Heat-Related Mortality During a 1999 Heat Wave in Chicago

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Background: During the summer of 1999, Chicago's second deadliest heat wave of the decade resulted in at least 80 deaths. The high mortality, exceeded only by a 1995 heat wave, provided the opportunity to investigate the risks associated with heat-related deaths and to examine the effectiveness of targeted heat-relieving interventions.

Methods: We conducted a case–control study to determine risk factors for heat-related death. We collected demographic, health, and behavior information for 63 case patients and 77 neighborhood-and-age-matched control subjects and generated odds ratios (ORs) for each potential risk factor.

Results: Fifty-three percent of the case patients were aged <65 years, and psychiatric illness was almost twice as common in the younger than the older age group. In the multivariate analysis, the strongest risk factors for heat-related death were living alone (OR=8.1; 95% confidence interval [CI], 1.4–48.1) and not leaving home daily (OR=5.8; 95% CI, 1.5–22.0). The strongest protective factor was a working air conditioner (OR=0.2; 95% CI, 0.1–0.7). Over half (53%) of the 80 decedents were seen or spoken to on the day of or day before their deaths.

Conclusions: A working air conditioner is the strongest protective factor against heat-related death. The relatively younger age of case patients in 1999 may be due to post-1995 interventions that focused on the elderly of Chicago. However, social isolation and advanced age remain important risk factors. Individual social contacts and educational messages targeted toward at-risk populations during heat waves may decrease the number of deaths in these groups.

Medical Subject Headings (MeSH): case–control studies, environment, heat, heat stress disorders, heat stroke, mortality, temperature (Am J Prev Med 2002;22(4):221–227)

Introduction

In 1995, Chicago experienced a record-breaking 4-day heat wave. The temperature and humidity reached historical peaks, and the medical examiner's office reported 437 heat-related deaths. An extensive investigation[1] identified advanced age and inability to care for oneself as major risk factors, similar to findings from a heat wave investigation in Missouri in 1980.[2,3] Reporting a working home air conditioner was the most important protective factor against heat-related death.

Following the 1995 heat wave, Chicago's mayor formed the Commission on Extreme Weather Conditions. It developed a comprehensive Extreme Weather Operations Plan, which targeted information and interventions to persons at risk for heat-related health conditions, focusing largely on the elderly (Extreme Weather Operations Plan 1996, updated spring 1999). On July 29, 1999, the Plan was activated when the National Weather Service issued a heat warning. Despite extensive heat-wave response activities throughout Chicago, more than 80 deaths were attributed to the 3-day heat wave that occurred on July 29–August 1, 1999.

We conducted a study to further define risk factors for heat-related death. The results of our analysis will help refine targeted heat-wave–response activities in Chicago to prevent future heat-related deaths among high-risk populations.

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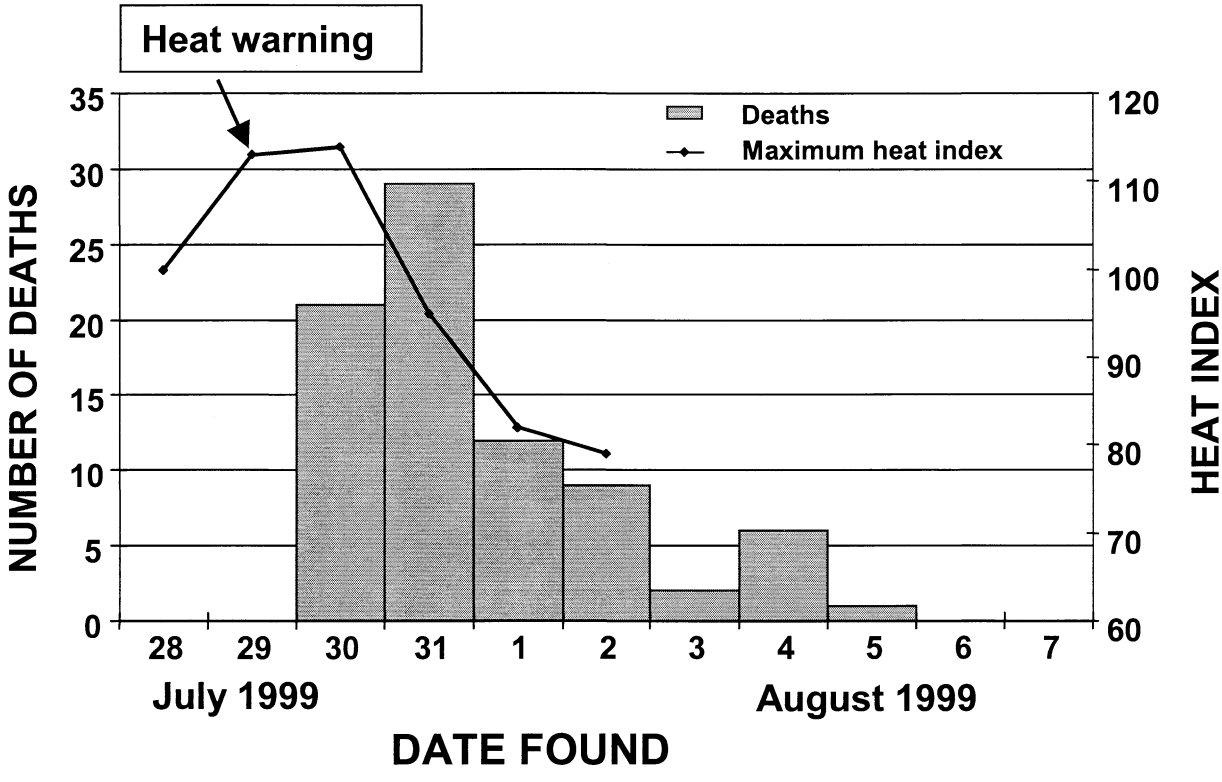

Figure 1. Heat-related deaths, Chicago, July 29–August 6, 1999 (N=80)

Methods

Study Design

We conducted a case–control study from August 10 through August 28, 1999, in Chicago, Illinois, modeled on the investigation that followed the 4-day heat wave in Chicago in 1995.[1]

Case–Patient and Control–Subject Identification

Persons eligible for inclusion in the study were Chicago residents who died in Chicago from July 29 through August 6, 1999, for whom heat was identified by the Cook County Medical Examiner's Office as the underlying (primary) or contributing (secondary) cause of death. We chose this 9-day period because the official date of death in Chicago is the date the decedent's body is found (Figure 1). (Note: The National Weather Service declared a heat warning on July 29. Despite the literature indicating that most heat deaths occur 2 to 3 days after the start of a heat wave, we wanted the opportunity to capture any deaths that might occur early in the heat wave. Our data showed no deaths on July 29, 21 deaths on the second day of the heat wave [July 30], and 29 deaths on the third day [July 31]. The Cook County Medical Examiner's Office uses "date the body was found" as the "date of death," so some of the deaths recorded on these dates likely occurred earlier.) The Medical Examiner's Office defined heat-related deaths according to criteria published by the National Association of Medical Examiners.[4] These include an antemortem body temperature greater than or equal to 105°F, or if cooling has been attempted, a lower body temperature with known mental status changes or elevated liver enzymes. Eighty decedents were eligible for inclusion.

See related Commentary on page 328.

We collected decedents' information by interviewing surrogate respondents. Appropriate surrogate respondents were persons who lived with or had repeated social contact with the decedents; these included family members, friends, neighbors, or landlords. Fifty-five percent of surrogate respondents saw the case patients daily, and 84% at least weekly. We identified surrogate respondents by visiting the homes of decedents and by reviewing death certificates, police reports, or death announcements. We identified and contacted surrogate respondents for 77 of the 80 decedents. For 8 of the 77 decedents, surrogate respondents (all kin) declined to participate in this study. We interviewed surrogate respondents for the remaining 69 decedents; each of 63 were marked with one or two control subjects. For six decedents, no appropriate control subject could be identified; these decedents were excluded from the analysis.

Control subjects were in Chicago at the onset of the heat wave and were matched to case patients by neighborhood and age (within 10 years). All control subjects were systematically selected by canvassing up to 64 residences in the decedent's neighborhood or apartment house, proceeding first in one direction and then another, as determined by a coin toss, until an age-matched control subject was found.

Data Collection

We administered a standardized questionnaire in person (approximately two thirds) or by telephone (approximately one third) to surrogate respondents for case patients, and in person for all control subjects. The questionnaire contained five categories: demographics, housing, mobility, medical information, and emergency measures taken during the heat wave. Staff members of the National Center for Environmental Health of the Centers for Disease Control and Prevention and from the Chicago Department of Public Health conducted the interviews. Other sources of data were death certificates and medical examiner or police reports, when available. If these documents became available after the surrogate respondent interview(s), we used this information only to complete unanswered questions. If an autopsy had been performed, the death certificate served as the primary source for cause of death.

Statistical Analysis

The matched analysis included 63 case patients and 77 control subjects. We estimated the odds ratios (ORs) and 95% confidence intervals (CIs) for each potential risk factor (Table 1) derived from the questionnaire, using LogXact-4 software for conditional logistic regression. With the exception of variables describing type of residence, all potential risk factors were dichotomized. Factors that were significant in the univariate analysis were studied further in a series of multivariate logistic regression models. After we controlled for additional covariates, the final multivariate model contained variables that remained significant ($p<0.05$) predictors of heat-related death.

Table 1. Representative variables in questionnaire used in the investigation of risks for heat-related death, Chicago, 1999

Personal information
Gender
Race
Ethnicity
Height and weight
Employment status
Ability to speak and read English
Length of residence in Chicago
Length of residence in current home
Housing
Number of persons living in home
Number and type of fans
Number and type of air conditioners
If didn't use air conditioner, why not?
Whether windows ever opened (yes/no)
Number of floors in building
Floor resided upon
How often left home in average week
Pet in home (yes/no)
Income
Knowledge about and response to heat-wave dangers
Medical information
Confined to bed (yes/no)
Able to care for self (yes/no)
Amount of alcohol consumed
Current smoker (yes/no)
History of condition below (and whether medication taken)
Asthma
Other lung disease
Heart disease
Liver disease
High blood pressure
Trouble sleeping
Depression
Mental problems
Cancer
Kidney disease
Mobility
Number of group activities per week
Number of social services per week

Results

Study Population Characteristics

Demographic characteristics of the matched case patients and control subjects were similar (Table 2). None of the decedents were children. Two deaths were exertional in nature. Heatstroke was the primary cause of death in 29 case patients, and heat as the contributing cause in 34.

Risk Factors and Protective Factors in Univariate Analysis

There was an increased risk of heat-related death in persons with cardiac disease or psychiatric illness, and in persons who lived alone, did not leave home daily, resided on the top floor of a building, or had an annual income of <$10,000 (Table 3).

Psychiatric illness was disproportionately high among case patients aged <65 years. Forty-five surrogate respondents provided information about psychiatric illness among the case patients. Surrogate respondents reported such illness in 64% ($n=16$) of 25 case patients aged <65 years and in only 35% ($n=7$) of 20 case patients aged ≥65 years. Mental problems other than depression, including developmental delay and schizophrenia, were reported in 11 (32%) case patients aged <65 years (Table 3).

Significant protective factors included having a working home air conditioner, participating in group activities, having a pet in the home, and taking extra showers or baths during the heat wave (Tables 3 and 4). A working fan in the home was not significantly protective; 90% of case patients and 88% of control subjects reportedly had working home fans. Working air conditioners were reported for 16% of case patients, compared with 58% of control subjects (Table 3). One case patient and seven control subjects used official cooling centers (Table 4).

Public Awareness of Potential Health Hazards of Heat Wave

Ninety percent of control subjects stated they were aware of the heat warning issued for Chicago by the

Table 2. Selected characteristics of case patients who died from heat-related health conditions and matched control subjects, Chicago, July 29–August 6, 1999

Characteristics	Case patients *n*=63 *n* (%)	Control subjects *n*=77 *n* (%)
Age (years)		
<65	34 (53.0)	40 (51.9)
≥65	29 (46.0)	37 (48.1)
Median age (years)	63	63
Age range (years)	36–93	35–90
Race		
Black	32 (50.8)	40 (51.9)
White	30 (47.6)	27 (35.1)
Asian or Pacific Islander	0 (0.0)	6 (7.8)
Other or Unknown	1 (1.6)	4 (5.2)
Hispanic	1 (1.8)	4 (5.5)
Gender		
Female	32 (50.8)	38 (49.3)
Male	31 (49.2)	37 (48.1)
Missing data[a]	0 (0.0)	2 (2.6)

[a]Missing data due to incomplete questionnaires.

National Weather Service. Ninety-five percent said they were aware of the health dangers of the heat (specifically, that it could kill them), and 96% of those aware indicated that they learned this information through television.

Results of Multivariate Analysis

In the multivariate analysis, a working air conditioner remained significantly protective; the most important risk factors for heat-related death were living alone and not leaving home daily (Table 5). Using a non-additive model for attributable risk, 92% of case-patient deaths could have been prevented with a working air conditioner and absence of the two risk factors.

Rate of Death, Stratified by Age

Fifty-three percent of case patients were aged <65 years, compared with only 31% (p=0.0012) in the 1995 Chicago heat wave (S. M. Kieszak, personal communication, National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, GA, 2001). However, the rate of heat-related death in adults attributed to the 1999 heat wave, based on population statistics from the 2000 U.S. census[5] (Table 6), was highest in the very elderly. Interestingly, the rate in the group aged 65 to 74 was similar to that in the group aged 45 to 64 (Table 6).

Timing of Last Contact Before Death

Our questionnaire did not address when the decedent was last contacted before death. However, this was recorded on police or medical examiner reports for 58 of 80 decedents. Of these 58 decedents, 31 (53%) were seen or spoken to on the day of or the day before their deaths. For most, contact was made by a family member; in a few instances, it was by a landlord or city worker. The medical examiner and police reports also indicated that at least 3 of the 80 decedents had signs or symptoms of heat-related illness before death. There was abdominal pain with vomiting in one, stomach cramps in another, and moaning in a third who was spoken to through a door, but not directly observed.

Table 3. Medical and living conditions by case patient or control subject status,[a] Chicago, 1999

Variables	Case patients *n*=63 *n* (%)	Control subjects *n*=77 *n* (%)	OR (95% CI)
Medical/psychiatric conditions			
Heart condition	30 (62.5)	11 (15.5)	7.2 (2.5–20.8)*
Psychiatric illness[b]	23 (51.1)	13 (18.3)	5.7 (1.9–16.8)*
Depression	17 (40.5)	12 (17.1)	4.1 (1.3–12.5)*
Other mental problem	11 (26.8)	2 (2.9)	11.7 (1.5–92.2)*[c]
Living conditions			
Lived alone	35 (56.5)	23 (30.3)	5.4 (1.8–15.9)*
Did not leave home daily[d]	39 (67.2)	25 (33.8)	4.5 (1.7–11.7)*
Lived on top floor	31 (50.0)	15 (19.5)	4.0 (1.7–9.3)*
Had annual income <$10,000	26 (72.2)	25 (42.4)	3.1 (1.0–9.7)*[e]
Had working fan	56 (90.3)	67 (88.2)	0.71 (0.2–2.3)
Had working air conditioner	10 (15.9)	44 (57.9)	0.12 (0.0–0.3)*

*$p \leq 0.05$.
[a]Based on the number of completed responses to each survey question; odds ratios are adjusted for the matching variables of neighborhood and age.
[b]Psychiatric illness variable describes all persons for whom depression and/or other mental problem was reported; both conditions reported for five case patients and one control subject.
[c]Few control subjects with the problem, so the CI is wide.
[d]During an average week.
[e]Actual lower level of is CI 1.02, rounded to 1.0.
CI, confidence interval; OR, odds ratio.

Table 4. Social contact and behaviors during the heat wave by case patient and control subject status,[a] Chicago, 1999

Variable	Case patients *n*=63 *n* (%)	Control subjects *n*=77 *n* (%)	OR (95% CI)
Social contacts			
Participated in group activities (clubs, religious or support)	26 (47.3)	55 (73.3)	0.3 (0.1–0.7)*
Friends in Chicago	52 (85.3)	67 (87.0)	0.9 (0.4–2.3)
Relatives in Chicago	52 (88.1)	66 (85.7)	1.3 (0.4–3.7)
Pet in home	11 (17.5)	28 (36.4)	0.3 (0.1–0.8)*
Behaviors during heat wave[b]			
Took extra baths/showers	11 (37.9)	48 (64.0)	0.3 (0.1–0.9)*
Visited cooling center(s)	1 (1.9)	7 (9.2)	0.2 (0.0–1.5)

*$p \leq 0.05$.
[a]Based on the number of completed responses to each survey question; odds ratios are adjusted for the matching variables of neighborhood and age.
[b]July 29–August 1, 1999.
CI, confidence interval; OR, odds ratio.

Discussion

New Information

In our study, more than half of the case patients were aged <65 years. This finding was unexpected[2,6,7] and may reflect the success of the public health community's efforts to target interventions toward Chicago's elderly. However, even though the proportion of deaths among younger persons increased in 1999, the rate of heat-related death in persons aged ≥75 years was more than 20 times the rate among persons aged 25 to 44, and approximately 3.5 times the rate among people aged 45 to 64. Thus, although we recommend that middle-aged persons be targeted for heat-related educational activities, especially in view of potential years of life lost, the targeting of the elderly, especially those aged ≥75 years, should remain a public health priority.

Comparison with 1995 Chicago Heat Wave Study

The major risk factors and protective factors identified in this investigation were similar to those in the 1995 study.[1] There was an increased risk of heat-related death in persons with cardiac disease or psychiatric illness (not stratified by age in 1995), and in persons who lived alone, did not leave home daily, or resided on the top floor of a building. The question of income was not broached in the 1995 study, but lower income was a significant risk in 1999. In both studies, home air conditioning was a major protective factor. Fans were not significantly protective, either when evaluated separately in the two studies or when examined in a pooled analysis using 1995 and 1999 data. Visiting cooling centers was not shown to be significantly protective, probably because few people used them.

Table 5. Association of protective or risk factors with heat-related death in multivariate analysis,[a] Chicago, 1999

Variable	OR (95% CI)
Had working air conditioner	0.2 (0.1–0.7)
Lived alone	8.1 (1.4–48.1)
Did not leave home daily[b]	5.8 (1.5–22.0)

[a]Adjusted for neighborhood and age.
[b]In an average week.
OR, odds ratio; CI, confidence interval.

Comparison with Other Studies

In 1999, psychiatric illness was clearly an important risk factor for heat-related death among younger adults. Of the 34 case patients who were aged <65 years, nearly 50% (or 64% of those for whom we have specific data) reportedly had a psychiatric illness. This finding is similar to results from a 1995 Wisconsin study, where psychotropic medication use was listed as a contributing cause of death in 36% (17 of 47) of heat-related deaths in persons aged <65 years, but only 3% (1 of 34) of those aged ≥65.[6] A heat wave investigation in Cincinnati in 1999 also suggested that mental illness was a risk factor in younger decedents.[8] These data strongly suggest that persons with mental illness and their caretakers would likely benefit from specifically targeted education and interventions.

Exposure to air conditioning was a strong protective factor in our study, and fan use was not significantly protective, concurring with the studies following the 1980 Missouri heat wave.[2,3]

Finally, although older literature[9] indicates that children aged <1 year are at increased risk, we found no pediatric deaths; this agrees with other more recent work.[2,7,8] The reason for this change is unclear, but it may reflect greater access to air conditioning in public places, because this population is likely not socially isolated.

Table 6. Age-specific, heat-related death rates, Chicago 1999 heat wave[a]

Age group (years)	Percentage of total population	Population in each age group in 2000	Rate of heat-related death (# deaths)[b]
25–44	33.4	966,467	0.9/100,000 (8)
45–64	18.9	547,196	5.5/100,000 (30)
65–74	5.5	159,915	7.5/100,000 (12)
≥75	4.8	138,888	20.9/100,000 (29)

[a]During and immediately after July 29–August 1, 1999.
[b]Population totaled 2,896,016, based on 2000 U.S. Census figures from City of Chicago Department of Public Health. Decedents totaled 80.

Implications for Prevention

In our study, 53% of decedents for whom data were available were visited or spoken to on the day of or the day before death. Heatstroke can occur rapidly.[2,10] In fact, 61% of heatstroke victims in Missouri in 1980 had symptoms for <24 hours before being hospitalized or found dead.[2] At least three Chicago decedents did have signs or symptoms of heat-related illness before death that were not recognized and did not prompt medical intervention. We, therefore, suggest that the general public and city workers be informed of the signs and symptoms of the two most serious types of heat-related illness: heat exhaustion (heavy sweating, paleness, muscle cramps, tiredness or weakness, dizziness or headache, nausea or vomiting, faintness) and heatstroke (oral temperature >103°F; rapid, strong pulse; red, hot, and dry skin; throbbing headache or dizziness; nausea; confusion; unconsciousness).[11] Sweating may also occur in heatstroke, contrary to the belief that the skin is always dry[12] (E. M. Kilbourne, personal communication, Agency for Toxic Substances and Disease Registry, CDC, 2001). Untreated heat exhaustion can progress to heatstroke.[13] We suggest that people at high risk for heat-related death be visited at least twice per day for a face-to-face assessment of their health status and inspection of their environment. This responsibility can be shared by families, neighbors, and city workers. We suggest that the visitor:

1. Turn on the air conditioner if one is present; if absent, open windows (taking neighborhood safety into consideration) if the outside air is cooler and moving.
2. Provide a bottle of water (that the high-risk person can open easily) to reinforce the importance of drinking fluids.
3. Explain that spending increased time outside of the home in air-conditioned places has been shown to decrease deaths from heat-related illness[1,3] and that transportation to community cooling centers is available and free (in some cities, such as Chicago).
4. Disclose electricity rates for running standard-sized air conditioners on an hourly basis to dispel misconceptions about electrical costs.

Preventive measures are essential because, even when treated, the mortality rate of heatstroke can approach 33%.[14] In addition, permanent neurologic damage occurs in up to 14% of survivors, and its likelihood increases with longer duration of heatstroke.[15]

Strengths and Weaknesses of the Study

One strength of this study is the high quality of data available for analysis. In the Cook County Medical Examiner's Office, all medical examiners classify heat-related deaths according to the criteria published by the National Association of Medical Examiners.[4] Furthermore, in Chicago, all deaths that are potentially heat related are referred to the medical examiner's office. To conduct this study, we used a design, control-recruitment strategy, and questionnaire similar to those from the 1995 heat-wave investigation,[1] which enabled us to compare results. This comparison may be useful in Chicago, where changes in the characteristics of the decedent population may reflect the success of the focused prevention strategies implemented since 1995, and in other cities where specific information about risk factors may be used to further target response activities.

During this investigation, we were able to interview surrogate respondents for a large proportion (79%) of the decedents and to include their responses in the analysis. However, the quality of surrogate data can be of questionable reliability; this is an important limitation to our findings. We attempted to compensate for lack of knowledge on the part of surrogate respondents by including a "don't know" answer for each question and interviewing more than one surrogate respondent per case patient if needed (asking only questions not previously answered). We interviewed the next of kin for 48 of 69 decedents; in all but five, the family member provided the vast majority of the decedent's data. For 12 decedents, we interviewed more than one surrogate respondent. Due to this same concern about reliability, we did not analyze data that would have required surrogate-respondent knowledge of a case patient's personal awareness, such as whether the case patient knew about the official heat warning. Finally, bias may be introduced when control subjects are asked to disclose their own medical histories, especially psychiatric illnesses, compared with asking surrogate respondents to disclose case patients' histories.

Conclusions

In 1995, investigators attributed hundreds of deaths in Chicago to a 4-day heat wave. Subsequently, the Mayor's Commission on Extreme Weather Conditions developed an extensive Extreme Weather Operations Plan. Its interventions included activating an extreme-weather command center in times of crisis, providing air-conditioned places throughout the city during heat waves, and proactively telephoning and visiting elderly residents to check on their well-being. These interventions probably increased the number of daily contacts some of the elderly had during the 1999 heat wave. Although attributing the lower number of deaths in 1999 to the city's heat-response activities is not possible because the two heat waves differed in duration and meteorologic characteristics, the notably different demographic distribution among the case patients suggests these interventions may have been helpful. If indeed the outreach and response activities helped reduce the number of deaths among the elderly during the heat wave, health officials in Chicago effectively designed their response strategy according to available knowledge about populations at high risk for heat-related health conditions. In addition, the high penetration of knowledge about the dangers of heat among the control subjects suggests that the general educational efforts of the city also succeeded. In the future, targeting specific educational messages and outreach efforts to other populations, such as caretakers of younger residents with psychiatric illness, may result in additional reductions in heat-related deaths.

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