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All scientific information in this document is derived from peer-reviewed assessments, including those published by the United States Global Change Research Program and the Intergovernmental Panel on Climate Change, from other peer-reviewed literature, or from federal government agencies.
Overview

Extreme heat events pose a serious danger to people throughout the United States. Studies conducted by the Centers for Disease Control and Prevention (CDC) have shown that exposure to extreme heat can increase discomfort and fatigue, cause heat cramps, and increase emergency room visits and hospitalizations. It can also kill. From 1999 through 2009, extreme heat exposure caused or contributed to more than 7,800 deaths in the United States (Kochanek et al, 2011).

Extreme heat is a real danger to human health that will become worse with time. Experts project that as our climate changes, extreme heat events in the United States will become more frequent, longer lasting, and more severe. By the end of this century, extremely high temperatures that currently occur once every 20 years could happen as often as every two to four years.

**Learning about how to prepare for and respond to extreme heat events will help protect our communities, especially the most vulnerable populations, from avoidable death and hardship.**

This document describes extreme heat events, how an extreme heat event threatens public health, and how to prepare for and respond to such an event. It explains how the frequency, duration, and severity of extreme heat events are increasing as a result of climate change, and includes links to local programs and real-world examples from across the country.

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**RARE HEAT EVENTS WILL BECOME MORE COMMON**

By the end of this century, an extreme heat event that currently occurs once every 20 years could occur every two to four years in most parts of the country. This example is based on how the climate is expected to change under a high greenhouse gas emissions scenario (A2; see page 7 for a description of scenarios).
Understanding Extreme Heat Events

What Is an Extreme Heat Event?

While there is no single agreed upon definition of an extreme heat event, most definitions refer to an extended period of time (several days or more) with unusually hot weather conditions that potentially can harm human health.\(^5\)

The U.S. Environmental Protection Agency defines extreme heat events as “periods of summertime weather that are substantially hotter and/or more humid than typical for a given location at that time of year.”\(^4\)

One of the most severe extreme heat events in recent U.S. history occurred in July 1995 in Chicago. During this event, the extended increase in daily maximum temperatures (black line) as compared to the average for 1990-2000 (blue line) had an estimated result of more than 650 deaths.\(^3\)
Health Effects of Extreme Heat Events

Heat waves can be deadly. Extreme heat was the leading cause of weather-related deaths in the United States from 2000 through 2009. From 1999 through 2009, extreme heat exposure caused more than 7,800 deaths in the United States.

In addition to deaths, extreme heat events cause a wide range of other health problems such as rashes, cramps, heat exhaustion, and heat stroke. Extreme heat can also make existing medical conditions worse. Though harder to count than deaths, these health conditions affect far more people and lead to extra emergency room visits and hospitalizations.

Extreme heat events are a problem around the world. For example, in 2003, an extreme heat event in Europe killed 14,800 people in France alone.
Everyone should take steps to protect themselves and their families’ health during an extreme heat event, but some people are more vulnerable than others. Young children, people aged 65 and older, persons with certain disabilities, those living in poverty or social isolation, and the homeless have a much higher risk of heat-related health problems than other people living in a population.\textsuperscript{4,9,10,11}

If current population trends continue, the number of vulnerable Americans aged 65 and older will continue to grow.\textsuperscript{2} In addition, the number of people living in urban areas may continue to increase exposing more vulnerable individuals in the future to the “urban heat island” effect (see figure at right).\textsuperscript{2} Changes in health care, transportation patterns, and urban design could either increase or decrease the risk, but these changes are harder to predict than population trends.

Cities can be up to 10°F warmer than surrounding rural areas and can maintain warmer temperatures throughout the night. Concrete and asphalt in cities absorb and hold heat. Tall buildings reduce potentially cooling air flows. Urban environments may lack trees and other vegetation that provide shade and increase cooling through evaporation. As a result, city-dwellers may experience longer and more severe periods of extreme heat compared to rural or suburban dwellers.\textsuperscript{2}
Climate Change and Extreme Heat Events

Climate Change and a Warming World

The Earth is getting warmer because people are adding greenhouse gases, such as carbon dioxide and methane, to the atmosphere. Most of these gases are being released as a result of burning fossil fuels like coal, oil, and natural gas. As these gases build up in the atmosphere, they trap extra heat and cause average temperatures to increase—a process called global warming. Warmer temperatures lead to many other changes in the atmosphere, on land, and in the oceans. Together, these changes are known as climate change.

Average temperatures around the world have become warmer since the start of the 20th century, and they have risen at a particularly fast rate during the last 50 years. Nine of the ten warmest years on record have occurred since 2000.

Like the rest of the world, the United States has become warmer. The U.S. average temperature has risen more than 2.0°F over the past 50 years, and it is projected to rise more in the future. Some parts of the country have experienced more warming than others (see figure).
Future Climate Change

Scientists expect the Earth to keep getting warmer in the years ahead. Their projections are based on past and current observations, trends in greenhouse gas emissions, and computer models that show how additional greenhouse gases in the atmosphere will affect average climate conditions in different parts of the world. Climate models project a continued increase in the Earth's average temperature over time. The amount of warming depends on the time period under consideration, and the greenhouse gas emissions scenarios (see box below).

Because it is difficult to project far-off future emissions and other human factors that influence climate, scientists use a range of emissions scenarios using various assumptions about future economic, social, technological, and environmental conditions.

Scientists have modeled future temperature changes based on a variety of greenhouse gas emissions scenarios. Each scenario is based on a set of assumptions about population trends, economic development, and technology—all of which affect the amount of greenhouse gases emitted over time. The figure shows the best estimate (solid line) and likely range (shaded area) of how much temperature will have changed at different points in time relative to the 1960–1979 average for emissions scenarios cited in various graphics throughout this publication.
Extreme Heat Events Will Become More Frequent and More Severe

Scientists expect climate change to lead to longer, more severe, and more frequent extreme heat events. Even using different climate models and emissions scenarios, the results generally point to extreme heat events becoming worse in almost every regard.²,³

**Duration**

Increases in average temperatures are projected to make extreme heat events last longer. Under an emissions scenario in which average temperatures have risen 6.3°F (IPCC A2 scenario), most Americans could expect to see extreme heat events lasting 10 to 20 days longer than in the past (see page 9 first figure).³

**Severity**

Another effect of higher average temperatures is more severe heat events. The likelihood of more hot weather and more record hot weather increases as average temperatures increase (see upper right figure).¹⁶ The box on the top of page 10 provides examples of how climate is projected to change in the United States. This particular study modeled how summertime temperatures in New Hampshire and Illinois could feel in the future. Under the higher emissions scenario, by the late part of this century, people in New Hampshire would experience a summer climate close to the current norm for North Carolina, while those in Illinois would experience a climate like that currently experienced in Louisiana or Texas.

**Frequency**

Climate change will also cause extreme heat events to happen more often. Studies show that by the end of this century, the number of days with temperatures reaching 100°F or more is projected to increase dramatically across the United States as a result of climate change. What the public now considers to be an exceptional event could become routine across much of the country (see page 9 second figure).²
When average temperatures increase, the longest extreme heat events (here, defined as the longest event occurring in a 20-year period) will become even longer than in the past (1961–1979). In the warmest scenario, most of the country would experience an increase in its longest extreme heat event of 10-20 days.\(^3\)

Whether using a lower or higher emissions scenario, the number and distribution of days per year over 100°F are expected to increase dramatically.\(^2,17\)
Projected Health Effects of Extreme Heat Events in the Future

As temperatures rise and extreme heat events become longer, more severe, and more frequent, experts expect to see more health problems and deaths caused by heat. Researchers have looked at a variety of scenarios and models, and consistently have reached the same conclusions:

• With climate change, the number of deaths due to extreme heat is expected to keep increasing over time.
• Higher emissions scenarios project a more dramatic rise in heat-related deaths over time.

These projections are not precise. For example, they assume that the death rate associated with a particular level of extreme heat (such as a 100°F day in Chicago) will be similar to the patterns observed in the past. But if the relationship between heat and death rates changes in the future, the expected number of deaths might increase or decrease. For example, people might get more used to extreme heat and communities might plan and prepare for heat more effectively. Changes in demographics could also affect the number of heat related deaths.
Responding to Extreme Heat Events

Extreme Heat Programs: Working to Protect Public Health

Many of the negative health effects attributable to extreme heat events are preventable.1,11 Many cities throughout the United States and abroad have successfully developed and deployed extreme heat programs over the past 30 years, protecting public health and saving lives.1,11 The most effective programs incorporate a variety of elements, which are found in federal recommendations and can be adapted according to local conditions and needs.4,10 Protecting the public from extreme heat events also can be part of a broader process of planning for natural hazards and disaster preparedness. These efforts require engaging many of the same stakeholders, affect many of the same vulnerable populations, and call for similar types of public outreach and education.

How Do Extreme Heat Programs Perform?

Ideally, public health officials would evaluate the effectiveness of extreme heat programs and quantify the number of lives saved. In reality, though, it can be difficult to judge a program’s performance, as its elements change over time and the number and nature of extreme heat events vary from year to year. As a result, few extreme heat programs in the United States have been studied in depth to determine if they are truly effective. However, the limited number of studies that have taken place have concluded that extreme heat programs save lives.3,18

Developing and implementing extreme heat programs does not have to cost a lot of money.4 Given the potential to save many lives for a relatively small cost, communities may benefit from establishing extreme heat programs as an adaptive response to the very real threat that climate change poses.
Kansas City developed its extreme heat program after a heat event in July, 1980, which caused a number of deaths in the metropolitan area. Kansas City’s program relies on numerous partnerships to help identify people at risk and coordinate services. The Kansas City Health Department is the lead agency for the city’s extreme heat program. As such, the Health Department:

- Assists the National Weather Service in determining whether to issue heat-health notifications and notifies other program partners of extreme heat decisions.
- Coordinates extreme heat-related response activities.
- Develops and coordinates extreme heat-related public messaging, media, and communication strategies.
- Collects and summarizes information on the health impacts of extreme heat and interventions undertaken during specific events.
- Suggests improvements to health surveillance systems.

The Kansas City Health Department also coordinates pre-season and end-of-season meetings with partners to review community plans and evaluate performance. At these meetings, the Health Department and its partners can consider recruiting additional partners to help serve difficult-to-reach high-risk segments of the population, such as the elderly, “shut-ins,” and the homeless.

Over time, the Health Department’s role has shifted from providing assessment and intervention services to its current role of declaring events, coordinating partners, and managing public information and education efforts. This new role keeps the program effective by leveraging partnerships to extend the reach of information and services to the most vulnerable people during heat events.
Conclusion

More Extreme Heat Events Will Increase Need for Public Health Programs

Deaths and illnesses associated with extreme heat events will likely increase as more frequent, longer, and more severe future extreme heat events occur. There is a clear need for enhanced recognition of the public health challenges that future extreme heat events will pose.

Currently, effective programs offer hope that this health challenge can be met. Today, a wide range of creative and resourceful partnerships in locations across the country address the challenges of extreme heat events. As the earth continues to warm, public health officials will need to develop and implement extreme heat programs that are flexible enough to manage under extraordinary conditions that will become increasingly common.

Examples of materials that are available already for interested parties to incorporate in an extreme heat program are provided below.

Many cities have developed specific tools to aid in the assessment of potential risk to populations during an extreme heat event or to help with the response to these conditions. Source: Baltimore City Health Department, 2009.
**Climate Change and Extreme Heat Events**

**HEAT EXHAUSTION**

- Heavy sweating
- Weakness
- Cold, pale, clammy skin
- Fast, weak pulse
- Nausea or vomiting
- Fainting

**WATCH FOR THE SIGNS**

Seek medical care immediately if you have or someone you know has symptoms of heat sickness. Warning signs and symptoms vary but may include:

- High body temperature (104°F or higher rectally)
- Hot, red, dry or moist skin
- Rapid and strong pulse
- Possible unconsciousness

**HEAT STROKE**

Check on the elderly, or people aged 65 years or older, to make sure they are safe by staying cool, hydrated, and informed.

**People with a chronic medical condition** are less likely to sense and respond to changes in temperature. Also, they may be taking medications that can intensify the effects of extreme heat.

**WHO NEEDS SPECIAL CARE?**

The elderly, people with a chronic medical condition, children, homeless or poor, outdoor workers, and athletes are most at-risk to heat sickness.

**Athletes and people who exercise** in extreme heat are more likely to become dehydrated and are more likely to get heat sickness.

- Limit outdoor activity, especially mid-day when it is the hottest part of the day.
- Schedule workouts and practices earlier or later in the day to avoid midday heat.
- Pace activity. Start activities slowly and pick up the pace gradually.
- Drink from two to four cups of water every hour while exercising. Muscle cramping may be an early sign of heat sickness.

**People who work outdoors** are more likely to become dehydrated and are more likely to get heat sickness.

- Drink from two to four cups of water every hour while working. Don’t wait until you are thirsty to drink.
- Avoid alcohol or liquids containing large amounts of sugar.
- Wear and reapply sunscreen as indicated on the package.
- Ask if tasks can be scheduled for earlier or later in the day to avoid midday heat.

**FOR MORE INFORMATION**

[www.cdc.gov/nceh/extremeheat](http://www.cdc.gov/nceh/extremeheat)

Public health agencies are increasingly providing information on appropriate extreme heat event responses. Source: CDC, 2011.
Examples of Resources for Further extreme heat events-related Information

### Understanding the Health Risks of Extreme Heat Events

<table>
<thead>
<tr>
<th>Resource</th>
<th>Link</th>
</tr>
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<tbody>
<tr>
<td>Excessive Heat – NOAAWatch</td>
<td>noaawatch.gov/themes/heat.php</td>
</tr>
</tbody>
</table>

### The Impact of Climate Change on Extreme Heat Events

<table>
<thead>
<tr>
<th>Resource</th>
<th>Link</th>
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</thead>
<tbody>
<tr>
<td>Global Climate Change Impacts in the United States</td>
<td>globalchange.gov/publications/reports/scientific-assessments/us-impacts/full-report</td>
</tr>
<tr>
<td>Climate Change Indicators in the United States</td>
<td>epa.gov/climatechange/indicators.html</td>
</tr>
</tbody>
</table>

### Guidance for Developing Extreme Heat Events Programs

<table>
<thead>
<tr>
<th>Resource</th>
<th>Link</th>
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<tbody>
<tr>
<td>Health Canada: Developing Heat Resilient Communities and Individuals in Canada</td>
<td>hc-sc.gc.ca/ewh-sem/climat/adapt/heat-chaleur-eng.php</td>
</tr>
<tr>
<td>U.S. Environmental Protection Agency: Extreme Heat Events Guidebook</td>
<td>epa.gov/heatisld/about/heatguidebook.html</td>
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</tbody>
</table>

### Examples of Local Extreme Heat Program Resources

<table>
<thead>
<tr>
<th>Resource</th>
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<tbody>
<tr>
<td>Baltimore City Health Department: Code Red Heat Alert Information (homepage)</td>
<td>baltimorehealth.org/coderedinfo.html</td>
</tr>
<tr>
<td>City of Boston: Helping the Homeless During Extremely Hot Weather</td>
<td>cityofboston.gov</td>
</tr>
<tr>
<td>City of Kansas City, Missouri: Heat Information</td>
<td>kcmo.org/CKCMO/Depts/Health/Heatinformation/</td>
</tr>
<tr>
<td>City of Phoenix Salvation Army: Heat Relief Response: The Salvation Army Emergency Disaster Heat Emergency Response</td>
<td>usw.salvationarmy.org</td>
</tr>
<tr>
<td>City of San Jose, California: Heat Wave Response</td>
<td>sanjoseca.gov</td>
</tr>
<tr>
<td>City of Toronto: Hot Weather Response Plan</td>
<td>toronto.ca/health/heatalerts/beathet_program.htm</td>
</tr>
<tr>
<td>St. Louis, Missouri: Operation Weather Survival</td>
<td>crh.noaa.gov/lsx/?n=ows</td>
</tr>
<tr>
<td>Washington, D.C: Heat program resources (homepage)</td>
<td>dcema.dc.gov</td>
</tr>
<tr>
<td>U.S. EPA: Heat Island Effect</td>
<td>epa.gov/heatislands</td>
</tr>
</tbody>
</table>
References


17. The lower emissions scenario = B1; the higher emissions scenario = A2.
