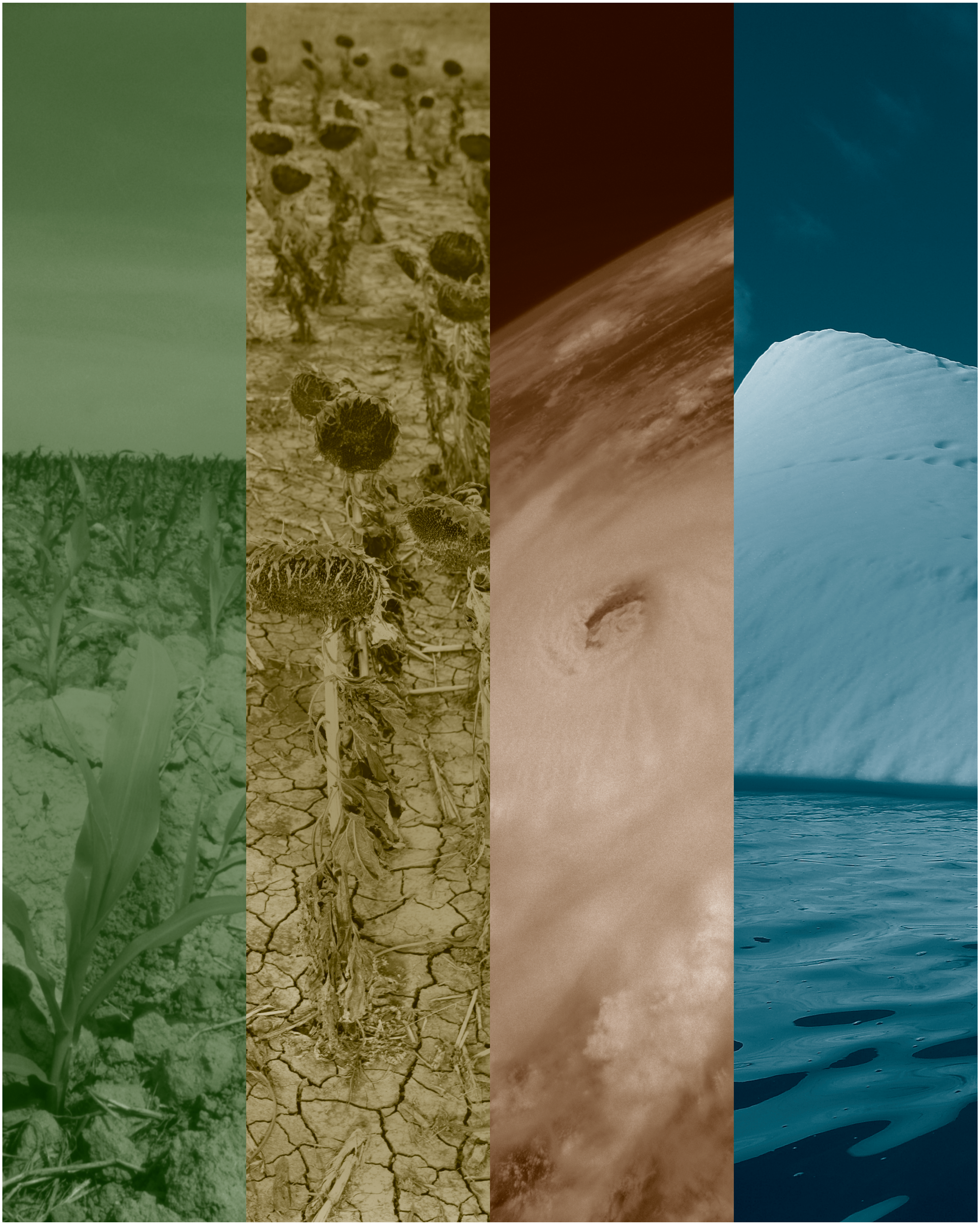

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Executive Summary

Extreme heat is a major public health concern in the United States. Temperatures are increasing across the country, with more frequent and severe heat waves in many regions. This trend is projected to continue. Exposure to heat may increase the risk of illness particularly among sensitive groups such as people who do not have access to air conditioning, older adults, young children, people working outdoors, athletes, the socially isolated, people with existing chronic conditions, and some communities of color. Health departments, their partners, and other government agencies have undertaken a variety of strategies to protect the public from high temperatures. One potential strategy is a heat response plan - a coordinated plan that describes and organizes activities to prevent heat-related morbidity and mortality in a community.

Health departments at all levels (state, local, Tribal, and territorial) and their partners can develop and implement a response to protect their community and vulnerable populations. There is evidence that heat response plans can protect health, but mixed evidence on the effectiveness of individual components of a heat response plan and the degree of overall health protection. This document is intended to give a summary of extreme heat, the health burden of heat exposure, the impacts of climate change, and components and effectiveness of heat response plans with a focus on relevant peer-reviewed literature and existing heat response plans. Resources and examples of successful implementation and potential collaborative efforts are included.

Introduction to Extreme Heat

What is extreme heat?

Extreme heat is generally defined as one or more days of unusually hot or humid weather conditions that can potentially harm human health. The definition of extreme heat varies based on many different factors, including location, weather conditions (such as temperature, humidity, and cloud cover), and the season or time of year.[1] Table one below gives examples of how the National Weather Service (NWS) Weather Forecasting Offices (WFO) in the Baltimore/Washington region (LWX) and Des Moines, Iowa region (DMX) define heat watches, warnings, and advisories.[2,3]

Table 1: Examples of National Weather Service definitions for heat alerts in the Baltimore/Washington Region and Des Moines, Iowa region. Source: https://www.weather.gov/lwx/WarningsDefined, https://www.weather.gov/dmx/dssheat[2] [3]

National Weather Service Term	Definition from the National Weather Service, Baltimore/Washington Region	Definition from the National Weather Service, Des Moines , Iowa, Region
Excessive Heat Watch	Potential for the heat index value to reach or exceed 110 °F degrees (east of the Blue Ridge) or 105 °F (west of the Blue Ridge) within the next 24 to 48 hours.	Heat Index values are expected to reach or exceed 110°F and not fall below 75°F for at least a 48 hour period, beginning in the next 12 to 48 hours.
Excessive Heat Warning	When the heat index value is expected to reach or exceed 110 °F (east of the Blue Ridge) or 105 °F (west of the Blue Ridge) within the next 24 to 48 hours.	Heat Index values are expected to reach or exceed 110°F and not fall below 75°F for at least a 48 hour period, beginning in the next 24 hours.
Heat Advisory	When the heat index is expected to reach 105 to 109 °F (east of the Blue Ridge) or 100 to 104 °F (west of the Blue Ridge) within the next 24 to 48 hours. A Heat Advisory may be issued for lower criteria if it is early in the season or during a multi-day heat wave.	Temperatures of at least 100°F or Heat Index values of at least 105°F are expected generally within the next 24 hours.

The heat index is one way to measure how hot it feels outside. The heat index is a measure of both temperature and humidity and accounts for the fact that sweat does not evaporate as easily when the air contains greater amounts of moisture. The combination of high temperature and high humidity is dangerous for human health, as illustrated in Figure One.

Figure 1:

Temperature (˚F)

Relative Humity (%o)

00	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	96	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

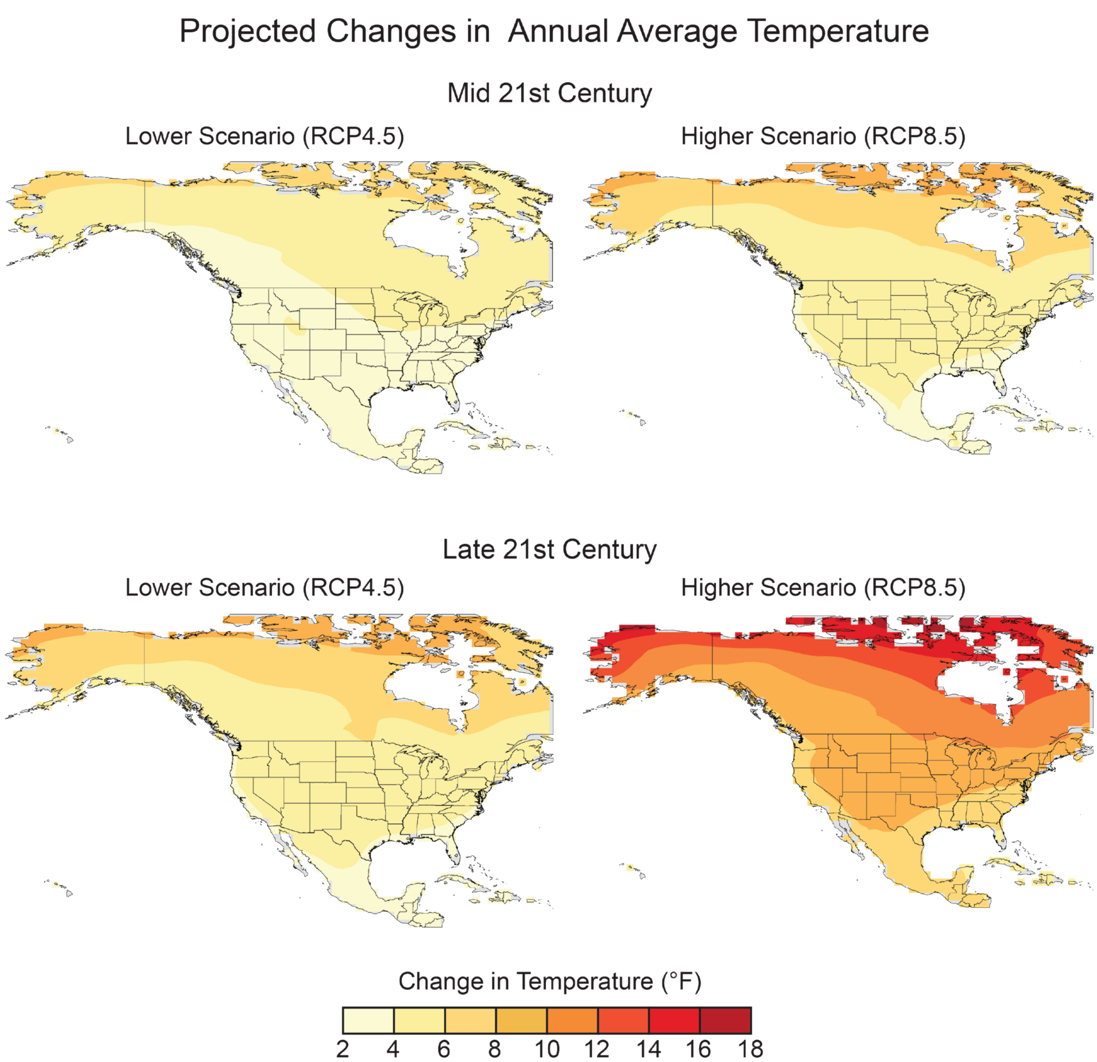
Caution · Extreme Caution · Danger · Extreme Danger

The National Weather Service Heat Index. Source (more information available at https://www.weather.gov/safety/heat-index)

Impact of climate change on extreme heat

Climate change is leading to increased temperatures across the globe. Annual average temperature in the United States was 1.2°F (0.7°C) warmer from 1986–2015 than 1901–1960.[5] Temperature measurements on land and by satellite consistently show rapid warming since 1979 in most areas. The frequency of cold waves has decreased, whereas the frequency of heat waves has increased over the last 50 years. These trends are expected to continue, with U.S. temperatures projected to increase by about 2.5°F (1.4°C) for the period 2021–2050 and by as much as 5.8°–11.9°F (3.2°–6.6°C) by late century (2071–2100) depending on the climate scenario.[6] Figure Two illustrates these projected increases in temperature across North America.

Figure 2.



Projected changes in annual average temperature, mid and late 21st century, under two climate scenarios. Figure source: CICS-NC and NOAA NCEI. Metadata and download available at https://science2017.globalchange.gov/chapter/6/

In the future, extreme heat events may become more common, more severe, and last longer. Areas that currently experience few extreme heat events may experience them more frequently, while areas that currently experience extreme heat often, may have more severe extreme heat in the future. Geographical differences may impact the use of heat response plans since some heat events are episodic (occur a few days out of the year), while others are chronic heat events (occur many days out of the year).[5]

Even brief or small temperature increases above seasonal norms may result in illness and deaths. These warmer than average temperature days can occur in the spring and early summer before people are usually accustomed to these temperatures. Some of the deadliest heat waves have occurred in northern communities where people are not as adapted to extreme heat and many houses and apartments lack air conditioning[7,8]. The impact of heat on human health is outlined in the section below.

For more information on extreme heat and climate change, see:

"*Climate Change and Extreme Heat: What You Can Do to Prepare*" https://www.cdc.gov/climateandhealth/pubs/extreme-heat-guidebook.pdf

"*Climate Change and Extreme Heat Events*" https://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf

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How extreme heat affects health

Exposure to extreme heat can cause a range of health effects, from mild to life-threatening. From 1999 to 2009 extreme heat exposure caused or contributed to more than 7,800 deaths in the United States.[9] Heat exposure can lead to direct heath impacts including heat rashes, cramps, heat exhaustion, and heat strokes and indirect impacts by exacerbating pre-existing conditions.[10] Heat stroke is the most serious medical condition caused by extreme heat, requiring emergency treatment. Heat stroke generally refers to a core temperature of at least 104°F (40°C) and central nervous system dysfunction that can lead to death. Heat exhaustion is less severe than heat stroke. Although associated with an elevated core temperature, heat exhaustion does not cause altered mental status. Persons with heat exhaustion might present with headache, dizziness, profuse sweating, nausea and/or vomiting. Heat exhaustion usually resolves with fluids (oral or IV, depending on severity)[11]. Heat cramps are muscle spasms, often in the abdomen, arms, or calves, caused by a large loss of salt and water in the body. Heat cramps can occur from prolonged exposure to extreme heat combined with dehydration. They commonly occur while participating in strenuous outdoor activities such as physical labor or sports.

A woman takes a break while exercising outside on a sunny day.

Heat can also exacerbate chronic conditions, resulting in increases in hospital visits for renal, cardiovascular, and respiratory conditions.[12,13] Extreme heat events are associated with an increase in emergency medical services calls[14] and emergency department visits.[15] Mental health can also be impacted by heat waves. Hansen et. al. found a positive association between temperature increase and hospital admissions for behavioral and mental disorders.[16] In addition to the risk of hospital admissions, there is also evidence of an increased risk of suicide during high temperatures.[17]

Heat wave impacts on a community may vary based on the length of the heat wave, when it occurs in the season, the severity of the heat wave, and the adaptive capacity (the ability to prepare for, respond to, and cope with heat events) of the community.[7, 18] The first heat wave of the year can have an increased effect on illness and mortality than subsequent heat waves. With continued warming, increases in heat-related illness and deaths are projected to outweigh reductions in cold-related deaths in most regions.[19]

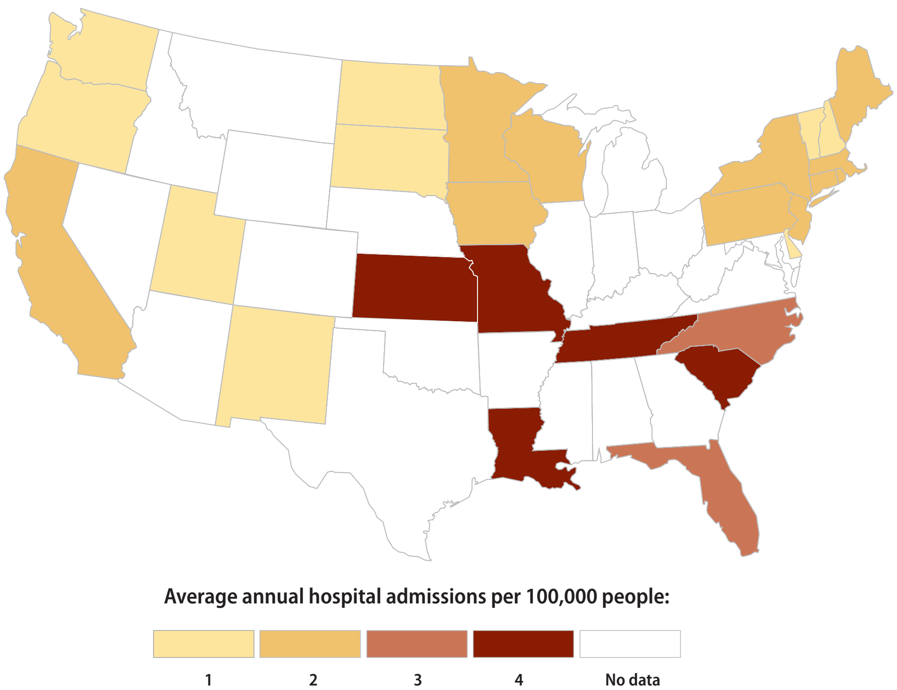
Heat-related impacts on health may be immediate or delayed, which is also referred to as a lag effect. Davis and colleagues noted a one-day lag in emergency department (ED) admissions for persons aged 20–49 years following a ≥3-day heat wave.[20] One to three-day lags in elevated cardiovascular mortality have also been seen after hot days.[21] In New York City (NYC), elevated mortality during and up to three days following extreme heat has been observed, with an average of 115 non-external cause deaths associated with extreme heat each year.[22]

In the absence of air conditioning, indoor temperatures can be much hotter than outdoors.[23] High indoor temperatures can persist several days after the end of a heat wave, leading to health impacts from indoor heat exposure.[24]

Historic morbidity and mortality data

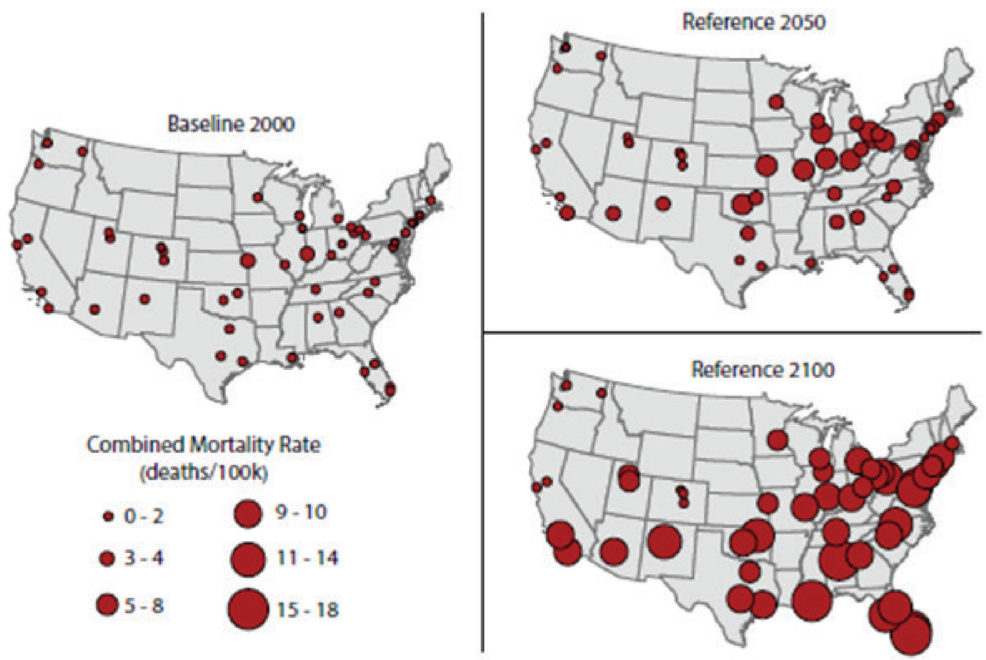
Each summer an average of more than 65,000 Americans visit the emergency room for acute heat illness.[25] Figure three illustrates hospital admissions due to heat from 2001–2010 for several states. The number of deaths varies each year depending on the degree of temperature elevation and the characteristics of the populations that are exposed to high temperatures. Analysis of national mortality data from 1999–2009 showed an average of 658 heat-related deaths every year[26], while a subsequent study analyzing mortality data for 2006–2010 estimated an average of 666 heat-related deaths every year.[27] These results likely are an underestimation of the actual health burden attributable to extreme heat, as the death records from which the cause of death information is obtained often do not list potential exposure to heat as an underlying or contributing cause of death.

Figure 3.



Hospital admissions due to heat, 2001 – 2010, CDC National Environmental Public health Tracking Network. This map shows the number of hospital admissions for heat-related illnesses per 100,000 people in 23 states that participate in a national hospital data tracking program. States shaded dark red have three to four cases per 100,000 people in a typical year. States without shading do not participate in the data tracking program. Source:[1] https://www.epa.gov/sites/production/files/2016-10/documents/extreme-heat-guidebook.pdf

Figure 4



Estimated net mortality rate from extremely hot and cold days (number of deaths per 100,000 residents) under the reference scenario for 49 cities in 2050 and 2100. Red circles indicate cities included in the analysis; Cities without circles should not be interpreted as having no extreme temperature impact. Source: EPA. 2015. Climate Change in the United States: Benefits of Global Action. United States Environmental Protection Agency, Office of Atmospheric Programs, EPA 430-R-15-001.[28]
https://www.epa.gov/cira/climate-action-benefits-extreme-temperature

At-risk groups

Extreme heat poses a significant threat to health and well-being among[29] all populations. However, the impacts of extreme heat disproportionately affect certain populations more than others, such as people who do not have access to air conditioning, older adults, young children, people working outdoors, athletes, the socially isolated, people with existing chronic conditions, and some communities of color.[19, 30] This section describes individual characteristics, social determinants of health, and geography/infrastructure characteristics that can influence vulnerability to heat.

Extreme heat risk is affected by:

1) exposure to high temperatures
2) sensitivity of population to adverse health effects of heat events; and
3) adaptive capacity of the population to reduce exposure (i.e., the ability to prepare for, respond to, and cope with heat events)[31, 32]

Individual characteristics and social determinants of health

Older Adults

Older adults (persons aged 65 and older) are particularly vulnerable to the health impacts of extreme heat events and heat waves. An assessment of the 2003 Paris heat wave identified a 40% increase in deaths for 65-year olds and a 70% increase in deaths for 85-year olds.[33] The most common health impacts of heat waves among older adults include cardiovascular disease, cerebrovascular disease, renal failure, diabetes, heat-related illness, dehydration, and respiratory illness.[34] An assessment of a 2006 California heat wave found that older patients had elevated rates of emergency hospitalizations during the heat event, especially for diabetes and respiratory illness.[34] Older populations are at greater risk for dehydration because of their reduced sense of thirst and higher likelihood of taking medications that may cause more frequent urination and perspiration. Older populations are also more likely to suffer from chronic respiratory illness, which can be exacerbated by heat-related ground-level ozone.[36]

In the coming decades, the older adult population is projected to grow substantially in the United States.[30] In 2060, this population is expected to be 98 million, more than double its estimated population of 46 million in 2016, which will result in an increase in the group's share of the total population from 15 to 24 percent.[37] As the population of older adults grows, there will be more people who will be at risk for heat-related illness and death.[38]

Older adults can also be vulnerable to the health impacts of power disruption associated with many hazard events, including heat waves. A 2003 New York City power outage resulted in about a 28% increase in deaths, with the highest burden among older populations.[39] Older adults are more likely to have reduced mobility, be dependent on electronic medical equipment or have cognitive disabilities, which may make evacuations or sheltering in place difficult or dangerous. In addition to increased prevalence of physical and cognitive health conditions, older populations are also likely to be socially and geographically isolated. Older adults living alone or residing in rural areas are less likely to benefit from community resources for heat impact mitigation and adaptation available in more urban areas. Persons living in nursing homes and residential care facilities are also vulnerable to climate change-related extreme weather events. Analyses of a 2003 European heat wave found nearly a 100% increase in the number of deaths in nursing homes; this rate of increase was dependent on age and level of care.[33, 41] Residents of nursing homes or residential care facilities are also more likely to have cognitive disabilities including dementia, which may impair their ability to seek help or receive treatment. Evacuations often present a unique challenge for nursing homes and residential care facilities, as residents must be evacuated to a facility with a similar level of care, including the transfer of patient information, medicine and medical records, and other medical equipment.[42]

Infants and Children

Infants and young children (age 4 and younger) face a much greater risk of heat-related illnesses than teens and adults.[19] Infants and young children are very sensitive to external temperature variations, as their internal temperature regulation system is less developed than adults.[43] They have a decreased sweating capacity, which makes evaporative cooling less effective.[43] Children are less likely to recognize the earliest symptoms of heat-related illnesses (e.g., excessive thirst, rapid heartbeat, dizziness, or muscle camps), take rest breaks and stay hydrated during hot weather. In 2018, 53 children died from heatstroke after being left or trapped in a vehicle during high temperatures. Often times the caregiver has forgotten the child in the car.[44]

A number of mechanisms connect exposure to extreme heat to adverse health outcomes in children of all ages. An analysis of a 2006 California heat wave found significant increases in hospital admissions for children aged 0–4 years, especially for respiratory illnesses, dehydration, and renal illnesses.[34] Children are vulnerable to ground-level ozone, which increases with rising during high temperatures. A child's respiratory rate can be 2–3 times higher than an adult respiratory rate, and exposure to poor air quality can affect lung development.[45] Extreme heat has also been linked to reduced cognitive skill development and performance. A study of 10 million school-aged children showed that high temperatures reduced test scores and theorized that each degree Fahrenheit temperature increase reduces the amount learned by about 1%. Schools can nearly offset these effects with a working air conditioning system.[46]

Existing Medical Conditions and Disabilities

Extreme heat is a threat multiplier and modifies existing health impacts. People with pre-existing medical conditions such as cardiovascular illness, respiratory illness, and diabetes, people who are taking medications that may increase susceptibility to heat-illness, people with mental and cognitive health conditions, chronic physical conditions and disabilities, and persons dependent on electronic medical equipment are particularly vulnerable to extreme heat.[38] Exposure to extreme heat can amplify existing medical conditions, resulting in premature death and disability. Some underlying conditions (e.g., Alzheimer's disease or mental illness) can make it difficult for a person to limit their exposure or adapt to extreme heat events. In addition, certain medications may impact the body's ability to regulate internal temperature, maintain fluid, or electrolyte balances.[38]

Of the estimated 700 excess deaths during a 1995 Chicago heat wave, 39% had prior heart conditions.[8] The process of thermoregulation also increases a person's respiratory rate, which can affect populations with lung diseases such as chronic obstructive pulmonary disease (COPD).[48] Extreme heat accelerates the creation of ground-level ozone, which increases rates of cardiovascular mortality. Ground-level ozone can also exacerbate respiratory health conditions (e.g., COPD and asthma).

Another health condition that can modify vulnerability to extreme heat is diabetes. Populations with diabetes account for a significant number of hospitalizations during extreme heat events.[50] Diabetes affects one's ability to regulate body temperature, as diabetes can reduce the amount of sweat produced for cooling and reduce skin blood flow.[50] Additionally, many diabetes medications, including insulin and oral hypoglycemics, can cause dehydration and can lose their effectiveness in extreme temperatures.[50]

Some medications can make people more vulnerable to the health impacts of extreme heat. Diuretics can increase urination and perspiration and contribute to dehydration, especially when combined with antipsychotics and other medicines that reduce thirst sensation and otherwise affect thermoregulation.[35] A study during a 2003 heat wave in France found that heat-related illness patients prescribed anticholinergics, anti-psychotics, and anxiolytics were more likely to be seen in the emergency room compared to community controls prescribed other medications. The study also found that diuretic use was associated with increased risk of death.[51] Other drugs, including antidepressants, antihistamines, and antiparkinson medications, may also increase vulnerability to extreme heat events.[51]

Extreme heat can both directly and indirectly affect mental health in all ages. It was observed that during the 1999 heat wave in Chicago, psychiatric illnesses among younger age groups was twice that among older age groups. This was possibly due to interventions following the 1995 heat wave in Chicago, which focused on the elderly.[52] A study of the relationship between mental health and extreme heat in Australia found that hospital admissions for mental and behavioral disorders increased 7.3% during heat waves.[16] A study of deaths of people with psychosis, dementia, and alcohol misuse between 1998 and 2007 found an increased risk for death as temperatures increased.[53] Physical disability may increase vulnerability to extreme heat events, as populations with reduced mobility or sensory disabilities may need support or transportation to respond to extreme heat events.

Increased Social Isolation, Linguistic Isolation, and Living Alone

Social isolation can refer to the quantity and frequency of social relationships, engagement with formal and informal networks and the quality of those relationships, and perceived loneliness.[54] Social isolation can be a function of physical isolation and disability, chronic health problems, or linguistic isolation. Family, friends, and other community members can provide best practices and other advice to stay safe during extreme heat events, identify heat-related illness and provide medical support, and help access food, water, medicines, and emergency services.[55] Community also protects against the health impacts of extreme heat through emotional support to alleviate trauma and stress caused by the extreme weather event.[54]

An analysis of the health impacts of a 1995 Chicago heat wave demonstrated that populations who were socially isolated or lived alone were at increased risk for heat-related morbidity and mortality.[8] This risk was higher for populations who were bedridden, older, or without access to air conditioning. This finding was confirmed by an analysis of a 1999 Chicago heat wave that identified living alone and not leaving the home daily as the most important risk factors for heat-related death.[52] Similarly, an analysis of a 2003 Paris heat wave uncovered particularly high mortality rates for single and divorced subjects.[56]

Linguistic isolation refers to persons or households that either do not speak English or do not speak a language similar to other persons in their community or social network. Language can act as a barrier to information, and those who cannot speak English.[57] However, populations who do not speak English may have strong social networks and receive communication through them. Most emergency alerts in the United States are issued in English, making populations with limited English proficiency more vulnerable as they may miss or not understand warnings and alerts in weather reports. The number of Hispanic and migrant workers in New York state has been increasing, and both employees and employers cite language barriers as one of the top obstacles in the work place.[59] These challenges could impact implementation of heat mitigation strategies.

Outdoor Workers and Athletes

Outdoor workers, who are often exposed to extreme heat and humidity for prolonged periods, are at increased risk for heat-related illness.[30, 60] Two primary sources for heat stress among workers include: 1) the environmental conditions in which they work and 2) the internal heat generated by physical labor.[60] In addition, the use of personal protective equipment (PPE) and clothing can increase the heat burden of the worker, making them more susceptible to heat-related illnesses.[61] Outdoor workers become overheated when the body is unable to lose enough heat through evaporation to balance the heat generated by physical work and external heat sources.[60] As a result, they are at increased risk for heat-related illness, reduced worker vigilance, lapse in safety and work capacity, as well as occupational injury.[30]

Industries with workers at risk for occupational heat exposure include the agricultural/forestry/fishing, construction, mining, services, transportation, manufacturing, emergency response, as well as the armed services. In the United States, persons working in the agricultural industry have an extreme heat mortality rate nearly 20 times greater than the average American worker. Of the 423 United States occupational extreme heat-related deaths between 1992 and 2006, nearly 20% occurred in crop workers.[66] This population is disproportionately non-white and immigrant and primarily from Mexico, Central America, and South America. Some workers may also be paid a piece rate (like many migrant farm workers), and choose to decline rest and work breaks if they negatively affect their income. Between 2003 and 2008, 36% of all occupational extreme heat-related deaths occurred in construction workers. Firefighters and armed service members are vulnerable to extreme heat because of the physical exertion required and use of heavy protective uniforms and other equipment.[67]

Similarly, athletes are vulnerable to heat-related illness because of exposure to outdoor air temperatures and physical exertion. Among high school athletes, heat-related illness is the third-leading cause of death.[66] Heat-related illness in athletes is especially severe when the athlete is not well-hydrated or has not been acclimatized to the level of physical activity in hot weather.[66]

Race and Ethnicity

Non-white populations are disproportionately represented among the more socioeconomically disadvantaged groups in the United States. Racial and ethnic health disparities are not just a function of income, as these disparities occur at every income level and result from systemic racism.[70] Race and ethnicity is associated with morbidity and mortality to extreme heat.[71] For example, in New York City, non-Latino Black residents are at increased risk of death during heat waves.[72] Generations of systemic racial discrimination can affect many other determinants of health, including access to air conditioning and ability to afford to run it, housing quality, access to education, limited transportation, access to health education and health care, social isolation, inadequate access to public shelters (e.g., cooling centers), as well as limited access to routine and emergency health care. In addition, these groups experience a greater incidence of chronic medical conditions (e.g., cardiovascular and kidney disease, diabetes, asthma, and COPD) that are worsened by heat-related health impacts.[30]

Many non-white populations often lack access to the political decision-making process which impacts the cultural competency of emergency response and informational materials.[73] Distrust of first responders may inhibit access to emergency response services and other adaptive and protective resources. Non-white populations are more likely to be low income or live under the poverty line and have pre-existing health conditions that modify vulnerability to extreme heat events. Increasing temperatures are impacting indigenous peoples due to lack of adequate housing and air conditioning and increased exposure at outdoor cultural ceremonies.[74] In cities, non-white populations are more likely to live in urban heat islands, neighborhoods with impervious surfaces and low tree coverage, and areas with limited access to green space.[75] Lastly, non-white populations own fewer air conditioners than do white populations.[71]

Although some non-white populations are more likely to be low income, have pre-existing health conditions, live in urban heat islands, and less likely to own air conditioning, many pathways that modify vulnerability to extreme heat vary by race and ethnicity. An age-adjusted analysis of a 1995 Chicago heat wave demonstrated that the extreme heat event disproportionately impacted black residents.[67]

Income and Educational Attainment

Social determinants, including income and educational attainment, are correlated to numerous health outcomes, including heat-related illness. In the United States, the gap in life expectancy between the richest 1% of the population and the poorest 1% is 14.6 years.[70] Similarly, the average college graduate lives five years longer than someone without a high school degree.[76] Income and education are themselves correlated. Populations without a high school diploma have greater unemployment and earn nearly $700 a week less than populations with a bachelor's degree.[77] This population is more likely to reside in housing that may lack adaptive features such as insulation and air conditioning.[70]

Without adequate access to medical care, low-income populations with preexisting health conditions are less likely to seek treatment during extreme heat events. Households that are financially insecure may lack the resources to pay energy costs or purchase other household amenities necessary during extreme heat events.[78] Low-income populations are often more exposed to extreme heat, as they more commonly reside in urban heat islands and adjacent to freeways and other emissions sources.[79] The homes in these neighborhoods often lack air conditioning, and residents may be transportation-dependent and lack the public transportation options necessary to access cooling centers and other services located outside their homes.

Infrastructure and geography

Unhoused Populations

Persons experiencing homelessness are among the most exposed and the most vulnerable to all climate change-related hazards. This population is more likely to have major pre-existing physical and mental health conditions and often lacks resources necessary to prepare for or recover from extreme heat events. During a 2005 Arizona extreme heat event, nearly two-thirds of heat-related mortality cases were among persons experiencing homelessness.[78] Unhoused populations are often overlooked in emergency response plans and may be less receptive to outreach, engagement, and other preventative measures.

A tent alongside a fence on a concrete pathway. Unhoused populations are often overlooked in emergency response plans.

Housing Quality and Air Conditioning

Although neighborhood land use patterns modify exposure to extreme heat events, exposure is also affected by housing characteristics. The most important housing characteristic affecting heat vulnerability is the absence of working air conditioning. In the United States and other high-income countries, the majority of extreme heat deaths occurs indoors.[80] A 2006 study of the relationship between indoor heat and outdoor temperature found that during extreme heat events, many indoor temperatures exceeded levels dangerous to human health.[80] Homes and buildings may continue to be dangerously hot even after temperatures cool outside. Research shows that indoor heat waves start later but last longer than outdoor heat waves, as buildings might take time to cool.[24] The differential rate of cooling suggests that characteristics such as building density, building age, building materials, and cooling capacity, which is influenced by the prevalence of air conditioning, adequate insulation, and green roofs, are relevant to identifying buildings conducive to and people at-risk for extreme heat events.[78]

Air conditioning is the most effective protective strategy against heat-health impacts for at-risk groups. Many studies have demonstrated the relationship between air conditioning access and extreme heat vulnerability. An assessment of the relationship between air conditioning, income, and extreme heat mortality in California found central air conditioning negatively correlated with heat-related mortality.[81] An analysis of a 1995 Chicago heat wave demonstrated that access to a working air conditioner, or even an air-conditioned lobby, greatly reduced the risk of mortality.[8] Persons who lived in single-room-occupancy hotels and other apartment buildings were less likely to have air conditioning. Access to air conditioning is also not evenly distributed by race. A study of racial disparities and air conditioning prevalence in four American cities found double the rates of central air conditioning ownership in white/other households than black households.[82] Additionally, the cost of electricity may be a disincentive to air conditioning use during extreme heat events for low income residents.[83]

An analysis of place-based vulnerability to extreme heat in New York City found that serious housing violations and deteriorating and dilapidated buildings were associated with vulnerability to extreme heat.[83] Research is mixed on whether housing age may modify vulnerability to extreme heat, as housing age, poverty, and lack of green space are often highly correlated.[78 80] An analysis of a 2003 French heat wave demonstrated that living in buildings without insulation increased vulnerability to extreme heat.[84] Both this analysis and an analysis of a 1995 Chicago heat wave found that individuals that lived on the top floor of multi-story buildings were more vulnerable than populations in single-family homes.[8 84] Rural homes are also less likely to have air-conditioning compared to urban homes.[85]

Urban Heat Island Effect and Land-use

Physical neighborhood characteristics can modify the degree to which a person is exposed to extreme heat. An urban heat island is an urban area that is warmer than adjacent rural areas due to land use patterns and other human activities. Cities with 1 million or more people can have an annual mean air temperature 1.8-5.4°F (1–3°C) warmer than surrounding rural areas.[87] Attributes of urban heat islands include impervious surfaces, such as pavement and roofs, multi-story buildings, and the absence of tree canopy and other green space. Impervious surfaces, such as asphalt, absorb heat while tall glass buildings reflect sunlight and block wind.[86] A robust urban tree canopy and other greenspace can protect against extreme heat. These features provide shade and reduce air pollution.[75] Tree canopy and green space also facilitate evapotranspiration, which dissipates heat.[86] Lastly, because of their proximity to freeways, high traffic corridors, factories, and other air pollution sources, the hot, dry temperatures associated with urban heat islands also accelerates the creation of ozone and other pollutants.

Many studies have demonstrated that populations that live in urban heat islands are at increased risk for heat-related illness.[71] For example, an analysis of a 2003 French heat wave found that surface temperature was associated with health impacts, and proximity of the home to green space was protective against these health impacts.[84] Similarly, research into the relationship between green space and the health impacts of extreme heat among older adults in eight Michigan cities found that rates of cardiovascular mortality increased in zip codes with less green space.[88]

Populations that live in urban heat islands are often vulnerable to extreme heat events through socioeconomic or demographic pathways. An analysis of local vulnerability to extreme heat in New York found significant positive associations between heat-related illness and urban heat islands as well as poverty, housing conditions, access to air conditioning, elderly populations, and pre-existing health conditions.[83] Non-white populations are disproportionately represented in urban heat islands, even after researchers adjusted for racial disparities in both rates of home ownership and household poverty.[75] As such, communities of color are disproportionately exposed to both high temperatures and air pollutants.

Rural populations may have a heightened degree of vulnerability due to lack of resources, access to healthcare, and geographical isolation. Rural populations are more likely to be older and may have less access to air conditioning [85] or public transportation[89] amplifies risk among rural residents. They are at a higher risk also because they may not get the care they need in a timely manner.[89, 90] Some rural areas have higher rates of hospitalization for heat related illness than urban areas, for example in Illinois[91] Although studies have shown high personal outdoor heat exposure in urban areas, indoor heat exposure is higher in rural areas. [92]

Heat Response Plans

What is a heat response plan?

A heat response plan is a coordinated plan that describes and organizes activities to prevent heat-related morbidity and mortality. A heat response plan may be a stand-alone plan or an annex to an all-hazards plan depending on your jurisdiction. The plan guides government agencies and partners to provide services and information to the public and at-risk groups during periods of dangerously high heat. FEMA's Comprehensive Preparedness Guide (CPG)-101 states that "EOPs [Emergency Operations Plans] are plans that define the scope of preparedness and emergency management activities necessary for that jurisdiction".[93]

A heat response plan may cover a broad geographic scope (such as a state or large county) or a smaller area (an individual city, school, or neighborhood). Heat response plans may be focused on emergency response or may include information on long-term adaptation. A heat response plan can be activated in response to temperature information from the National Weather Service (NWS). The NWS sends advisory information for a heat watch, a heat warning, or a heat advisory. As a health department constructs a heat response plan in collaboration with partners such as emergency managers and service providers, local conditions, heat thresholds, capacities, resources, and vulnerable populations can be considered.

Development of a heat response plan can be complicated, and many partners with varying expertise are often involved to help improve the usefulness of the plan. Below are examples of types of partners and organizations that have participated in state or local heat response plans around the United States.

Emergency management organizations

State, county, tribal, and local health departments

National Weather Service (NWS)

Hospitals and healthcare coalitions

Colleges and universities

Department of Education

School districts/corporations

Department of Agriculture

Department of Labor

Meals on Wheels or other food or senior organizations

Visiting Nurses Associations

American Red Cross

Emergency Medical Services

Fire departments

Police departments and law enforcement organizations

Public utilities commission/Utility companies

Parks department

Public works

Animal control services

Medical Reserve Corps

Aging and Adult services

Human services

Emergency Response Teams

Faith-Based Organizations

Youth sports organizations

Community advocacy organizations

City planners or regional commissions

Occupational Safety and Health Professionals

There is evidence that heat response plans are beneficial, but there is mixed evidence on the effectiveness of individual components of a heat response plan and the degree of overall health protection. Boekmann and Rohn conducted a systematic review of peer-reviewed literature to determine if heat prevention and climate change adaptation are decreasing mortality.[94] The study included 30 articles. They observed a decrease in sensitivity to heat; however, the authors were hesitant to attribute reduced mortality to individual adaptations because of the lack of data on the effectiveness of the specific adaptations. A study in Frankfurt, Germany compared the heatwave of 2003 to the heatwaves of 2006, 2010, and 2015 to discern whether the heat health action plan (HHAP), implemented after the 2003 heatwaves, was effective.[95] The 2003 heatwave had a greater excess mortality than the 2015 heatwave. However, they state that it is unlikely that the lower mortality is a result of the HHAP because the duration of the heatwave was longer for the 2003 heatwave.

Researchers have looked at other indicators besides mortality to determine effectiveness. One study utilized emergency medical services (EMS) runs as an indicator for warning system effectiveness.[96] They found a 49–73% reduction in EMS runs during a 1999 heat wave when compared to a 1995 heat wave, when no warning system was utilized. A study on the heat health warning system in Philadelphia determined the number of lives saved by utilizing the warning system and then calculated the economic gain of saving those lives.[97] They found that the costs associated with operating the warning system were small in comparison to the economic gain of saving 117 lives. These studies have shown a possible decrease in morbidity, mortality, and other indicators in subsequent heatwaves after a heat response plan has been implemented, but stronger evidence would be beneficial.

The health impacts caused by extreme heat are preventable and can be reduced with planning and early public health responses. Heat response plans are one way how public health agencies can become involved to limit the health effects of extreme heat. This document provides examples of strategies to ensure an effective and equitable approach to mitigating the health impacts of extreme heat in your jurisdiction. The considerations and strategies presented here are based on scientific evidence and successful implementation by health departments and other agencies around the country.

Potential components of a heat response plan

- Overview of the anticipated impacts of extreme heat
- Description of thresholds for activation
- Identification of at-risk populations and geographies within the jurisdiction
- Relevant local community considerations
- Identification of preparedness, response, and recovery actions and partnerships necessary to mitigate adverse health consequences
- Delineated roles and responsibilities including how agency efforts will be coordinated with other partners and stakeholders
- Evaluation and revision processes

Potential components of a heat response plan

Threshold for activation

A threshold for activation is a certain temperature or number of days (or nights) above a specific temperature or humidity that "triggers" aspects of a heat response plan. For example, a community might implement cooling centers if a weather forecast calls for maximum temperatures above the 95th percentile (e.g., within the top 5% of hottest days for the jurisdiction in comparison to historic summer temperatures). There are many factors that can be used to determine the threshold for activation based on local climate, vulnerability, capacity, and adaptations already in place.

May through September are generally the warmest times of the year throughout most the United States, but different regions have varying heat impacts. Some areas have persistent chronic heat, and others face heat on an episodic basis.[98, 99] For example, in the Southwest, some areas may face 100 or more days per year over 100° F (38° C), while some Northeast jurisdictions may have only a single 95° F day (35° C) on average (CDC Environmental Public Health Tracking Network).

The National Weather Service (NWS) uses four heat categories to communicate the heat threat, and many of the jurisdictions that have extreme heat response plans tie activations to NWS heat threat categories. The most severe type of alert is an Excessive Heat Warning. Below are the general criteria for the alerts.[100] See Table one for examples of localized NWS heat products.

Excessive Heat Warning—Take Action! An Excessive Heat Warning is issued within 12 hours of the onset of extremely dangerous heat conditions. This Warning is initiated when the maximum heat index temperature is expected to be 105° F or higher for at least 2 days and nighttime air temperatures will not drop below 75°F; however, these criteria vary across the country, especially for areas not used to extreme heat conditions. If you don't take precautions immediately when conditions are extreme, you may become seriously ill or even die.

Excessive Heat Watches—Be Prepared! Heat watches are issued when conditions are favorable for an excessive heat event in the next 24–72 hours. A Watch is used when the risk of a heat wave has increased but its occurrence and timing is still uncertain.

Heat Advisory—Take Action! A Heat Advisory is issued within 12 hours of the onset of extremely dangerous heat conditions. An Advisory is issued when the maximum heat index temperature is expected to be 100° F or higher for at least 2 days, and nighttime air temperatures will not drop below 75° F; however, these criteria vary across the country, especially for areas that are not used to dangerous heat conditions. Take precautions to avoid heat illness. If you don't take precautions, you may become seriously ill or even die.

Excessive Heat Outlooks— are issued when the potential exists for an excessive heat event in the next 3–7 days. An Outlook provides information to those who need considerable advanced warning to prepare for the event.

Some areas have worked with NWS to set extreme heat thresholds that are specific to the threats in their area. Calibrating thresholds based on local information and climate averages can be beneficial for activation thresholds for a heat response. Considering chronic versus episodic heat events may help in adjusting resource allocation throughout the warm season. If warnings are issued too often, partner agencies may become over burdened with health messages[101] or may not be as willing to incorporate the alert threshold into their planning process.

Criteria for activation can use thresholds to scale response. Similar to the approach under the National Response Framework's National Incident Management System and coordination using the Incident Command System (ICS), responses can be modular and expand upon severity.[102] Factors that may be considered when determining severity are maximum temperature, heat index, duration, complexity, NWS alert information, power outages, and health outcome information.

Activation

Activation of this plan is done in phases based on categorical indexes of severity relevant to temperatures, duration, complexity and alert data sent by the NWS. The severity index categories and corresponding response activities can be found in the figure below.

Figure 5.

Category 1:

Pre/Post-Heat event (Preparedness and Recovery)

Category 2:

NWS issues a heat watch or warning for any community in Arizona

Category 3:

Daily temperature high ≥107°F and low ≥87°F while in a heat watch or warning

Category 4:

3 or more consecutive days with a high ≥107°F and low ≥87°F while in a heat watch or warning (heat wave condition)

Category 5:

Power outage during Monsoon Season (June 15th through September 30th)

Example of Activation Criteria for the Arizona Department of Health Services Extreme Heat Incident Response Plan. Source: [98]

A person runs in front of a computer generated background showing charts and graphs. Health data can be used to inform heat warning thresholds.

Using health data to inform heat warning thresholds

University partners can be helpful in identifying thresholds for public health agencies who are developing a heat response plan. Public health agencies can take advantage of resources such as state climatologist for identifying potential researchers who can help them develop thresholds.

One method would be to assess daily illness and death events against temperature metrics. Categorizing triggers into categories may make it easier for planners to help determine when a heat-health intervention could be implemented. Categories could include a minimum risk, increasing risk, and excess risk temperature trigger. Health outcomes to consider could include all-cause mortality, cardiovascular mortality, and heat-related mortality. Additionally, emergency department and inpatient data on heat-related illness for each range of temperatures can help better categorize risk for triggers. A study in Arizona compared temperature metrics against heat-health outcomes found that for emergency department visits; minimum risk temperature was 71.6° F (22° C), increasing risk temperature was 84.2° F (29° C), and excess risk temperature was 102.2° F (39° C), also using maximum temperature. The study found an association of heat-health outcomes with maximum temperature (More details found in box below).[103]

A 2019 study analyzed the relationship between heat index and adverse health outcomes and found that there are significant health impacts occurring at temperatures below those at which heat alerts are typically issued.[104] Thus, many areas around the country may have heat warning thresholds that are set too high to adequately protect health.

Using data to set activation thresholds – local examples

New York City collaborated with a local NWS office and NYC Emergency Management to assess the public health risk of heat waves and to set criteria for alerts for excessive heat.[105] They estimated the weather-mortality relationship and used the results to support specific temperatures for activating heat alerts in the city. The New York State Department of Health also shared results of their heat-morbidity study with their local NWS offices and demonstrate incidence of heat impacted illness at lower than current threshold temperatures.[105] These two studies resulted in lower heat warning thresholds (which were originally based only on climatic averages) by incorporating research on the health effects of heat events in the region.[107]

In Arizona, efforts have been made to describe a possible method for identifying thresholds for heat. These trigger points may not be generalizable for all climates, but the methods may be repeatable. A quantitative study by Petitti *et al*[103] at Arizona State University analyzed temperature with illness and death events in Maricopa County, Arizona. The study categorized thresholds as minimum risk temperatures, increasing risk temperatures, and excess risk temperatures. Results found strong associations with all-cause mortality, cardiovascular disease mortality, heat-related mortality, and heat hospitalizations and emergency department visits. Excess heat-related mortality temperature was observed at 105.8°F (41°C), but increasing risk temperature for heat-related deaths was found below that level at 91.4°F (33°C) using maximum temperature as the risk factor.[103]

Rhode Island, Maine, New Hampshire, and Vermont partnered with the National Weather Service to form a Northeast Regional Heat Collaborative.[107] This multi-agency partnership led to increased understanding of heat-related hospitalizations and deaths and successfully changing the NWS Heat Advisory Policy for all of New England to better improve health outcomes.[107] The Regional Collaborative pooled data across New England in order to better represent the association between the impacts of heat on hospitalizations and deaths and help inform public health policy.[107]

Identifying vulnerable populations and locations

As discussed at length in the at-risk groups section, a variety of factors affect vulnerability to heat. When developing a heat response plan, resources exist to identify at-risk populations including the CDC vulnerability assessment technical guidance document and the social vulnerability index.[108] Mapping is a useful tool to help identify specific communities or areas that would benefit from heat response plan interventions. Vulnerability mapping uses multiple factors (such as income levels and access to transportation) in order to identify at-risk areas. The knowledge from this type of mapping can be used to inform particular interventions such as cooling centers or energy assistance.[109]

Potential interventions

Once the population has been characterized, appropriate response actions can be established and a heat response plan can be formulated effectively. Potential actions include:

- Surveillance
- Heat-Health Messaging and Communications
- Social care and front line health
- Neighbor outreach
- Cooling centers
- Water bottle distribution
- Fan distribution and use
- Energy assistance
- Changes to the built environment
- Workplace Heat Alert Program

A summary of the effectiveness of each of these interventions, based on peer-reviewed literature, is outlined below.

Surveillance

Some heat response plans utilize syndromic surveillance to track hyperthermia, heat related ER visits, and EMS activity.[110] One study found that using ER visit data was reliable to help inform public health interventions.[111] A study that reviewed heat-health action plans from World Health Organization member states found a lack of surveillance measures.[112] Surveillance can begin early in the heat season, for example the Maryland State Heat Emergency Plan performs syndromic surveillance of emergency departments during their pre-summer activities beginning in April.[113]

Surveillance data can also be useful in describing vulnerable populations within a community and determining targeted interventions. Epidemiologists can help identify risk factors within jurisdictions using health outcome data from hospitals and death certificate data. Epidemiological data can show specific age groups, places, and times of greatest risk. For example, persons experiencing homelessness may face increased risk. Therefore, identification of previous adverse outcomes during heat waves of persons experiencing homelessness could lead to planning actions for initiating resources to aid the homeless during periods of extreme heat, such as cooling centers. If epidemiological data show a large proportion of morbidity and mortality occurs in older adults[114], persons with a chronic medical condition, or persons taking prescription medicines that affect the body's ability to control its temperature, a public health agency may want to initiate an intervention aimed at these groups, such as heat safety brochures placed at senior centers.[115]

Timing of public health messaging can benefit from using surveillance data. For example, if an unexpected high temperature event occurred in the early spring, a health department may consider sending out earlier than planned messages on heat safety. Additionally, during a mass gathering event such as a marathon or outdoor concert, there may be a potential risk for excess heat-related illness during an excessive heat event or high temperatures. Surveillance of hospital data or EMS calls in near-real time can help public health agencies and stakeholders manage nearby EMS resources (e.g. Fire/Ambulance) or hospital staffing to react to medical surge of heat cases.

Heat-health messaging and communications

A communication strategy is an integral part of a heat response plan. Target audiences for communication may include internal audiences (within a health department), critical partners (e.g., first responders, healthcare system), community organizations and key stakeholders, and the general public. In a study of local and county heat response plans in the United States, communications and community outreach were the most commonly reported interventions.[116] One study performed in 2008 found that 89% of respondents that were aware of heat wave alerts obtained their information from television, radio, and newspaper. These may also include foreign language television channels, radios, and newspapers. The internet was the second-most used source.[117] It should be noted that methods of media consumption may be different now. Other forms of communication have been used as well. A "Heatline," a hotline for heat alert information, was used in the summer of 2002 in Philadelphia and received 2,300 calls.[97]

One of the main challenges with communication is reaching the most vulnerable or at-risk populations.[96] Staff working with vulnerable populations in Toronto during heat responses felt that the vulnerable populations, including older adults and elderly and socially isolated persons were not as aware of the heat alert compared to the general public.[97] In addition, inspiring people to take action and modify behaviors is also difficult. A study conducted in Dayton, Ohio; Philadelphia, Pennsylvania; Phoenix, Arizona; and Toronto, Ontario found that the majority of respondents were aware of heat warnings (92%, 91%, 90% and 83% respectively), however far less modified their behavior (Dayton 57%, Philadelphia 47%, Phoenix 35%, and Toronto 46%).[118] Similar results were observed in a study in Portugal, where nearly all people surveyed were aware of the heat warnings (92%), but those over age 75 and those with less education were less likely to comply with the messaging.[96, 97] One Arizona study found that less than 50% of people over age 65 changed their behaviors after receiving heat messaging.[96]

A study in France found 74% of respondents could recall hearing or seeing heat alert information on the radio or television. The same study found that 48% of respondents took protective measures in 2005 and 63% of respondents took protective measures in 2006. People who were aware of the alert modified their behaviors.[97] A survey in New York City also found that most people receive heat-health information from TV (75% of general population, and 82% of the most at-risk population). Follow-up focus groups identified health and medical reporters, meteorologists, doctors and the health department as trusted sources of information about heat.[119]

In the heat response literature, self-perception has been shown to detract from response to the communication messages being provided. By interviewing people over age 75, researchers in the United Kingdom found that these participants did not see themselves as vulnerable or old, but they did think that others of their age were vulnerable.[96] Similar results were seen in a St. Louis study where the older adults were not worried about heat because of their life experience, noting that they have lived in the same area without air conditioning their entire life without any problems. In this same survey they also found that older adults did not go to cooling centers because they felt that the shelters were for poor people.[97] They also found that the elderly did not go to cooling centers because they felt that the shelters were for low-income people. A study in Montreal, Canada conducted two focus groups, one with individuals diagnosed with schizophrenia and one with individuals with alcohol and drug addictions.[120] They found that while they have been identified as vulnerable groups from a public health perspective, they did not consider themselves to be more vulnerable. In the focus group with individuals with drug and alcohol addictions stated that they may be less vulnerable because they have learned to be resourceful through life events.[120]

Public health agencies can utilize various types of communication methods to reach target audiences during an extreme heat event. Some of those methods are discussed below.

Using the National Weather Service Heat Risk Tool to aid communication

The National Weather Service maintains several communication products that communicate heat risk, one of which is the Heat Risk Tool (currently only available for the western United States). This web-based tool provides a seven-day forecast with a heat risk score. The heat risk is shown in a numeric (0–4) and color (green/yellow/orange/red/magenta) scale that is similar to the Air Quality Index (AQI). The tool supplements Watch/Warning/Advisories and can help organizations take actions for each risk level for vulnerable populations.

Figure 6: Risk categories from the NWS heat risk tool

CATEGORY	LEVEL	MEANING
Green	0	No Elevated Risk
Yellow	1	Moderate Risk for those who are sensitive to heat, especially those without effective cooling and/or adequate hydration
Orange	2	Moderate Risk for those who are sensitive to heat, especially those without effective cooling and/or adequate hydration
Red	3	High Risk for much of the population, especially those who are heat sensitive, and those without effective cooling and/or adequate hydration
Magenta	4	Very High Risk for entire population, due to long duration heat with little or no relief overnight

Interactive National Weather Service (iNWS) - is a mobile decision support services tool. It is an experimental service intended for NWS partners, emergency managers, community leaders, other government agencies, and the media. Interactive National Weather Service (iNWS) A jurisdiction that enrolls in iNWS alerts will receive customized text message and e-mail alerts. This timely messaging service allows users to rapidly deploy additional messaging in the case of an excessive heat warning, watch, advisory, or outlook. iNWS can also consolidate messages from multiple weather forecast offices within the jurisdiction into one platform.

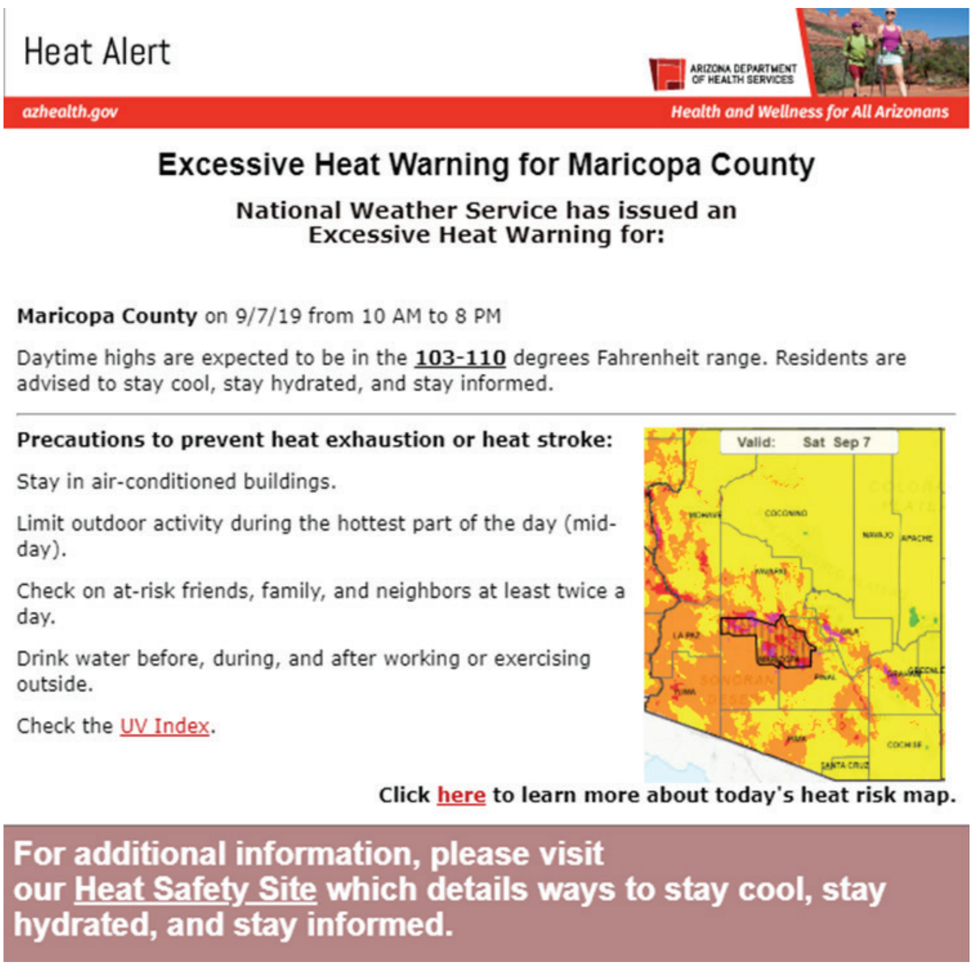
Public Service Announcements - Public service announcements can be used during natural disasters and severe weather to provide timely messages to vulnerable populations, such as those who might be affected by excessive heat. CDC has developed videos, scripts, and audio recordings that can be used to relay messages via multiple media streams. For example, depending on the audience, jurisdictions might consider using TV, radio, website, or social media platforms. Additionally, vulnerable populations may face challenges due to language barriers. Jurisdictions can consider translating materials to reach these affected populations. Translation may increase the success for the communication campaign.

A person holds a smart phone displaying information about a heat wave.

Health Alert Network (HAN) - CDC uses an email alert system called the [Health Alert Network (HAN)] to share information with public information officers, federal, state, territorial, tribal, and local public health officials, clinicians, and public health laboratorians. This stakeholder network was designed to enable rapid distribution of public health information. A health department can use information from HAN to send heat alert information to groups potentially affected by a heat event.

Mass Email Campaign - Communication marketing platforms to disseminate to mass audiences are available for email and text message alerts. Tools such as Granicus/GovDelivery and Constant Contact allow organizations to quickly send messages to interested individuals who opt in to topics. A public health agency can add a link to its website to sign up for heat alerts and then disseminate tailored messages with public health prevention tips on heat safety. Public health agencies could use such platforms to notify schools about risks to children of exposure to excessive heat outdoors; they could also provide messages recommending that children be kept indoors. Activities such as after-school sports, outdoor school events, physical education classes, and recess may need to be held during cooler parts of the day, or alternatively, take place in an air-conditioned space.

Figure 7.



Example of e-mailed heat alert which incorporate the NWS Heat Risk Tool (Courtesy of the Arizona Department of Health Services)

Social Media - Platforms such as Facebook and Twitter can be used to notify partners and the public about upcoming heat alerts such as heat warnings and watches. Heat safety messages may need to be concise and offer a link for more details, such as to a heat safety website, to the local cooling center finder or suggest typically air-conditioned places in the community where people can get relief from the heat (for example language like "air-conditioned libraries, supermarkets, and malls are great places to stay cool". Organizations can also consider pre-scheduling general heat safety messages throughout the summer to keep up constant reminders. Ready.gov has a list of heat safety messages available for use on social media. Hashtags can also promote engagement on social media. The Ready.gov extreme heat safety social media toolkit provides a list of hashtags that may help coordination and awareness for partners working on heat in your jurisdiction.

Signage - Outdoor signage that includes safety messages to prevent heat illness can be helpful for placement of heat advisory information.[121] For example, heat safety signage at parks can inform hikers of health risks at trailheads. Signs can also remind hikers of how much water to bring, symptoms of heat illness, treatment of heat illness, and dangerous times to be out in the heat. Additionally, signage reminding persons of the dangers of heat stroke and possible death for children, pets, or adults who need additional assistance who are left in hot cars can reduce mortality. The temperature within a car parked in the sun can increase quickly, even at lower temperatures. Signage can also be used to identify a designated cooling center. Placing a sign on the front of a building with the hours the cooling center is open may help with accessibility. Placing a map of cooling centers located in a jurisdiction at places such as bus stops may also help increase use of these locations. Signs can be translated into languages relevant to the local population.

Figure 8.

Hydration signs in multiple languages

Figure 9. Outdoor heat safety signs

Figure 10. Outdoor heat warning signs for parking lots

Social care and Front Line health

Health and social service providers have been used to distribute information to the patients that they care for or to reach out to clients who could be at risk during an extreme heat event.[116] One survey focused on health and social care service providers who care for older adults. The majority of health and social service providers were not aware of local heat response plans. These providers did not perceive heat waves to be a frequent enough risk for the older population they cared for to add the extreme heat outreach to their workload.[122] Arizona's Extreme Heat Incident Annex outlines collaboration with regional behavioral health authorities and tribal regional behavioral health authorities to provide messaging to clients and conduct well-checks.[123] In Rome, Italy public health workers have utilized homes visits and phones calls during heat waves.[96] In Montreal, workers for regional health institutions would call individuals with mental health conditions that were known to live alone.[120] During focus groups with individuals diagnosed with schizophrenia, participants had mixed opinions about the phone calls. Some individuals found the calls useful, but others felt the calls gave them anxiety or made them uncomfortable. Participants stated that receiving calls from people they already have connections with would be preferable. More research may be needed to determine the effectiveness of utilizing front line health workers to protect health during heat waves.

Neighbor outreach

Neighborhood outreach can take many different forms. Some plans encourage family, friends, and neighbors to check on older adults or people that live alone. In Baltimore, Community Emergency Response Teams (CERT) went door-to-door to check on older adults and isolated residents.110 Maine's Extreme Heat Plan specifically mentions using social services organizations, such as Meals on Wheels. Volunteers for Meals on Wheels can check on older adults prior to or during heat waves situations to let them know that a heat event is occurring. New Hampshire public health practitioners post heat information at local grocery stores, hospitals, community centers, and homeless shelters. Once a heat emergency is reached, New Hampshire also considers cancellation of government-sponsored outdoor events and school-sponsored sporting events. In San Francisco there is a dedicated homeless outreach team. These outreach workers check on persons experiencing homelessness, obtain needed medical care for them, transport them to open cooling centers, and distribute water bottles. Arizona has similar homeless outreach programs.[123] Previously, New York City used postal service workers and doormen to help identify people who have not picked up their mail or have not left their apartments or flats.[96] Neighborhood outreach can overlap with other strategies, such as social care and front line health (outlined above), making it difficult to assess to direct health impact of individual strategies during heat waves. Still, this is a commonly used strategy.

Cooling centers

The implementation of cooling centers is one potentially effective intervention that has been widely used as a part of heat response plans.[8, 109] A cooling center (or "cooling shelter") is typically an air-conditioned or cooled building that has been designated as a site to provide cooler temperatures and safety during extreme heat. These buildings can be created in existing libraries, community centers, or private businesses. They can be organized and implemented by a variety of stakeholders and may be operated by a health department, city government, non-profit group, or a combination of agencies and partners.[127] The use of cooling centers is not a stand-alone strategy, and their effectiveness is enhanced if they are part of a comprehensive heat response plan. Some common themes from the literature regarding what assisted the implementation and utilization of cooling centers were communication strategies, community outreach, a large group of diverse stakeholders, and multi-functional facilities.

Low-income populations may have limited access to air conditioning[8] or may be hesitant to operate air conditioning and cooling units due to potentially high electricity costs during peak heat hours. Cooling centers can provide a cool environment for these individuals.[116] Their use has a high biological plausibility for reducing heat-related illness and death. In New York State, rural counties do not have many air-conditioned buildings and use outdoor resources as cooling centers including beaches, spray parks, community pools, and public parks.[128]

In 2017, the CDC released a technical guidance document on cooling centers called *The Use of Cooling Centers to Prevent Heat-Related Illness: Summary of Evidence and Strategies for Implementation* (https://www.cdc.gov/climateandhealth/docs/UseOfCoolingCenters.pdf). The authors searched the literature to identify the existing scientific evidence for the use of cooling centers. Although cooling centers are a widely used intervention in the United States, Europe, and Canada, there have been few studies researching direct health outcomes related to them. The authors found 17 highly relevant peer-reviewed articles and 3 relevant grey literature sources. Most research around cooling centers focuses on an evaluation of implementation and utilization. However, there is a lack of research directly relating use of cooling centers to health outcomes, and it is unclear to what extent cooling centers are actually used, making it important to combine this strategy with other response options. In Montreal, focus groups with individuals with schizophrenia and drug and alcohol addiction identified barriers that affected their use of cooling cites. Participants were aware that the recommendations were to use air-conditioned public venues, such as shopping malls, however some participants reported being asked to leave the shopping mall. Participants believed that it was because they were homeless.[112] Other barriers to cooling center use are lack of transportation to the center, lack of knowledge of their existence, and knowledge of what a cooling center is. Given strong evidence that extreme heat is harmful to health and that staying in a cool environment can help to maintain a safe core body temperature and reduce mortality, the evidence suggests that implementation of broader heat response plans that include cooling centers as one strategy might reduce heat-related mortality.

Water bottle distribution

Dehydration was found via surveillance data to increase during extreme heat events.[111] Providing water helps to avoid dehydration for those exposed to high temperatures. Brake and Bates conducted a study evaluated hydration status among miners working in high temperatures. They found that the miners were able to maintain hydration by consuming small amounts of water frequently (roughly 8.5 ounces every 15 minutes). They did not find any dehydration of miners while working despite miners beginning "their shifts insufficiently hydrated".[129] Hydration maintenance was attributed to the frequent water consumption and access to cold water, water flavorings, and yearly education.[129]

Some heat response plans establish mechanisms to distribute water or water bottles to vulnerable populations. Distribution commonly occurs at shelters or cooling centers. San Francisco distributes bottles of water to homeless populations as part of their homeless outreach. The San Francisco plan states," During heat waves, this [distribution of water bottles] has been the most effective way to lessen impact of dehydration."[126] Toronto's hot weather response plan also includes distribution of water bottles to the homeless population via safety patrols.[130] Benmarhnia and colleagues conducted focus groups with individuals with drug and alcohol addiction and found that participants liked to receive water bottles.[120] Additional research could identify if specific health outcomes are prevented by the provision of water during heat waves.

Fan distribution and use

Convection (transfer of heat) and evaporation of sweat are both mechanisms the human body uses to cool down. Use of an electric fan can facilitate these processes, helping to cool the body. Fans are low-cost, accessible, and require less energy to operate than air conditioning, and are thus an attractive option as an intervention to reduce heat-related illness.[131, 132] However, there is mixed evidence about the efficacy of fans during extreme heat events. [132] Factors such as temperature, humidity, hydration levels, and current health status could all impact the effectiveness of fan use in reducing body temperature and protecting health.

There are relatively few peer-reviewed research articles on fan effectiveness. A Cochrane review published in 2012 [133] concluded that existing evidence did not resolve uncertainties about the health effects of electric fans during heat waves, and suggested that randomized trials would help to fill the knowledge gap. A few studies have been conducted with young, healthy, male subjects. Ravanelli and Jay found that 7 out of 8 young, healthy males had elevated core temperature with no fan use, compared to 2 out of 8 with fan use.[131] Even at high temperatures (when the room was hotter than body temperature), the authors concluded that fans are beneficial for healthy people with uncompromised sweating mechanisms, as long as people stay sufficiently hydrated. A 2019 study[134] examined whether the heat index is a useful measure to use when making recommendations about fan use. They found that among young healthy males, fan use in very hot and dry conditions worsened internal temperature, heart rate, sweat rate and overall thermal comfort. However, during hot and humid conditions all factors except sweat rate improved with fan use.[134] The study concluded that fan use is "likely not advisable" during heat waves in very hot arid regions, but may be helpful in humid conditions.

Limited research has been conducted on fan use by populations that are most at-risk of adverse heat outcomes. One study was conducted with elderly adults aged 60-80 years.[132] Researchers monitored core temperature, heart rate, and sweat loss. They found that fan use increased heart rate and core temperature under certain conditions, indicating potential negative health consequences from fan use at high temperatures. While the differences between fan use and no fan use were small, exposure to high temperatures for longer durations could increase those differences. The study found an increase in sweat loss among young adults but not for elderly adults, concluding that when air temperature is greater than skin temperature, fan use is only beneficial if it is accompanied by greater sweat evaporation. In older adults, a reduced sweating capacity may explain why fan use had potentially harmful effects.

When the temperature in a room is above 99°F, the air circulated by fans is warmer than the body's temperature and could potentially exacerbate heat stress. For this reason, fan use is sometimes discouraged in rooms without air conditioning during extreme heat events with particular high temperatures.[1, 109, 134] There is some disagreement among study results, as the Ravanelli and Jay study showed that fans can reduce core body temperature in healthy adults even at temperatures above 107°F (42°C).[131] Additional research is needed on this topic.

Some emergency heat response plans encourage fan use or include efforts to distribute fans to people in need.[135] For example, as a part of heat season response in North Carolina, the Division of Aging and Adult Services coordinates the distributions of fan and some air conditioning units to older adults through Operation Fan Heat Relief.[136] A heat response plan may contain communication related to fan use at different temperatures. Dayton Ohio's plan includes messaging about fan use at temperatures over 95°F (35° C) in closed environments. [118] In many states, the Home Energy Assistance Program (HEAP) can assist eligible residents obtain a fan during the summer and a heat response plan could help disseminate this information among vulnerable populations.

There is little research about fan use as one component of a larger strategy – for example, the impact of fan use combined with communication strategies as part of a larger heat adaptation strategy. Additional research would help to inform actions by health departments and build the evidence base for fan use under certain conditions.

Energy assistance

Some heat response plans include increased messaging about energy assistance programs to help people pay for their electricity bills when temperatures become extremely high. These programs might allow people to continue to use their air conditioners, given that cost can be a major factor when considering air conditioner use.[118]

During a heat emergency in Dayton, Ohio, the Department of Health communicated with the utilities to discourage service disconnection.[118] Other plans established agreements with utility companies to avoid shutting off power during periods of extreme heat.[137] The Low Income Home Energy Assistance Program (LIHEAP) has several suggested strategies, including loaning or giving air conditioning units, and providing higher crisis or cooling benefit payments for electric bills to help offset the higher demand for air conditioning.[138]

Researchers in the New York City Department of Health and Mental Hygiene analyzed heat wave impacts and recommended that Home Energy Assistance Programs in the United States should be rebalanced between heating costs in the winter and cooling costs in the summer to reflect the changing climate.[139]

Changes to the built environment

The built environment refers to the physical environment constructed by humans including buildings and the overall community design. Research has been done to determine if manipulation of built environment design can affect health outcomes by providing cooler temperatures during periods of extreme heat. Although limited evidence exists on the effectiveness of built environment interventions in use, CDC's Climate and Health Intervention Assessment describes how to create cooler spaces for the residents and limit the urban heat island effect.[140]

Large parks and green spaces with an area greater than 10 hectares have been shown to reduce the air temperature on average 1-2 degrees Celsius. The cooling effect from these parks extends beyond the parks boundaries. Even small green spaces can reduce the air temperature in an urban area. Urban planners and designers can decide the best types of urban green spaces to maximize cooling.[142]

A person wearing a yellow safety vest cleans a rooftop solar panel..

Schinasi et al observed that microclimate indicators modify the association between temperature and morbidity and mortality in cities.[143] People living in areas with high ambient temperature and less vegetation have a higher risk of morbidity and mortality. Jeanerette and colleagues found that the rate of reported heat-related illnesses was associated with the neighborhood, daytime land surface temperature (LST) and the daytime LST of a respondent's home. The use of various methods for cooling such as increasing vegetation and white roofs can reduce temperature, and areas with the highest temperatures can be prioritized for planting because it will have the greatest effect in those areas.[144]

Workplace heat alert program

A written workplace Heat Alert Program (HAP) should be developed, and implemented whenever the National Weather Service or other weather service forecasts indicate that a heat wave is likely to occur the following day or days. HAPs may differ in detail from one worksite to another, and an example HAP is described below that may be modified for indoor or outdoor work settings. This intervention is based on recommended standards from the National Institute for Occupational Safety and Health (NIOSH).[146]

1. Each year, early in the spring, establish a Heat Alert Committee, which may consist of a responsible healthcare provider, industrial hygienist or qualified safety and health professional, safety engineer, operation engineer, and manager. Once established, this committee takes care of the following tasks:
    a. Arrange a training course for all involved in the HAP that provides procedures to follow in the event a Heat Alert is declared; emphasize the prevention and early recognition of heat-related illnesses and first aid procedures when a heat-related illness occurs.
    b. By memorandum, instruct the supervisors to perform these tasks:
        i. Reverse winterization of the site, that is, open windows, doors, skylights, and vents according to instructions and if appropriate (e.g., outside temperatures are cooler) for greatest ventilating efficiency at places where high air movement is needed.

        ii. Check drinking fountains, fans, and air conditioners to make sure that they are functional, that the neces-sary maintenance and repairs are performed, that they are regularly rechecked, and that workers know how to use them.

    c. Ascertain that, in the medical department, as well as at the job sites, all facilities required to give first aid in cases of heat-related illness are in a state of readiness.
    d. Establish criteria for the declaration of a Heat Alert.

2. Procedures to be followed during the state of Heat Alert are as follows:
    a. Postpone tasks that are not urgent (e.g., preventive maintenance involving high activity or heat exposure) until the heat wave is over.
    b. Increase the number of workers on each team in order to reduce each worker's heat exposure. Introduce new workers gradually to allow acclimatization (follow heat acclimatization procedure).
    c. Increase rest allowances. Let workers recover in air-conditioned rest places.
    d. Turn off heat sources that are not absolutely necessary.
    e. Remind workers to drink water in small amounts frequently to prevent excessive dehydration, to weigh themselves before and after the shift, and to be sure to drink enough water to maintain body weight.
    f. Monitor the environmental heat at the job sites and resting places.
    g. Check workers' core temperature during their most severe heat-exposure period.
    h. Exercise additional caution on the first day of a shift change to make sure that workers are not overexposed to heat, because they may have lost some of their acclimatization over the weekend and during days off.
    i. Send workers who show signs of a heat-related illness, even a minor one, for medical evaluation. Permission of the responsible healthcare provider to return to work must be given in writing.
    j. Restrict overtime work.
    k. Suspend piece-rate payment mechanisms.

More information on occupational exposures to heat and hot environments can be found at:

- National Institute for Occupational Safety and Health (NIOSH)
- Occupational Safety and Health Administration (OSHA)

Implementing a Heat Response Plan

Implementation of a heat response plan involves many participants across a range of sectors and departments. Health departments may or may not play a strong role in activation and implementation; this will most likely be determined during planning process. Most response plans are activated in a tiered system. Initially the health department may be the only agency involved, but as severity increases more partners will get engaged.

Information needs for a heat response are multifaceted. Weather data are crucial for situational awareness. Being aware in a timely manner of when a National Weather Service Alert is active can help with early planning. Meetings with National Weather

Service personnel can help to improve relationships in the planning and response to a heat event. Typically, a warning coordination meteorologist is in charge of NWS Warning Messages and would be stationed at your local forecast office. They may be helpful to include in development and maintenance of a heat response plan. Additionally, their expertise may be beneficial during a heat event. Some jurisdictions have multiple forecast offices, so it may be helpful to maintain relationships with all offices within the area.

At the state and local level, many organizations within their health department have a designated Public Health Emergency Preparedness (PHEP) Response Team that defines response to an emergency incident using an incident command structure (ICS) with operations, logistics, finance/administration, planning, and command areas. Operations members may play a role in crafting health messaging during an emergency; the ICS may include a public information officer to release messages for the public and other stakeholders. Logistics staff may play a role in disseminating the information to partners through various channels decided upon by the public information officer or another person within the ICS.

Web-based emergency management tools can increase situational awareness between multiple jurisdictions involved in a heat event by posting significant heat events to multiple partners simultaneously, thus enabling more timely assigning of actions, roles, and responsibilities. Having a platform to share updates on events such as power outages can aid risk mitigation strategies that might decrease risk for heat illness and death. For example, some vulnerable populations may require electricity for durable medical equipment. They could be at increased risk for adverse health outcomes if air-conditioning or electricity are unavailable during the summer. WebEOC is one example of a web-based tool that could be beneficial when coordinating between multiple partners to relocate these patients to suitable locations.

Epidemiologists at a public health agency may have access to public health surveillance databases to help describe heat health impacts on the population. Typically, heat-related emergency department visits and inpatient admissions for past events can be accessed through a hospital discharge database. Public health agencies may also have access to death records for persons exposed to excessive heat. Near real-time syndromic surveillance data containing information on patient chief complaints are available in some jurisdictions. This form of hospital-based surveillance provides emergency department visit data from reporting hospitals that are useful in providing an estimate of the number of patients being seen in the ED for heat-related illness. Many jurisdictions participate in the National Syndromic Surveillance Program and have access to this type of data through the BioSense Platform ESSENCE Tool. The Council of State and Territorial Epidemiologists (CSTE) has developed guidance on the use of syndromic surveillance for analysis of climate and health hazards. CSTE has also developed a heat syndrome query guidance document, which provides details on how to implement a syndrome for a public health agency and suggestions for use.

Plan Monitoring and Evaluation

Plan monitoring and evaluation can be useful in ensuring the plan operates as intended and that components of the plan are modified to improve service delivery. These evaluation processes can help ensure that public health can respond as feasibly and efficiently as possible to an extreme heat event. Coordination with the emergency preparedness program or staff within your organization can aid efforts to review and update a plan. Responsible officials in state or local agencies should recommend periodic updates of important information (e.g., changes of personnel and available resources). Revisions should also be forwarded to people on the distribution list who use the plan.

Populations, demographics, and other factors change over time, which is one of the reasons why heat response plans require iterative management. For example, one study compared the mortality rates from the St. Louis, Missouri heat wave in 1989 to the heat wave of 1995 and found higher mortality rates in 1989. There was an increase in air conditioner use and better public health response in 1995, but analysis showed that the 1995 population was more vulnerable because of higher elderly populations and poverty rates.[96] Based on these population changes a heat response plan may require changes in the allocation of resources or partners.

An example of plan maintenance is available at: Arizona Department of Health Services Heat Emergency Response Plan.

Changes can be made to a plan when the document is no longer current. Changes may arise when:

1. a hazard consequence or geographic risk area changes
2. the concept of operations for emergencies changes
3. departments, agencies, or groups that perform emergency functions are reorganized and can no longer perform the emergency tasks laid out in planning documents
4. warning and communication systems change
5. additional emergency resources are obtained through acquisition or agreement, the disposition of existing resources changes, or anticipated emergency resources are no longer available
6. a training exercise or an actual emergency reveals significant deficiencies
7. state/territorial or Federal planning standards relevant to the documents are revised

Methods of updating planning documents

1. **Plan Revision** - A revision is a complete rewrite of an existing plan that results in a new document. Revision is advisable when numerous pages of the document have to be updated, when major portions of the existing document must be deleted or substantial text added, or when the existing document was prepared using a word processing program that is obsolete or no longer available. Revised documents should be given a new date and require new signatures by officials.
2. **Minor Change** - A minor change to a planning document involves updating portions of the document by making specific changes to a limited number of pages. Changes are typically numbered to identify them and are issued to holders of the document with a cover memorandum that has replacement pages attached. The cover memorandum indicates which pages are to be removed and which replacement pages are to be inserted in the document to update it. The person receiving the change is expected to make the required page changes to the document and then annotate the record of changes at the front of the document to indicate that the change has been incorporated into the document. A change to a document does not alter the original document date; new signatures on the document may not need to be obtained.
3. **The Public Health Accreditation Board has created standards and measures** that advance public health by creating a national certifying accreditation process for health departments to ensure they are reviewing health department processes, developing capacity for core functions of public health, and guiding continuous quality improvement. Public health agencies seeking accreditation and those that are certified have measures which outline emergency response plan monitoring and evaluation. Under the Public Health Accreditation Board Standards and Measures, Version 1.5 (Accepted December 2013), Domain 2: Investigate Health Problems and Environmental Public Hazards to Protect the Community, Standard 2.2: Contain/mitigate health problems and environmental public health hazards, measure 2.2.2 A - a process for determining when the all hazards emergency operations plan (EOP) will be implemented is required to have a plan updated within the last five years. The health department must provide protocols in the plan that address environmental public health issues describing processes for the review of specific situations and for determining the initiation of the all hazards emergency operations plan. An Excessive Heat Plan can be used for this measure if it includes these directions on initiating the all hazards emergency operations plan.
4. **Exercising a Plan and After Action Reports** - One process for evaluating and monitoring a plan is to incorporate practicing the plan with partners either through a tabletop exercise or full scale exercise which simulates a scenario. Additionally, real-world events can be useful for determining what worked well, what issues arose, what improvements and protocols are indicated, and recommended improvements. Upon completion of an exercise or real-world event, the Public Health Accreditation Board recommends that significant environmental public health risks consider writing an After Action Report or (AAR). PHAB requires two examples of separate events completed in the last five years documented in AARs that describe successes, issues, and recommended changes in investigation and response

Considerations and Limitations

The development of heat response plans is still a fairly new endeavor for some health and emergency management departments. A study that included local and county health departments from 30 states found that only 40% of respondents had a heat response plan; counties with heat response plans typically have larger populations.[116] Tools and processes used for all-hazards plans or other response plans can be useful starting places for the development of heat response plans. Additional assistance may be needed to help local and county health departments develop and implement a heat response plan.

Evaluation of heat response plans is identified as a gap in much of the literature.[85, 112, 147] The lack of evaluation for heat response plans and individual interventions is identified as an area needing future research.[96, 97] In a review of 18 European heat health action plans, only seven mentioned evaluation.[112] Evaluating these plans is challenging because of lack of data, differing heat wave characteristics (duration, intensity), and simultaneous implementation of heat response plan interventions.[85] Mayrhuber and colleagues discuss the importance of studying heat response plans as a whole. While evaluation of heat response plans in their entirety may be difficult, the interventions work together to enhance one another, and separating them for evaluation purposes may be detrimental for the response.[96] Evaluation is critical because it provides information on the effectiveness of the interventions and identifies areas that need improvement. Lessons learned from implementing the plans and evaluation can be used to make changes and improvements to future heat response plans. What makes interventions effective is different for each intervention and can range from awareness, changes in behaviors, use of services, to reduction of morbidity and mortality.[97]

Forecasted temperatures or indices are commonly used to determine activation for heat response plans. For example, evaluation of the Baltimore Code Red program found that actual temperatures may be higher on some days than forecasted.[110] Accurate forecasts that predict high temperatures at least several days in advance are helpful to give ample time to activate the heat response plan.[148]

Power outages

In cities, elevated summertime heat can increase the overall energy demand for cooling. Generally, this peak in demand occurs during hot summer weekday afternoons, when offices and homes are running cooling systems, lights, and appliances. Studies have shown that for every 1°F (0.6°C) increase in summertime air temperature, the electricity demand in medium and large cities can increase by an estimated 1.5-2.0%. During extreme heat events, which are exacerbated by urban heat islands, the demand for cooling can over overload systems and result in power outages.[149, 150]

Given that some areas have power outages during extreme heat events, heat response plans may include plans for how to deal with power outages. Power outages have also been caused from severe weather events or over-use of the power grid.110, 126 Power outages disable air conditioner usage and can leave more people vulnerable to extreme heat. Air conditioning is a key intervention to prevent exposure to extreme heat. Even a few hours of air conditioning can be beneficial. In 2012 Maryland, Ohio, Virginia, and West Virginia experienced an extreme heat event that was preceded by storms and prolonged power outages. There were 32 heat-related deaths among the four states; 62.5% of the deaths occurred at home without air conditioning. The power outage was a contributing factor in at least 22% of the deaths.[26] There are jurisdictions that have considered power outage issues in their heat response plans. For example, San Francisco's Extreme Heat Response Plan states they predict that during extreme heat, power outages and blackouts will occur.126 Maine's heat response plan has outlined which agency will request additional assistance should there be blackouts or brown outs and they have identified some potential areas of concern and the mechanisms to obtain those additional resources.[124]

Air quality

During the summer, urban heat islands raise the demand for electrical energy for air conditioning. Companies that supply electricity often rely on fossil fuel power plants to meet this demand, which leads to an increase in air pollutants and greenhouse gas emissions in the atmosphere.[150] In 2017, 63% of the electricity generated at utility-scale facilities in the United States was from fossil fuels (coal, natural gas, petroleum, and other gases).[152] The remaining sources of energy was from nuclear energy (20%) and renewable energy (17%).[152] The primary pollutants emitted from power plants include sulfur dioxide, nitrogen oxides, particulate matter, carbon monoxide, and mercury. These pollutants contribute to poor air quality, as well as the formation of ground-level ozone (smog), fine particulate matter, and acid rain. Increased emission of greenhouse gases, such as carbon dioxide, contribute to global climate change.[150]

Innovations and Success Stories

Threshold changes in the Northeast

In 2007, the New York City Department of Health and Mental Hygiene conducted a study of the relationship between extreme heat and health. The researchers determined that heat index was a good predictor of heat health impacts and that the current thresholds should be lowered because risk began to steeply increase in a non-linear manner at temperatures lower than the thresholds in effect at the time.[106] Working with their local National Weather Service (NWS) office and emergency managers, NWS lowered the heat advisory threshold for NYC to any period reaching a heat index of 100°F or higher, or any two or more days with a temperature reaching 100°F or higher.

A collaborative effort between Brown University and health department researchers from Rhode Island, Maine, and New Hampshire investigated how high temperatures affect human health in the New England region.[153] The study found that hospital emergency department visits and deaths from all causes in Maine, New Hampshire and Rhode Island increased significantly (between 5.1% and 7.5% increase) on days when the heat index reached 95° F as compared to days with a maximum heat index of 75° F. The study also found that people with existing health conditions (e.g., asthma, heart disease, kidney disease) were at higher risk when the heat index reached 95° F degrees.[153] The results of this study were shared with officials at the National Weather Service's (NWS) New England and Regional offices, prompting a change in the policy for issuing heat advisories. The policy was updated to state that heat advisories would be issued when the heat index is forecast to reach 95° F for any amount of time on two or more consecutive days, or a heat index of 100° F for any amount of time on a single day. The previous policy initiated heat advisories when the daily maximum heat index was forecast to be 100° F for two or more consecutive days.[154]

Similarly, an extreme heat-health study conducted by the New York State Department of Health (NYSDOH) found that heat stress and heat-related illnesses occurred at much lower temperatures than the temperature criteria used by the NWS to initiate heat advisories.[105, 155] To reduce the impact of heat on health across the state, the NYSDOH worked closely with local NWS offices to develop a recommendation to lower the heat advisory thresholds. Based on these recommendations, effective June 2018, four NWS offices (Albany, NY; Binghamton, NY; Buffalo, NY; Burlington, VT) lowered the heat advisory criteria for New York State. With the new criteria, heat advisories are issued when heat indices of 95° F or more for two or more consecutive hours are expected. The revised criteria exclude Lower Hudson Valley, New York City & Long Island regions.[156]

Cooling assistance

Many states provide cooling assistance through the federal Home Energy Assistance Program's Low Income Home Energy Assistance Program (LIHEAP). The Cooling Assistance LIHEAP benefit is available to low-income households through state programs and helps eligible participants by offering assistance with utility bill payments or the provision of fans or ACs for their home. This cooling benefit can help reduce the impact of heat and prevent heat-related illness and death among vulnerable populations. The program primarily aims to benefit residents with pre-existing health conditions that can be exacerbated by extreme heat. Eligibility for cooling assistance benefits depends on current income guidelines and can vary by household size. In addition, the types of assistance can vary by state. For instance, some states such as New Jersey allow the assistance to be spent on utility costs during the summer to help with running air conditioning, while other states only allow the purchase and installation of air conditioning units. New York State's HEAP, run by the NYS Office of Temporary and Disability Assistance (OTDA) provides eligible New Yorkers with cooling benefits in the form of a fan or air-conditioning unit per applicant household. In 2018, the NYS DOH worked with the NYS OTDA to increase awareness of existing cooling benefits through promotional flyers and social media posts.

Creating heat-health alert thresholds for vulnerable communities

North Carolina's Department of Health and Human Services, partnering with local prevention specialists trained in heat-related illness prevention, implements heat-health alert systems targeted to specific vulnerabilities in southeastern North Carolina. The systems lower the alert temperature threshold from NWS heat advisory levels of 105° to 100° F. The systems specifically target farm workers, low-income earners, older adults receiving nutritional assistance, and youth using county parks and recreation, through partnerships with Manos Unidas, Robeson County Health Department, Sampson County Department of Aging, and Scotland County Health Department. Alerts are communicated through farm worker health trainings, an information campaign with a local housing authority, nutritional assistance site staff trainings, and parks and recreation staff trainings. The prevention information often complements existing efforts, such as integrating heat-related illness prevention for farmworkers with sun protection and pesticide information. These messages increase awareness among key service providers to vulnerable communities.

Utilizing syndromic surveillance during the summer heat

Pinal County Public Health Services District (PCPHSD) is a county health department in Arizona which implements heat surveillance during the summer. Data are used to determine the burden of heat illness among Pinal County residents, increase understanding of risk factors and populations, and to develop effective interventions to reduce the annual number of heat-related illness (HRI) cases. Temperatures in 2018 reached 116 °F during the summer. Each year, Pinal County has 150-250 emergency department or hospital admissions from the heat. PCPHSD participates in the Pinal Heat Relief Network, which provides heat relief to residents through hydration stations, cooling centers, and water donation coordination. In addition to increasing understanding of risk factors, the data aimed at helping the Heat Relief Network identify where heat relief stations may need to be placed.

PCPHSD conducted heat syndromic surveillance using the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE). ESSENCE is a product of the Centers for Disease Control and Prevention's (CDC) BioSense Platform.

Project activities included a descriptive epidemiological analysis of heat illness cases from historical hospital discharge data, syndromic surveillance, and mortality surveillance of HRI cases among county residents during May-September of 2018, medical chart reviews, and interviews with cases who visited an emergency room or were admitted to a hospital for HRI. The surveillance helped identify factors associated with heat illness (e.g. occupational, recreational, and economic). Interviews also provided an opportunity to disseminate heat safety resources that would help prevent future issues.

As a result of the county efforts, surveillance data and information on eight Excessive Heat Warnings throughout the summer was sent to 40 Heat Relief Network partners. Pinal also developed a heat safety resources packet (includes heat safety tips, utility assistance, and homelessness resources) that was disseminated to cases during interviews.[157]

Some topics to consider in the creation of a heat response plan:

- The relationship between temperature and mortality and morbidity in your area, which can inform thresholds of activation;
- Location and geographic distribution of vulnerable populations (see "At-Risk Groups" section of this document):
  - over 65 and under 5 years of age
  - live in nursing homes or assisted living facilities
  - work primarily outdoors and athletes
  - have medical conditions that decrease the ability to adapt to heat;
  - are socially or linguistically isolated
  - are unable to access/afford air conditioning
- Your local climate record and observed regional temperature trends;
- The prevalence of air conditioning in the public/work buildings and private residences and the ability of your population to acquire cooling units and pay for utilities;
- Your health and human services/family support services/social services or other responsible agencies' capacities to provide cooling services, staff cooling centers, transportation, and offer other heat –relief services and activities;
- The availability of other non-governmental service agencies that provide services to vulnerable populations;
- Current capacity and systems in place to communicate and educate the public and at-risk populations;
- Coordination of different organizations roles in planning and dissemination of heat response plan.
- Location of assets, e.g.:
  - Public air conditioned buildings
  - Shady spaces
  - Cooling centers or community support centers hosted by partners
  - Transportation routes

Selected Resources

General Extreme Heat Health Information

- National Integrated Heat Health Information System: NIHHIS
- The Global Heat Health Information Network: GHHIN
- Excessive Heat Events Guidebook from EPA, CDC, and FEMA: https://www.epa.gov/sites/production/files/2016-03/documents/eheguide_final.pdf
- Minnesota Extreme heat Toolkit: https://www.health.state.mn.us/communities/environment/climate/docs/mnextremeheattoolkit.pdf
- CDC's Extreme Heat Guide: https://www.cdc.gov/disasters/extremeheat/heat_guide.html
- CDC's Heat-Related Illness Infographic: https://www.cdc.gov/disasters/extremeheat/warning.html
- Climate and Health Assessment chapter on heat-related death and illness: https://health2016.globalchange.gov/temperature-related-death-and-illness
- Health Canada Extreme Heat Events Guidelines: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/climate-change-health/extreme-heat-events-guidelines-technical-guide-health-care-workers.html

Climate and Extreme Heat

- Climate Science Special Report Chapter on Temperature Changes in the US: https://science2017.globalchange.gov/chapter/6/
- Fourth National Climate Assessment https://nca2018.globalchange.gov/chapter/2/
- CDC's climate and extreme heat guidebook: https://www.cdc.gov/climateandhealth/pubs/extreme-heat-guidebook.pdf

Sample Heat response plans

- Office of the Assistant Secretary for Preparedness and Response (ASPR) Sample heat response plan: https://www.cdc.gov/nchs/nvss/index.htm

At Risk Populations

- Arizona Department of Health Services Older Adult Toolkit: http://www.azdhs.gov/preparedness/epidemiology-disease-control/extreme-weather/index.php#heat-elderly
- Minnesota Department of Health data source appendix for characteristics that increase the risk of heat-related illnesses: https://www.health.state.mn.us/communities/environment/climate/docs/appendix_f.pdf
- Minnesota Department of Health appendix on Categories of medicines that may increase the risk of heat-related illnesses: https://www.health.state.mn.us/communities/environment/climate/docs/appendix_b.pdf

Workplaces

- National Institute for Occupational Safety and Health (NIOSH): https://www.cdc.gov/niosh/topics/heatstress/default.html
- Occupational Safety and Health Administration (OSHA): https://www.osha.gov/SLTC/heatstress/index.html

Tracking and Surveillance

- CDC's Heat Stress Illness tracking page: https://ephtracking.cdc.gov/showTrackingHeatStressIllness
- New York State county heat and health profile reports: https://www.health.ny.gov/environmental/weather/profiles/
- CSTE Guidance document for heat-related syndromic surveillance https://cdn.ymaws.com/www.cste.org/resource/resmgr/pdfs/pdfs2/CSTE_Heat_Syndrome_Case_Defi.pdf

Cooling Centers and Mapping

- CDC's "The Use of Cooling Centers to Prevent Heat-Related Illness: Summary of Evidence and Strategies for Implementation": https://www.cdc.gov/climateandhealth/docs/UseOfCoolingCenters.pdf
- Maricopa County Cooling Stations and Water Donation Map: https://www.maricopa.gov/2461/Cooling-Stations-Water-Donation
- Missouri Data Portal Cooling Centers Map: https://data.mo.gov/Health/Missouri-Cooling-Centers-Map/2wki-9iz8/data
- National Weather Service Heat Risk Map: https://www.wrh.noaa.gov/wrh/heatrisk/
- New York State Heat Vulnerability Index: https://www.health.ny.gov/environmental/weather/vulnerability_index/index.htm
- New York State Cooling Centers Map: https://apps.health.ny.gov/statistics/environmental/public_health_tracking/tracker/#/CCMap

Communication materials and trainings

- Ready.gov heat toolkit: https://www.ready.gov/heat-toolkit
- Oregon Health Authority risk communication resource toolkit for partners: https://www.oregon.gov/oha/PH/Preparedness/Partners/Pages/riskcommunicationtools.aspx

- CDC Recognizing, Preventing and Treating Heat-Related Illness course for coaches, teachers, parents, and high school athletes: https://www.cdc.gov/nceh/hsb/extreme/Heat_Illness/index.html
- CDC Locker room flyer for athletes: https://www.cdc.gov/nceh/hsb/extreme/Heat_Illness/Heat%20Related%20Illness%20_What%20You%20Should%20Know%20Poster.pdf
- CDC Parent handout on heat and athletes: https://www.cdc.gov/nceh/hsb/extreme/Heat_Illness/Parent_Caregiver%20Information%20.pdf
- CDC Heat and Athletes website: https://www.cdc.gov/disasters/extremeheat/athletes.html
- CDC Extreme heat video: https://www.youtube.com/watch?v=e2mZGhOIFG0
- CDC Warning Signs and Symptoms of Heat-Related Illness Fact Sheet: https://www.cdc.gov/disasters/extremeheat/warning.html
- CDC Extreme Heat Infographic: https://www.cdc.gov/cpr/infographics/beattheheat.htm
- Tri-fold for low-income earners who may be experiencing energy poverty: https://publichealth.nc.gov/chronicdiseaseandinjury/doc/StayingCoolDuringTheHeat(TriFoldEnglish).pdf
- Foldable heat illness prevention card for workers (English): https://publichealth.nc.gov/chronicdiseaseandinjury/doc/WhatToDoDuringHeatHealthAlerts(FoldableCardEnglish).pdf
- Foldable heat illness prevention card for workers (Spanish): https://publichealth.nc.gov/chronicdiseaseandinjury/doc/WhatToDoDuringHeatHealthAlerts(FoldableCardSpanish).pdf

Appendix

Methods

An initial peer-reviewed and grey literature search was conducted for the search term "heat response plans," in the spring of 2018. Additional input was received from grantees of CDC's Climate-Ready States and Cities Initiative. Relevant articles and six publicly available state and city heat response plans were reviewed. Based on this initial information, a narrative review was then conducted with assistance from the CDC Library using PubMed, Embase, ProQuest, Agriculture & Environmental Science databases and Scopus databases. The literature search focused on a review of heat response plans. The goal was to seek information to inform health departments on various aspects of heat response plans, including evidence for their use and implementation. Abstracts including the phrases "heat response plans,"" heat wave response plan," "extreme heat plan," "heat action plan," "heat health action plan," "heat wave prevention plan," "heat wave action plan," "heat mitigation plan," and "heat wave plans" were included. The search had no lower restriction on date range and included articles through May 2018. The search yielded 199 articles. All of the abstracts for the articles were reviewed. Additional articles were identified through snowball searching by examining citations and "cited by" references. Additional citations and resources were recommended by CDC staff, the author team, reviewers, and subject matter experts.

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