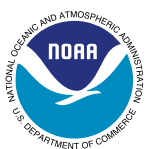


Excessive Heat Events Guidebook

EPA 430-B-06-005 | June 2006



FEMA

United States Environmental Protection Agency
Office of Atmospheric Programs (6207J)
1200 Pennsylvania Avenue NW, Washington, DC 20460



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For further information

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This guidebook reflects the commitment of individuals who contributed their time and expertise to guide its development while evaluating a wide range of information. The key contacts at each of the partnering agencies were instrumental in the guidebook's development. Alan Perrin and Jason Samenow of EPA served as the guidebook's day-to-day project managers from its conceptualization through production. Jannie Ferrell and Mark Tew of NOAA's NWS, George Luber and Mike McGeehin of CDC, and Carl Adrianopoli of DHS similarly served as the principal guidebook contacts at their respective agencies, facilitating access to the respective staff and resources of those agencies. David Mills of Stratus Consulting managed the guidebook's technical development as the primary EPA consultant. He was greatly assisted in this work by Dr. Laurence Kalkstein of Applied Climatologists Inc. and the University of Delaware Center for Climatic Research. Dr. Kalkstein helped pioneer, and continues to lead, the development of integrated meteorological and human health models for forecasting excessive heat event (EHE) conditions. He also contributed a wealth of background information in the form of published articles about and insight into forecasting EHEs, quantifying their health impacts, and coordinating the development of EHE watch/warning systems.

Ultimately, though, this guidebook could not have been developed without the involvement of the members of the Technical Working Group (TWG) that was assembled to help identify and summarize essential information and to comment on drafts of the guidebook. Their collective experience designing, implementing, supporting, operating, and evaluating EHE notification and response programs throughout the United States and Canada was an invaluable resource. The members of the TWG are as follows:

- ▶ Nancy Day and Marco Vittiglio, *Toronto Public Health*
- ▶ Timothy Burroughs, Nikolaas Dietsch, Anne Grambsch, and Kathy Sykes, *EPA*
- ▶ Tony Haffer, Melinda Hinojosa, and Paul Trotter, *NOAA/NWS*
- ▶ Jerry Libby (retired) and Lawrence Robinson, *City of Philadelphia Department of Public Health*
- ▶ Christopher Payne, *Cincinnati Health Commissioner's Office*
- ▶ Liz Robinson, *Energy Coordinating Agency of Philadelphia.*

The TWG's guidance and perspective make this guidebook such a potentially useful resource. The members' enthusiasm and commitment of time to the guidebook's development are deeply appreciated by the partnering agencies and those involved with the guidebook's technical development.

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Pamela Blixt, *City of Minneapolis Emergency Preparedness Coordinator*; Robert Davis and Chip Knappenberger, *New Hope Environmental Services*; Kristie Ebi, *Exponent Inc.*; Pat Finnegan, *Metropolitan Chicago Healthcare Council*; Robert French and Warren Leek, *Maricopa County*; Stephen Keach, *Perrin Quarles Associates*; Sari Kovats, *London School of Hygiene and Tropical Medicine*; Marc Rosenthal, *Yale University*; Jonathan Skindlov, *Salt River Project Water Resource Operations*; Steven Wallace, *University of California, Los Angeles Center for Health Policy Research*; and Scott Wright, *University of Utah*.

List of Acronyms and Abbreviations

CDC	Centers for Disease Control and Prevention
CSA	Canadian Standards Approved
DHS	U.S. Department of Homeland Security
EHE	excessive heat event
EMS	emergency medical service
EPA	U.S. Environmental Protection Agency
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PCA	Philadelphia Corporation for Aging
SMSA	standard metropolitan statistical area
SSC	spatial synoptic classification
TWG	Technical Working Group
UL	Underwriter Laboratories



Summary

Introduction

Excessive heat events (EHEs) are and will continue to be a fact of life in the United States. These events are a public health threat because they often increase the number of daily deaths (mortality) and other nonfatal adverse health outcomes (morbidity) in affected populations. Distinct groups within the population, generally those who are older, very young, or poor, or have physical challenges or mental impairments, are at elevated risk for experiencing EHE-attributable health problems. However, because EHEs can be accurately forecasted and a number of low cost but effective responses are well understood, future health impacts of EHEs could be reduced. This guidebook provides critical information that local public health officials and others need to begin assessing their EHE vulnerability and developing and implementing EHE notification and response programs.

Health impacts of EHEs

EHE conditions are defined by summertime weather that is substantially hotter and/or more humid than average for a location at that time of year. EHE conditions can increase the incidence of mortality and morbidity in affected populations. Recent examples of EHE health impacts include:

- ▶ More than 15,000 deaths in France alone (all of western Europe was affected) attributed to EHE conditions in August 2003
- ▶ More than 700 deaths attributed to EHE conditions in Cook County, Illinois, in July 1995
- ▶ Roughly 120 deaths attributed to EHE conditions in Philadelphia, Pennsylvania, in July 1993.

Concern over the potential future health impacts of EHEs follows research conclusions that EHEs may become more frequent, more severe, or both in the United States.

Responding to EHE conditions

The potential for reducing future health impacts of EHEs in the United States is significant for several reasons.

First, meteorologists can accurately forecast EHE development and the severity of the associated conditions with several days of lead time. This provides an opportunity to activate established EHE notification and response plans or to implement short-term emergency response actions absent an existing plan.

Second, specific high-risk groups typically experience a disproportionate number of health impacts from EHE conditions. The populations that have physical, social, and economic factors and the specific actions that make them at high risk include:

- ▶ Older persons (age > 65)
- ▶ Infants (age < 1)
- ▶ The homeless
- ▶ The poor
- ▶ People who are socially isolated

- ▶ People with mobility restrictions or mental impairments
- ▶ People taking certain medications (e.g., for high blood pressure, depression, insomnia)
- ▶ People engaged in vigorous outdoor exercise or work or those under the influence of drugs or alcohol.

Identifying these high-risk groups in given locations allows public health officials to develop and implement targeted EHE notification and response actions that focus surveillance and relief efforts on those at greatest risk.

Third, broad consensus exists on the types of actions that will provide relief to those at risk during EHEs and help minimize associated health impacts. These actions include:

- ▶ Establishing and facilitating access to air-conditioned public shelters
- ▶ Ensuring real-time public access to information on the risks of the EHE conditions and appropriate responses through broadcast media, web sites, toll-free phone lines, and other means
- ▶ Establishing systems to alert public health officials about high-risk individuals or those in distress during an EHE (e.g., phone hotlines, high-risk lists)
- ▶ Directly assessing and, if needed, intervening on behalf of those at greatest risk (e.g., the homeless, older people, those with known medical conditions).

Experience in several North American cities has demonstrated that comprehensive and effective EHE notification and response programs can be developed and implemented at relatively low cost. These programs generally use available resources instead of creating EHE-specific institutions. This approach recognizes that short-term resource reallocations for EHEs are justified by the severity of their public health risks, the limited duration and frequency of the events, and the cost-effectiveness of the reallocations.

Guidebook goals and next steps

This guidebook provides interested public health officials with enough background information on EHE risks and impacts to roughly assess potential local health risks from EHEs. In addition, it provides a menu of notification and response actions to consider when developing or enhancing a local EHE program.

The 2005 U.S. hurricane season was a stark reminder that inadequate public and private preparation and response to well-forecasted and well-understood extreme meteorological phenomena can have severe public health consequences.

The remaining public health challenge for EHEs is to develop and implement meaningful EHE notification and response programs that increase public awareness and lessen future adverse health impacts.

EHEs can increase the number of deaths (mortality) and nonfatal outcomes (morbidity) in vulnerable populations, including older people, the very young, the homeless, and people with cognitive and physical impairments (*NOAA, 1995; American Medical Association Council on Scientific Affairs, 1997; Semenza et al., 1999*). Climate research suggests that future health risks of EHEs could increase with an increase in EHE frequency and severity (*Meehl and Tebaldi, 2004*). At the same time, demographic patterns including increasing urbanization will increase the size and percentage of the vulnerable U.S. population. To develop appropriate EHE responses, local officials need to understand the risks that these events pose to their populations and their response options. The intent of this guidebook is to address both needs.

1.1 Why Care about EHEs?

Studies estimate that the combined EHE-attributable summertime mortality for several vulnerable U.S. metropolitan areas is well above 1,000 deaths per year (*Kalkstein, 1997; Davis et al., 2003a*). Although similar research to quantify EHE-attributable mortality in rural areas has not been completed, recent research (*Sheridan and Dolney, 2003*) found evidence of such an impact.

Despite the history of adverse health impacts, there is consensus that most of these outcomes are preventable (*CDC, 2004a*). Lessening future adverse health outcomes from EHEs will require improving the awareness of public health officials and the general public about the health risks of EHEs while continuing to develop and implement effective EHE notification and response programs.

1.2 Guidebook Goals

This guidebook has two basic goals: first, to provide local health and public safety officials with the information they need to develop EHE criteria and evaluate the potential health impacts of EHEs, and second, to offer a menu of EHE notification and response actions to be considered.

To meet these goals, this guidebook is organized as follows.

Chapter 2 provides information on EHE-attributable health impacts and sources of risk that affect the vulnerability of individuals and communities to EHEs. Specific information provided in the chapter includes:

- ▶ A general EHE definition
- ▶ Guidance on criteria for EHE forecasting and identifying EHE conditions
- ▶ Estimates of the number and rate of EHE-attributable summertime deaths for select U.S. metropolitan areas
- ▶ A review of the meteorological, demographic, behavioral, and regional characteristics that increase health risks from EHEs.

Chapter 3 gives the menu of notification and response options that local officials can use as a starting point when considering whether to develop or enhance an EHE program. This menu consists of the following information:

- ▶ The components of current EHE notification and response programs
- ▶ Case studies of specific EHE response programs to understand their development and lessons learned
- ▶ A review of the efficacy of EHE response programs.

Chapter 4 provides recommendations that should be considered when developing an EHE notification and response program. Specifically, this chapter contains:

- ▶ Guidance on specific actions to consider when planning to develop or enhance an EHE program
- ▶ Recommendations for coordinating EHE programs with other public health programs (e.g., ozone alert programs).

In addition, the guidebook includes a series of appendices with information that officials may want to incorporate in other materials or make available independent of the guidebook. This information includes:

- ▶ A partial list of resources for additional information on EHE-attributable health risks and impacts and details on EHE programs (**Appendix A**)
- ▶ Guidance on the personal use of portable electric fans during EHEs (**Appendix B**)
- ▶ A summary of specific actions people and communities can take in response to forecast EHE conditions to reduce the risk of experiencing heat-attributable health problems (**Appendix C**).

1.3 Guidebook Development

Other documents have summarized the health risks of EHEs, described the factors that increase an individual's health risk during these conditions, and recommended elements for EHE notification and response programs (e.g., *Basu and Samet, 2002; Bernard and McGeekin, 2004; CDC, 2004a,c; FEMA, 2005b; U.S. EPA, 2005*).

This guidebook, however, is unique because it was developed as a collaborative effort among several of the principal federal agencies responsible for addressing EHEs: the Centers for Disease Control and Prevention (CDC), the National Oceanic and Atmospheric Administration's (NOAA's) National Weather Service (NWS), the U.S. Department of Homeland Security (DHS), and the U.S. Environmental Protection Agency (EPA) along with three other institutions with extensive experience developing and operating recognized EHE programs in the United States and abroad: the Philadelphia Health Department, Toronto Public Health, and the University of Delaware Center for Climatic Research.

Summarizing the collective insight and experience of the individuals from these organizations was facilitated through the participation of their staff in a Technical Working Group (TWG). The TWG helped shape the guidebook's content through regular group discussions and review of draft versions of the guidebook.

This chapter first defines an EHE and reviews possible criteria for identifying EHE conditions, followed by a discussion of the range of EHE-attributable medical conditions, adverse health outcomes, and mortality estimates for several U.S. metropolitan areas. It also reviews the characteristics that can affect an individual's health risk and the incidence of adverse health outcomes in a population.

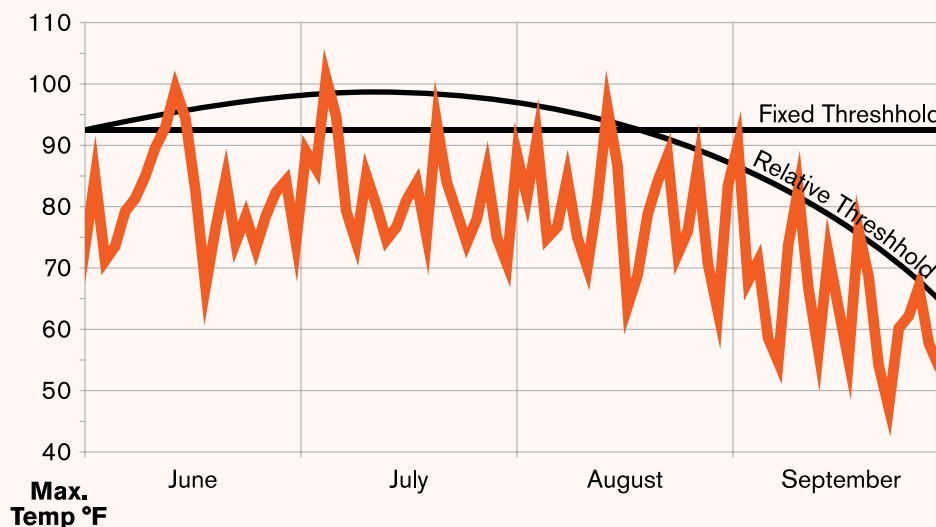
2.1 Defining an EHE

EHE conditions are defined by summertime weather that is substantially hotter and/or more humid than average for a location at that time of year. Because how hot it feels depends on the interaction of multiple meteorological variables (e.g., temperature, humidity, cloud cover), EHE criteria typically shift by location and time of year. In other words, Boston, Philadelphia, Miami, Dallas, Chicago, San Diego, and Seattle are likely to have different EHE criteria at any point in the summer to reflect different local standards for unusually hot summertime weather. In addition, these criteria are likely to change for each city over the summer. As a result, reliable fixed absolute criteria, e.g., a summer day with a maximum temperature of at least 90°F, are unlikely to be specified.

There are different ways to identify EHE conditions. Some locations evaluate current and forecast weather to identify EHE conditions with site-specific, weather-based mortality algorithms. Other locations identify and forecast EHE conditions based on statistical comparisons to historical meteorological baselines. For example, the criterion for EHE conditions could be an actual or forecast daily high temperature that is equal to or exceeds the 95TH percentile value from a historical distribution for a defined time period (e.g., the summer or a month-long window centered on the date).

Figure 2.1 presents a hypothetical example that shows the difference in defining EHE conditions when using a seasonally adjusted relative temperature versus a fixed temperature criterion.

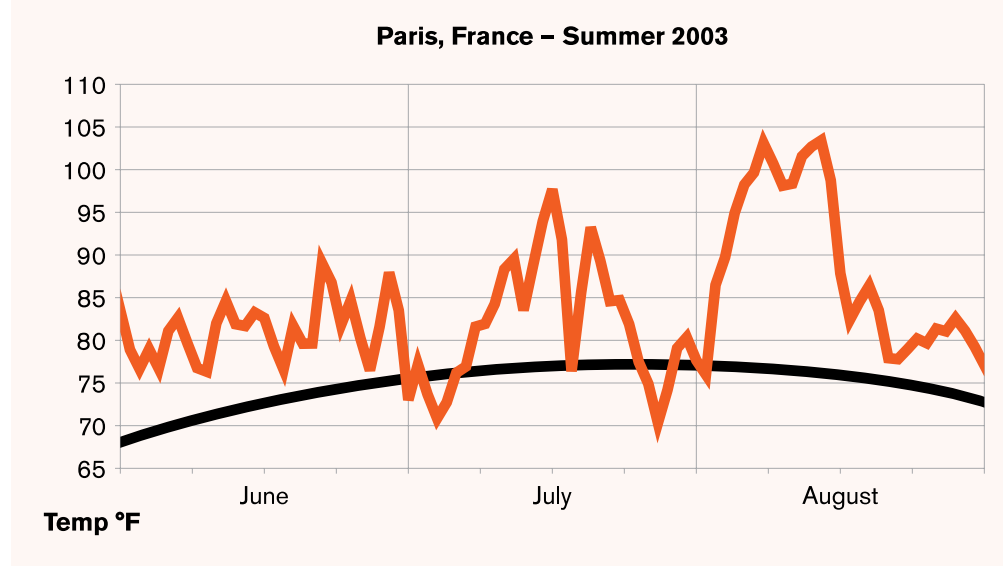
Figure 2.1. An example illustrating the difference between a seasonally adjusted relative temperature threshold and a fixed absolute temperature threshold for defining EHE conditions. *Source: Personal communication, B. Davis, New Hope Environmental Services, August 2005.*



Representations of actual EHEs can help illustrate these conditions. During the summer of 2003, Western Europe experienced EHE conditions of unprecedented severity. *Figure 2.2* presents the June through August 2003 daily maximum temperature readings in Paris with the corresponding average daily maximum temperature from the historical record.

Although the June and July temperatures in *Figure 2.2* may not seem exceptional, the extent to which they generally exceeded the long-term average shows why Paris experienced EHE conditions. The period from August 3 to August 17, however, is notable for its absolute temperatures and its tremendous deviation from typical conditions. Reflecting the significant health risks of EHE conditions, France experienced roughly 15,000 heat-related deaths during this period (*Koppe et al., 2004*).

Figure 2.2. Actual (red line) vs. average (black line) daily maximum temperatures



2.2 Health Risks Attributable to EHE Conditions

Maintaining a consistent internal body temperature, generally 98.6°F, is essential to normal physical functioning (*American Medical Association Council on Scientific Affairs, 1997*). EHE conditions stress the body's ability to maintain this ideal internal temperature. If individuals fail or are unable to take steps to remain cool and begin to experience increasing internal temperatures, they increase their risk of experiencing a range of potential adverse health outcomes.

Table 2.1 lists some of the medical conditions directly attributable to excessive heat exposure, along with recommended responses.

EHE conditions can result in increases in the number of cases of other health problems as well. For example, EHEs can increase the number of patients experiencing circulatory system conditions. These additional problems come from the added strain on the heart, increasing circulation to regulate internal temperatures, or to overcome the effects of dehydration, which thickens the blood, making it harder for the heart to pump.

Table 2.1. Medical conditions directly attributable to excessive heat exposure

Medical Condition	Symptoms	Responses
Heat cramps	Painful muscle cramps and spasms, usually in muscles of legs and abdomen. Heavy sweating.	Apply firm pressure on cramping muscles or gently massage to relieve spasm. Give sips of water; if nausea occurs, discontinue water intake. Consult with a clinician or physician if individual has fluid restrictions (e.g., dialysis patients).
Heat exhaustion	Heavy sweating, weakness, cool skin, pale, and clammy. Weak pulse. Normal temperature possible. Possible muscle cramps, dizziness, fainting, nausea, and vomiting.	Move individual out of sun, lay him or her down, and loosen clothing. Apply cool, wet cloths. Fan or move individual to air-conditioned room. Give sips of water; if nausea occurs, discontinue water intake. If vomiting continues, seek immediate medical attention. Consult with a clinician or physician if individual has fluid restrictions (e.g., dialysis patients).
Heat stroke (sunstroke)	Altered mental state. Possible throbbing headache, confusion, nausea, and dizziness. High body temperature (106°F or higher). Rapid and strong pulse. Possible unconsciousness. Skin may be hot and dry, or patient may be sweating. Sweating likely especially if patient was previously involved in vigorous activity.	Heat stroke is a severe medical emergency. Summon emergency medical assistance or get the individual to a hospital immediately. Delay can be fatal. Move individual to a cooler, preferably air-conditioned, environment. Reduce body temperature with a water mister and fan or sponging. Use air conditioners. Use fans if heat index temperatures are below the high 90s. Use extreme caution. Remove clothing. If temperature rises again, repeat process. Do not give fluids.

Sources: CDC, 2004a; Kunihiro and Foster, 2004; NWS, 2004.

2.3 Quantifying the Health Impacts of EHEs

Quantifying the health impacts of EHEs is complicated by the differences in quantification methods and a lack of accurate data.

The most conservative quantification method counts only outcomes on EHE days where the attribution information (e.g., primary diagnosis, cause of death) lists excessive weather-related heat exposure or a condition unequivocally associated with excessive heat exposure, such as heat stroke. This approach underestimates the health impacts of EHEs because not all the heat-related cases will include an attribution that recognizes this impact. More inclusive methods quantify EHE health impacts based on increases in outcomes during EHE periods compared to long-term averages. But such approaches can be absolute and attribute all observed increases in outcomes to EHEs, overestimating the heat-related mortality. Alternatively, the approach can be partial and attribute only a portion of the observed increase in outcomes to EHEs based on professional judgment or the results of additional analyses such as regression.

2.3.1 EHEs and U.S. mortality

There are a number of methods for estimating the public health threat and impact of EHEs. Since these methods can have a significant impact on the resulting estimate, it is important to recognize their differences when reviewing information describing the public health burden of EHEs.

The most conservative estimate of EHE mortality counts only cases in which exposure to excessive heat is reported on a death certificate as a primary or contributing factor. Using this approach, it was estimated that extreme heat from weather conditions is, on average, responsible annually for 182 deaths in the United States (*CDC, 2002*).

The conservative nature of this estimate due to the narrow criteria is recognized in the study itself (*CDC, 2002*). The accuracy of this estimate would improve with widespread adoption of revised criteria for attributing a death to excessive heat exposure. Typically, medical examiners list heat exposure as a primary or contributing cause of death only if the core body temperature exceeds 105°F. In the revised criteria, a death also can be classified as heat-related if the person is “found in an enclosed environment with a high ambient temperature without adequate cooling devices and the individual had been known to be alive at the onset of the heat wave” (*Donoghue et al., 1997*). Importantly, the National Association of Medical Examiners supports using these broader criteria, and medical examiners in several large cities (e.g., Philadelphia) have adopted them.

Alternative EHE mortality estimates come from analyses of daily urban summertime mortality patterns in the United States (*Kalkstein and Greene, 1997; Davis et al., 2003a*). These studies first defined EHE conditions and then calculated the number of EHE-attributable deaths based on differences in daily deaths on EHE days compared to longer-term averages. Although differences in the time series, definitions of urban populations, and other analytical methods prevent an exact comparison of results from Kalkstein and Greene (*1997*) and Davis et al. (*2003a*), their findings correspond closely [for details of the studies’ methods and the comparison of results see accompanying background technical report (*Mills, 2005*)]. *Table 2.2* presents the estimates of heat-attributable excess deaths and mortality rates from these studies.

The results in *Table 2.2* are notable for several reasons. First, despite differences in methods and the locations evaluated, the studies’ results fall in a narrow range of roughly 1,700-1,800 total heat-attributable deaths per summer. These estimates are roughly an order of magnitude greater than the comprehensive national annual average of 182 deaths with a listed cause of death of “excessive heat due to weather conditions” (*CDC, 2002*). This difference highlights the importance of the method (i.e., excess incidence or attributed outcomes) used to quantify EHEs’ health impacts. Although summing the results across different groups of locations minimizes some of the initial distinctions in the studies, some of the location-specific results in *Table 2.2* show that significant differences can result from applying different methods to essentially the same mortality and meteorological data.

Second, both studies’ results show significant regional variation: EHEs have the greatest impact in the Northeast and Midwest and the least impact in the South and Southwest. This result is consistent with hypotheses that populations in the most vulnerable areas are not as acclimatized to elevated temperatures and that structures in less susceptible areas

Table 2.2 Estimates of heat-attributable deaths per summer and mortality rates in select U.S. metropolitan areas

Standard Metropolitan Statistical Area (SMSA)	Deaths¹ (Estimated average summertime heat-attributable deaths from 1990 population)	Deaths² (Estimated average summertime heat-attributable deaths from 1990 population)	Mortality Rate¹ (Estimated heat-attributable deaths per 100,000, 1990s baseline)	Mortality Rate² (Estimated heat-attributable deaths per 100,000, 1990s baseline)
Birmingham	42	N/A	5.00	N/A
Providence	47	N/A	4.14	N/A
Hartford	38	N/A	3.28	N/A
St. Louis	79	0	3.17	0.00
Kansas City	49	0	3.10	0.00
Buffalo	33	19	2.78	1.63
Indianapolis	36	N/A	2.61	N/A
Memphis	25	N/A	2.48	N/A
Columbus	33	N/A	2.45	N/A
Minneapolis	59	0	2.32	0.00
Chicago	191	193	2.32	2.34
Philadelphia	129	71	2.19	1.21
Denver	42	22	2.12	1.09
Detroit	110	124	2.12	2.39
Greensboro	22	0	2.10	0.00
Nassau, New York City, Newark	362	552	1.85	2.82
Louisville	17	N/A	1.79	N/A
Boston	96	56	1.76	1.03
Pittsburgh	39	40	1.63	1.69
New Orleans	20	30	1.56	2.31
Tampa	28	0	1.35	0.00
Baltimore; Washington, D.C.	84	40	1.25	0.59
Cleveland	29	23	1.01	0.80
Dallas	36	0	0.89	0.00
Atlanta	25	75	0.84	2.51
Cincinnati	14	0	0.77	0.00
Portland	9	32	0.50	1.76
Los Angeles and Riverside	72	216	0.50	1.50
San Francisco	28	138	0.45	2.21
San Antonio	4	N/A	0.30	N/A
Houston	7	0	0.19	0.00
Seattle	5	96	0.17	3.27
Jacksonville	0	N/A	0.00	N/A
Miami, Fort Lauderdale	0	0	0.00	0.00
Phoenix	0	6	0.00	0.30
Salt Lake City	0	N/A	0.00	N/A
San Diego	0	N/A	0.00	N/A
Norfolk	N/A	0	N/A	0.00
Charlotte	N/A	0	N/A	0.00
Total	1,810	1,733		

Note: N/A, not applicable, refers to a metropolitan area not examined in one of the studies.

1. Kalkstein and Greene, 1997.

2. Davis et al., 2003a.

are better designed to accommodate elevated temperatures. However, fewer locations were evaluated in the South and Southwest because of the studies' population selection criteria, so support for these hypotheses remains qualified. This regional result is more evident in *Figure 2.3*, which presents the Kalkstein and Greene (1997) results along with a similar result for Toronto (*N. Day, personal communication, Toronto Public Health, 2005*).

EHE-attributable mortality estimates from specific EHEs are also available:

- ▶ **Chicago, 1995, mid-July EHE:** The county coroner certified 465 heat-related deaths in Chicago (Cook County, Illinois) from July 11 to July 27, 1995 (*CDC, 1995*). More than 700 deaths in Chicago were eventually attributed to this EHE (*e.g., Palecki et al., 2001*). The difference reflects deaths directly attributed to heat by the medical examiner (*CDC, 1995*) and estimates of the total excess mortality attributable to the EHE based on studies of daily mortality patterns (*Palecki et al., 2001*).
- ▶ **Philadelphia, 1993, early-July EHE:** The county coroner certified 118 heat-related deaths in Philadelphia from July 6 to July 14, 1993 (*CDC, 1994*).

These estimates demonstrate that an EHE in the United States can easily be responsible for hundreds of deaths in a large metropolitan area.

2.3.2 EHEs and U.S. morbidity

EHE morbidity studies are relatively rare because of a lack of suitable daily time-series data. Further, when such studies are attempted, only the most severe morbidity outcomes (emergency room visits and hospitalizations) tend to be evaluated because of the limited number of locations where patients can be seen and be treated.

One of the few U.S. EHE morbidity studies examined Chicago hospital admissions during the July 1995 EHE. Semenza et al. (1999) calculated that this EHE was responsible for more than 1,000 hospital admissions, and anecdotal evidence strongly suggests that this EHE increased the incidence of Chicago emergency room visits. Specifically, the *Natural Disaster Survey Report: July 1995 Heat Wave (NOAA, 1995)* reported that on the second day of the EHE, only a few Chicago emergency rooms were directing ambulances to other facilities because of crowding (i.e., operating in bypass status), but by the fourth day, 18 city emergency rooms were doing so.

