

HEAT-RELATED DEATHS DURING THE JULY 1995 HEAT WAVE IN CHICAGO

JAN C. SEMENZA, PH.D., M.P.H., CAROL H. RUBIN, D.V.M., M.P.H., KENNETH H. FALTER, PH.D.,
JOEL D. SELANIKIO, M.D., W. DANA FLANDERS, M.D., D.Sc., HOLLY L. HOWE, PH.D.,
AND JOHN L. WILHELM, M.D., M.P.H.

ABSTRACT

Background During a record-setting heat wave in Chicago in July 1995, there were at least 700 excess deaths, most of which were classified as heat-related. We sought to determine who was at greatest risk for heat-related death.

Methods We conducted a case-control study in Chicago to identify risk factors associated with heat-related death and death from cardiovascular causes from July 14 through July 17, 1995. Beginning on July 21, we interviewed 339 relatives, neighbors, or friends of those who died and 339 controls matched to the case subjects according to neighborhood and age.

Results The risk of heat-related death was increased for people with known medical problems who were confined to bed (odds ratio as compared with those who were not confined to bed, 5.5) or who were unable to care for themselves (odds ratio, 4.1). Also at increased risk were those who did not leave home each day (odds ratio, 6.7), who lived alone (odds ratio, 2.3), or who lived on the top floor of a building (odds ratio, 4.7). Having social contacts such as group activities or friends in the area was protective. In a multivariate analysis, the strongest risk factors for heat-related death were being confined to bed (odds ratio, 8.2) and living alone (odds ratio, 2.3); the risk of death was reduced for people with working air conditioners (odds ratio, 0.3) and those with access to transportation (odds ratio, 0.3). Deaths classified as due to cardiovascular causes had risk factors similar to those for heat-related death.

Conclusions In this study of the 1995 Chicago heat wave, those at greatest risk of dying from the heat were people with medical illnesses who were socially isolated and did not have access to air conditioning. In future heat emergencies, interventions directed to such persons should reduce deaths related to the heat. (N Engl J Med 1996;335:84-90.)

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HOT summer weather cannot be prevented; however, morbidity and mortality related to summer heat can be reduced.¹ Previous research shows that the excess mortality associated with sustained hot weather affects predominantly high-risk populations living in urban areas where there has not been a heat wave for several years.²⁻⁷ Simple measures such as increasing fluid intake and gaining access to air conditioning can reduce heat-related mortality.^{1,8} However, im-

plementing preventive strategies targeted to groups at risk has proved to be difficult, and many preventable deaths continue to occur throughout the United States during the summer months.⁹

From July 12 through July 16, 1995, in Chicago, the maximal and minimal temperatures reached unprecedented highs, and the high temperatures were accompanied by extremes of relative humidity (Fig. 1).¹⁰ Within a few days of the onset of the heat spell, the Cook County Medical Examiner's Office reported a sharp increase in the number of heat-related deaths.¹¹

We conducted a case-control study to determine risk factors for death due to cardiovascular causes or related to the heat. Our main objective was to identify effective public health strategies for reaching people at risk and preventing deaths in future heat waves.

METHODS

Study Design and Case Definition

We conducted a case-control study from July 21 through August 18, 1995. Eligible case subjects were persons older than 24 years of age who died in Chicago from July 14 through July 17, for whom the cause of death listed on the death certificate met one of three criteria: heat was listed as the immediate or underlying cause of death, with no reference to cardiovascular disease; cardiovascular disease was listed as the primary cause of death, with no reference to heat; or cardiovascular disease was listed as the primary cause and heat as a contributing cause of death. We included deaths due to cardiovascular causes in the case definition because previous studies had demonstrated an excess of deaths from cardiovascular disease during periods of high heat.^{1,5}

In order to avoid the delay that might be involved in obtaining the death certificates of all eligible subjects, all death certificates issued in July 1995 were collected by the Vital Statistics Division of the Department of Public Health in Chicago and assigned temporary identification numbers. From a review of those death certificates, we identified 680 potential subjects who met our case definition; we then selected a random sample from each cause-of-death category, with stratification according to age, race, and date of death (Table 1). We chose the sample sizes for each category to give the study a statistical power of 80 percent for detecting an odds ratio of 2.0 among subjects with any predictive factor as

From the Epidemic Intelligence Service, Epidemiology Program Office (J.C.S., J.D.S.), and the National Center for Environmental Health (J.C.S., C.H.R., K.H.F., J.D.S., W.D.F.), Centers for Disease Control and Prevention, Atlanta; the Illinois Department of Public Health, Springfield (H.L.H.); and the Department of Public Health, Chicago (J.L.W.). Address reprint requests to Dr. Semenza at CDC-NCEH, 4770 Buford Hwy. (F46), Atlanta, GA 30341-3724.

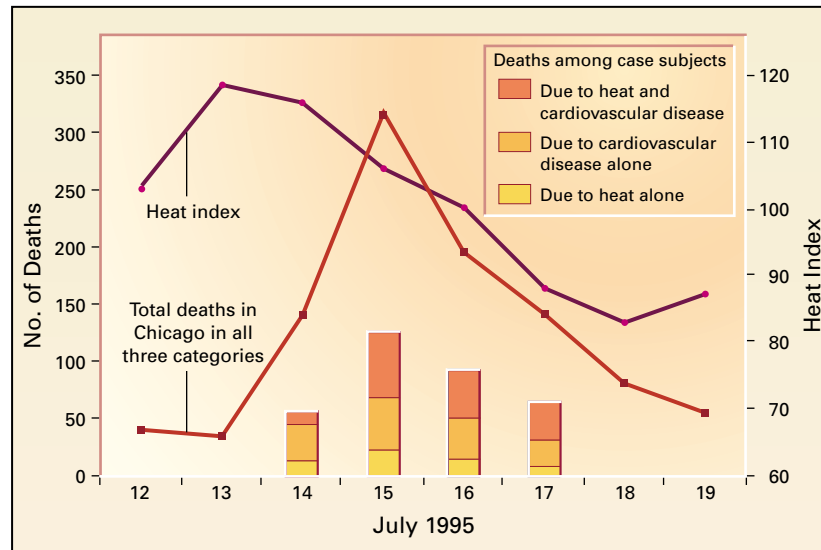


Figure 1. Heat Index, Total Deaths, and Deaths of Case Subjects Due to Heat, Cardiovascular Disease, and Heat and Cardiovascular Disease Combined in Chicago, July 12 through July 19, 1995.

The heat index, or apparent temperature, is a function of the temperature in degrees Fahrenheit and the relative humidity. It provides a measure of the evaporative and radiant transfer of heat between a typical human and the environment. Total numbers of deaths in Chicago with cardiovascular disease or heat as a primary or secondary cause were obtained from the Illinois Department of Public Health. The bars represent case subjects included in the analysis, according to cause of death.

compared with subjects without it, assuming that 18 percent of controls were exposed to any given risk factor, at a significance level of 0.05. We visited the residences of 420 potential case subjects and interviewed family members, neighbors, or friends of 372 of them (89 percent).

We identified one neighborhood control for each case subject, using a standardized search procedure; staff members began at the door of the subject's home and moved in a direction determined by coin tossing. A control of the same age was sought at the next residence. If no suitable control was identified at the buildings visited in one direction, the search was begun again from the residence of the case subject with the staff member moving in the opposite direction. The search was continued on the next floor or at the next apartment building, if necessary, with direction determined by coin tossing, until an appropriate control was found. A similar procedure was used for single-family homes. All searches were extended to the street, entire block, or neighborhood until an appropriate control was found. Controls were matched with the case subjects for age within 5 years, except for case subjects 80 or older, for whom the range was expanded to 10 years. Of 636 attempts to recruit controls, 59.4 percent led to interviews; in 14.8 percent of the attempts no one was at home; in 17.5 percent the persons identified did not match the case subjects for age; and 8.3 percent of potential controls declined to participate.

Using a uniform questionnaire, we obtained information by interviewing controls and surrogate respondents for the case subjects, such as family members, friends, or neighbors who were encountered when staff members visited the address on the death certificate. Additional information was obtained from the death certificate, police reports, and phone calls to the case subjects' next of kin. Information on the case subjects' living conditions was collected by the inspection of residences. Interviews were conducted by staff members of the Centers for Disease

Control and Prevention and by trained volunteers recruited by the Chicago Department of Public Health and the Office of the Mayor.

Statistical Analysis

We used matched-pairs analysis to estimate odds ratios and confidence intervals for each potential risk factor and cause-of-death category.^{12,13} For each risk factor, we calculated a summary odds ratio that combined the three odds ratios for the cause-of-death categories. This summary odds ratio was the weighted average of the three cause-specific odds ratios, with weights calculated from the corresponding sampling fraction and the relative frequency of each cause of death. We estimated the variance for the summary measure by using the delta method¹⁴ and treating the weights as constant. In univariate analysis of data on the total population of study subjects, we used 160 potential risk factors derived from the questionnaire.

Variables that were significant in the crude, univariate analysis were entered into a conditional, stepwise logistic-regression model. The final multivariate model contained the variables that were significant predictors of death in one or more cause-of-death categories. Summary odds ratios were calculated with use of the same weights as in the crude analysis. A summary generalized impact fraction was calculated from the summary odds ratio and the weighted numbers of case subjects exposed or control subjects not exposed to a particular factor, as a measure of the impact of these factors and their relevance for public health.¹³ Assuming that factors that increase risk are causally related to death, the calculation estimates the percentage of deaths attributable to a particular factor. For factors that decrease risk, the generalized impact fraction estimates the number of deaths attributable to the absence of the factor in some proportion of the population.

TABLE 1. SELECTION AND CHARACTERISTICS OF PERSONS WHO DIED OF HEAT-RELATED OR CARDIOVASCULAR CAUSES IN CHICAGO FROM JULY 14 THROUGH JULY 17, 1995, AND THEIR MATCHED CONTROLS, ACCORDING TO CAUSE OF DEATH.

VARIABLE	CAUSE OF DEATH						TOTAL	
	HEAT		HEAT AND CARDIOVASCULAR DISEASE		CARDIOVASCULAR DISEASE		Case Subjects	Controls
	Case Subjects	Controls	Case Subjects	Controls	Case Subjects	Controls		
	number (percent)							
Category								
Eligible subjects	84	—	353	—	243	—	680	—
Included in sample	80 (95)	—	201 (57)	—	192 (79)	—	473 (70)	—
Interviewed	62 (78)	65	157 (78)	162	153 (80)	151	372 (79)	378
Included in analysis	60	60	144	144	135	135	339	339
Characteristic								
Age (yr)								
<76	37 (62)	43 (72)	83 (58)	100 (69)	63 (47)	87 (64)	183 (54)	230 (68)
≥76	23 (38)	17 (28)	61 (42)	44 (31)	72 (53)	48 (36)	156 (46)	109 (32)
Race*								
Black	24 (40)	28 (47)	69 (48)	72 (51)	58 (43)	59 (44)	151 (45)	159 (47)
White	35 (58)	30 (50)	74 (51)	65 (46)	76 (56)	72 (54)	185 (55)	167 (50)
Other	1 (2)	2 (3)	1 (1)	5 (4)	1 (1)	2 (2)	3 (1)	9 (3)
Hispanic ethnic background	1 (2)	2 (3)	9 (6)	15 (10)	8 (6)	9 (7)	18 (5)	26 (8)
Sex								
Female	27 (45)	32 (53)	66 (46)	73 (51)	67 (50)	76 (56)	160 (47)	181 (53)
Male	33 (55)	28 (47)	78 (54)	71 (49)	68 (50)	59 (44)	179 (53)	158 (47)

*Missing data for the control groups are due to incomplete questionnaires.

RESULTS

Subjects

Of 750 persons — both case subjects and controls — for whom we had completed questionnaires, 678 (90 percent), or 339 matched pairs, were included in the analysis (Fig. 1 and Table 1). Case subjects whose surrogates were successfully surveyed were similar in terms of age, race, ethnic background, and sex to those whose surrogates were not surveyed. Table 1 shows selected demographic variables for case subjects and controls according to cause-of-death category. For the initial group of 680 eligible case subjects, the median age was 76 years. The proportions of black and white subjects were approximately equal among the case subjects and controls, and case subjects were generally older than controls in each cause-of-death category; the age difference was greatest between persons who died from cardiovascular causes and their controls.

Living Conditions and Social Contacts

There were fewer deaths among people who had a working air conditioner (odds ratio, 0.2; 95 percent confidence interval, 0.2 to 0.4) or had access to an air-conditioned lobby if the subject lived in an apartment building (odds ratio, 0.2; 95 percent confi-

dence interval, 0.1 to 0.5) than among those who did not (Table 2). Visiting an air-conditioned place during the heat wave, other than the subject's residence, was associated with lower mortality (odds ratio, 0.3; 95 percent confidence interval, 0.2 to 0.5). We did not detect any reduction in mortality in association with the use of electric fans (data not shown).

Living alone, as compared with living with others, was associated with a doubling of the risk of death during the hot weather (odds ratio, 2.3; 95 percent confidence interval, 1.4 to 3.5). More than half the case subjects (52 percent) lived on the top floor of a building, as compared with less than a third of the controls (32 percent) ($P < 0.05$). Of the case subjects, 57 percent lived in apartment houses, as compared with 47 percent of the controls, and 58 percent of the case subjects lived in buildings with flat roofs, as compared with 51 percent of the controls ($P < 0.05$).

The case subjects lived in homes with fewer rooms, on average, than did the controls. In addition, case subjects were less likely to leave home frequently, to have friends in Chicago, to have pets, and to participate in group activities than were controls.

Medical Factors

Preexisting medical conditions were associated with an increased risk of death during the heat wave

TABLE 2. LIVING CONDITIONS AND TYPES OF SOCIAL CONTACTS AMONG 339 MATCHED PAIRS OF CASE SUBJECTS AND CONTROLS.*

VARIABLE	CASE SUBJECTS	CONTROLS	ODDS RATIO (95% CI)†
	no. (%)		
Living conditions			
Had working air conditioner in home	81 (25)	170 (53)	0.2 (0.2–0.4)
Had access to air-conditioned lobby	28 (10)	54 (20)	0.2 (0.1–0.5)
Visited cooling shelters	14 (5)	22 (7)	0.5 (0.3–1.2)
Visited other air-conditioned places	67 (22)	130 (43)	0.3 (0.2–0.5)
Lived alone	156 (46)	112 (33)	2.3 (1.4–3.5)
Lived on the top floor‡	83 (52)	51 (32)	4.7 (1.7–12.8)
Type of residence			
Single-family home or duplex§	129 (39)	165 (50)	1.0
Apartment building	185 (57)	155 (47)	2.5 (1.5–4.2)
Other kind of building	13 (4)	7 (2)	8.1 (1.4–45.8)
Number of rooms			
1 or 2	65 (20)	53 (16)	3.4 (1.5–7.9)
3 or 4	87 (27)	72 (22)	2.8 (1.4–5.3)
5 or 6	135 (41)	134 (41)	1.6 (0.9–2.7)
>6§	40 (12)	68 (21)	1.0
Lived in building with flat roof	192 (58)	167 (51)	2.0 (1.2–3.2)
Social contact			
Participated in group activities (clubs, support groups, church)	140 (46)	167 (55)	0.7 (0.5–0.9)
Had access to transportation (car, bus, or train)	262 (79)	303 (92)	0.4 (0.2–0.6)
Had friends in Chicago	288 (90)	312 (97)	0.3 (0.1–0.6)
Did not leave home¶	75 (27)	19 (7)	6.7 (3.0–15.0)
Had pet in home	78 (24)	99 (30)	0.6 (0.4–0.9)

*For each variable, the denominator is based on the number of pairs with no missing data.

†Odds ratios are calculated as the risk of death among subjects with the characteristic in question, as compared with those without it, unless otherwise specified. CI denotes confidence interval.

‡The reference category was subjects who lived below the top floor of an apartment building.

§Reference category.

¶The reference category was those who left home at least once a week.

(Table 3). Confinement to bed was the strongest predictor of death; 16 percent of case subjects were bedridden, as compared with only 4 percent of controls (odds ratio, 5.5). The need for assistance from visiting nurses was associated with a mortality rate approximately six times higher than that among people who did not receive such assistance (odds ratio, 6.2); housekeepers, home health aides, and Meals on Wheels programs were also used by subjects at increased risk (odds ratios, 2.5 to 2.7). The city of Chicago sent social-service workers to visit people at risk and explain the dangers of hot weather; a decreased risk of death was found among the people they contacted (odds ratio, 0.7).

Persons whose deaths were listed on the death certificates as due to cardiovascular causes tended to have a higher frequency of preexisting medical conditions than those whose death certificates did not list cardiovascular disease (Table 4). Other risk fac-

tors among persons whose deaths were attributed to cardiovascular causes were similar in direction to those among persons for whom heat was either the primary or a contributing cause of death. Having a working air conditioner was associated with an 80 percent reduction in the risk of death due to heat and cardiovascular disease and a 66 percent reduction in mortality due to cardiovascular disease (odds ratio, 0.3; 95 percent confidence interval, 0.2 to 0.6).

Results of Multivariate Analyses

In multivariate analyses, the strongest protective factor was having a working air conditioner in the home (odds ratio, 0.3; 95 percent confidence interval, 0.2 to 0.6) (Table 5). We estimate that more than 50 percent of the deaths related to the heat wave could have been prevented if each home had had a working air conditioner (generalized impact fraction, 50.2 percent). Also effective in reducing the risk of heat-related death were visiting an air-conditioned place (odds ratio, 0.5; 95 percent confidence interval, 0.3 to 0.9) and having access to transportation (odds ratio, 0.3; 95 percent confidence interval, 0.1 to 0.5). Confinement to bed was correlated with the inability to care for oneself and was a strong risk factor for heat-related death. Living

TABLE 3. MEDICAL CONDITIONS AND CONTACTS WITH HEALTH CARE PROVIDERS AMONG 339 MATCHED PAIRS OF CASE SUBJECTS AND CONTROLS.*

VARIABLE	CASE SUBJECTS	CONTROLS	ODDS RATIO (95% CI)†
	no. (%)		
Medical conditions			
Confined to bed	51 (16)	13 (4)	5.5 (2.5–12.1)
Unable to care for self	77 (23)	29 (9)	4.1 (2.0–8.5)
Mental problem	52 (20)	23 (9)	3.5 (1.7–7.3)
Heart condition	92 (39)	46 (19)	2.3 (1.5–3.6)
Pulmonary condition	30 (13)	14 (6)	2.2 (1.0–4.9)
Body-mass index‡			
<24	131 (45)	89 (30)	1.4 (1.0–2.2)
24–27§	81 (28)	82 (28)	1.0
≥28	81 (28)	122 (42)	0.6 (0.4–1.0)
Contact with health care providers			
Visited by nurses	62 (20)	16 (5)	6.2 (2.9–13.4)
Contacted by city workers during heat wave	25 (9)	43 (16)	0.7 (0.3–1.7)
Used housekeeper or home health aide	54 (17)	27 (9)	2.7 (1.5–4.8)
Used Meals on Wheels	22 (7)	12 (4)	2.5 (1.0–6.5)

*For each variable, the denominator is based on the number of pairs with no missing data.

†Odds ratios are calculated as the risk of death among subjects with the characteristic in question, as compared with those without it, unless otherwise specified. CI denotes confidence interval.

‡The weight in kilograms divided by the square of the height in meters.

§Reference category.

alone, possibly indicating fewer contacts with family and friends and social isolation, was also associated with increased mortality (odds ratio, 2.3; 95 percent confidence interval, 1.2 to 4.4).

Other Factors Correlated with Risk

In an effort to identify practical intervention strategies, we attempted to determine the most effective means of communication with people at risk by considering information provided by the controls in interviews. We analyzed factors associated with a lack of awareness of the potential danger of sustained heat, since the univariate analysis had indicated that increased awareness (indicated by contact with city workers) was protective. The controls who listened to the radio were more likely than others to be aware of the health risks associated with hot weather (odds ratio, 2.1; 95 percent confidence interval, 0.8 to 5.6); the same was true of the controls who read the newspaper (odds ratio, 2.5; 95 percent confidence interval, 1.2 to 5.3). Virtually all controls watched television; thus, its contribution to their awareness of heat-related dangers could not be evaluated.

We also used information supplied by the controls to evaluate factors associated with the lack of air conditioning. Residents of apartment buildings were particularly likely to lack air conditioning (odds ratio, 3.4; 95 percent confidence interval, 2.1 to 5.4), as were subjects who lived in single-room-occupancy or other hotels (odds ratio, 6.2; 95 percent confi-

TABLE 4. SELECTED FACTORS ASSOCIATED WITH THE RISK OF HEAT-RELATED DEATH, ACCORDING TO CAUSE OF DEATH.

VARIABLE	CAUSE OF DEATH		
	HEAT	HEAT AND CARDIOVASCULAR DISEASE	CARDIOVASCULAR DISEASE
No. of case-control pairs	60	144	135
	odds ratio (95% confidence interval)*		
Heart condition	1.8 (0.6-5.4)	1.5 (0.8-2.8)	4.5 (2.3-8.9)
Mental problem	3.0 (0.8-11.1)	2.6 (1.1-6.2)	5.0 (1.4-17.3)
Confined to bed	2.0 (0.2-22.1)	4.3 (1.4-12.6)	9.0 (2.7-29.7)
Visited by nurses	10.0 (1.2-78.1)	3.8 (1.4-10.2)	8.7 (2.6-28.6)
Unable to care for self	9.0 (1.1-71.0)	1.9 (0.9-4.1)	6.2 (2.9-14.6)
Visited other air-conditioned places	0.1 (0.04-0.5)	0.4 (0.2-0.7)	0.4 (0.2-0.8)
Had working air conditioner	0.2 (0.1-0.6)	0.2 (0.1-0.4)	0.3 (0.2-0.6)
Lived alone	5.7 (1.7-19.3)	2.2 (1.2-3.9)	1.5 (0.9-2.6)
Did not leave home	1.8 (0.5-6.0)	7.3 (2.2-24.5)	7.8 (3.1-19.8)

*Odds ratios are calculated as the risk of death among subjects with the characteristic in question, as compared with those without it.

TABLE 5. ASSOCIATION OF RISK FACTORS WITH HEAT-RELATED DEATH IN THE WEIGHTED MULTIVARIATE ANALYSIS.

VARIABLE	CASE SUBJECTS (N=339)	CONTROLS (N=339)	ODDS RATIO (95% CI)*	GIF (%)†
	no. (%)			
Had working air conditioner in home	96 (28)	170 (50)	0.3 (0.2-0.6)	50.2
Visited other air-conditioned places	103 (30)	130 (38)	0.5 (0.3-0.9)	39.5
Had access to transportation	270 (80)	303 (89)	0.3 (0.1-0.5)	16.3
Confined to bed	51 (15)	13 (4)	8.2 (3.1-22.0)	13.7
Lived alone	156 (46)	112 (33)	2.3 (1.2-4.4)	27.1

*Odds ratios are calculated as the risk of death among subjects with the characteristic in question, as compared with those without it. CI denotes confidence interval.

†GIF denotes generalized impact fraction, an estimate of the percentage of deaths attributable to a particular factor or the absence of a particular factor.

dence interval, 0.6 to 61.4), as compared with people living in single-family houses. People were more likely to change their daily routines during hot weather — for example, by drinking extra fluids or taking extra baths — if they lived with at least one other person (odds ratio, 2.1; 95 percent confidence interval, 1.3 to 3.4) or if they had a pet (odds ratio, 2.1; 95 percent confidence interval, 1.3 to 3.5).

DISCUSSION

The people who are at greatest risk for death due to heat or to cardiovascular causes include those in frail health, such as elderly persons, and those who are socially isolated. People at risk were often in need of help from visiting nurses, housekeepers, or Meals on Wheels programs — an association that could have implications for preventive public health programs. Living conditions, including the type of building, the floor level, and the number of rooms, were also found to be important determinants of risk. The presence of air conditioning was inversely associated with mortality from both heat and cardiovascular causes.

Limitations

As is true in other studies that rely on information provided by surrogate respondents (in this case, family members, neighbors, or friends of people who had died), our results may underestimate the risk associated with social isolation, since people with few social contacts (and hence no identifiable surrogate) were excluded from the study. We did not find any demographic differences between the case subjects for whom surrogate respondents were available and those for whom they were not; however, we have no

details of the lifestyles of the case subjects without surrogates. Nonetheless, even after the exclusion of this most isolated segment of the population, we found a significant association between risk and variables measuring the degree of social isolation. Similarly, subjects interviewed personally and surrogate respondents are not equally credible, particularly in the case of socially isolated persons. Therefore, information concerning the case subjects' personal behavior and awareness and knowledge of health risks was excluded.

A limitation inherent in the use of death certificates is the potential misclassification of causes of death.¹⁵⁻¹⁷ Almost all death certificates listing heat as a cause of death were signed by personnel from the Medical Examiner's Office rather than by private health care providers. Despite the possibility of misclassification, we found that risk factors overlapped strongly between persons whose deaths were listed as related to heat and those whose deaths were listed as due solely to cardiovascular disease.

Strategies for Prevention

Home health care workers, friends, and the media can be effective in communicating health-protection messages directly to high-risk groups. Some of the people at highest risk of death during a heat wave are those who, as a consequence of preexisting illness, have ongoing connections to community services — through visiting nurses or Meals on Wheels personnel, for example. During periods of hot weather, these and similar public health programs provide an ideal opportunity for intervention. Media coverage of appropriate preventive measures can also be effective in increasing the public's awareness of the dangers of heat. Successful messages should encourage the modification of routine behavior in the direction of prevention.

Certain housing conditions may also entail a substantial risk of heat-related death. Living in an apartment was associated with increased risk, particularly if no air conditioner was available in the lobby. Socioeconomic differences that manifest themselves in housing may confound these findings to some extent; for example, the lack of a working air conditioner was more common among inhabitants of apartment buildings than among inhabitants of private homes. This information points to the importance of directing outreach efforts toward apartment dwellers.

Previous research has yielded conflicting results regarding the effects of electric fans in hot weather^{1,18-21} (and Steadman RG: personal communication). In our study, we did not find any evidence that the use of fans was protective, nor did we determine that any level of use of electric fans was associated with increased mortality. Interpretation of the data on the use of fans is complicated by the

need to take into account specific environmental factors (for example, whether the fan is used in a room with an open or a closed window) and the health status of individual subjects. The effectiveness of fans in preventing death during periods of high heat and humidity remains a matter of controversy and deserves further attention; nonetheless, the potential preventive value and effectiveness of electric fans seem minimal as compared with those of other clearly beneficial factors, such as increasing use of air conditioning.

The preexisting medical conditions of individual Chicagoans greatly affected how well they were able to deal with last summer's heat wave. Although obesity is usually associated with a decreased ability to acclimate to heat,^{22,23} we did not find an association between mortality and a body-mass index (defined as the weight in kilograms divided by the square of the height in meters) above the normal range. We did find that people with a body-mass index below the normal range had increased risk. For the elderly, a body-mass index lower than 24 may indicate a debilitating illness or poor nutritional status. In all three cause-of-death categories, subjects with diagnosed heart or kidney disease or mental illness had an increased risk of death. Other researchers have found that neuroleptic drugs can interfere with the physiologic response to extremes of temperature and therefore increase the risk of heat-related effects on health.^{1,24} We found that of the 59 case subjects who were at increased risk because of preexisting mental problems, 2 (3 percent) were taking some form of neuroleptic medication. Because of their medical problems, many of the people at highest risk have an established relationship with a health care provider; such providers may be able to increase patients' awareness of the dangers of heat and convey messages about preventive measures, even during annual visits that do not occur during hot weather.

Although previous studies have consistently confirmed that there is an excess of deaths due to cardiovascular causes during periods of high or prolonged heat and have supported the biologic plausibility of the exacerbation of existing ischemic heart disease by heat, little information has been available about specific risk factors for heat-related death^{3,4,25-31} (and Wainright S, et al.: personal communication). From our study we know that people who died of cardiovascular disease were somewhat older than those whose death certificates listed heat as the underlying or secondary cause of death (average, 76 vs. 70 years; $P < 0.001$) and had a greater frequency of preexisting medical conditions (84 percent vs. 73 percent, $P < 0.05$). Although the magnitude of risk varied among the cause-of-death categories, we found similar risk factors in these categories. Measures to prevent heat-related death are particularly important for people with cardiovascular disease.

Access to air-conditioned environments is the factor with the greatest protective effect with respect to heat-related mortality.^{1,8} We found that people who lived in apartments without air conditioning had a lower risk if they had access to an air-conditioned lobby. These results have important implications for public health. Providing air conditioning to common areas in buildings or in the immediate neighborhood or providing readily accessible transportation to public cooling shelters could help to reduce excess mortality during hot weather.

Excess deaths do not typically occur until the second, third, or fourth day of a heat wave.^{7,10} Specific information on how to avoid heat-related illness should be included in media coverage as soon as possible along with meteorologic forecasts of heat waves.

Conclusions

The risk factors identified in this study reflect the complexity of the environmental, social, and medical components of heat-related mortality. Since heat-related deaths are preventable, targeted actions by public health professionals, health care providers, and the media can save lives each summer. People, especially elderly people, who live alone and do not have networks of social contacts and those with debilitating conditions are at particularly high risk during heat emergencies. These people need to be made aware of simple ways they can adapt their daily routines to prevent death due to hot weather; air-conditioned environments should be made readily available and accessible. During the summer heat wave of 1995 in Chicago, anything that facilitated social contact, even membership in a social club or owning a pet, was associated with a decreased risk of death.

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REFERENCES

1. Kilbourne EM, Choi K, Jones TS, Thacker SB, Field Investigation Team. Risk factors for heatstroke: a case-control study. *JAMA* 1982;247:3332-6.
2. Clarke JF. Some effects of the urban structure on heat mortality. *Environ Res* 1972;5:93-104.
3. Ellis FP. Mortality from heat illness and heat-aggravated illness in the United States. *Environ Res* 1972;5:1-58.
4. Schuman SH. Patterns of urban heat-wave deaths and implications for prevention: data from New York and St. Louis during July, 1966. *Environ Res* 1972;5:59-75.
5. Jones TS, Liang AP, Kilbourne EM, et al. Morbidity and mortality associated with the July 1980 heat wave in St. Louis and Kansas City, Mo. *JAMA* 1982;247:3327-31.
6. Martinez BF, Annett JL, Kilbourne EM, Kirk ML, Lui KJ, Smith SM. Geographic distribution of heat-related deaths among elderly persons: use of country-level dot maps for injury surveillance and epidemiologic research. *JAMA* 1989;262:2246-50.
7. Kilbourne EM. Diseases associated with the physical environment. In: Last JM, ed. *Maxy-Rosenau public health and preventive medicine*. 12th ed. Norwalk, Conn.: Appleton-Century-Crofts, 1986:703-10.
8. Rogot E, Sorlie PD, Backlund E. Air-conditioning and mortality in hot weather. *Am J Epidemiol* 1992;136:106-16.
9. Heatstroke — United States, 1980. *MMWR Morb Mortal Wkly Rep* 1981;30:277-9.
10. July 1995 heat wave: natural disaster survey report 1995. Washington, D.C.: National Oceanographic and Atmospheric Administration, 1995.
11. Heat-related mortality — Chicago, July 1995. *MMWR Morb Mortal Wkly Rep* 1995;44:577-9.
12. SAS/STAT software: changes and enhancements, release 6.07. Technical report P-229. Cary, N.C.: SAS Institute, 1992.
13. Kleinbaum DG, Kupper LL, Morgenstern H. *Epidemiologic research: principles and quantitative methods*. Belmont, Calif.: Lifetime Learning, 1982.
14. Agresti A. *Categorical data analysis*. New York: John Wiley, 1990:56-8.
15. Alderson MR, Meade TW. Accuracy of diagnosis on death certificates compared with that in hospital records. *Br J Prev Soc Med* 1967;21:22-9.
16. Gwynne JF. The unreliability of death certificates. *N Z Med J* 1974;80:336.
17. Beadenkopf WG, Abrams M, Daoud A, Marks RU. An assessment of certain medical aspects of death certificate data for epidemiological study of arteriosclerotic heart disease. *J Chronic Dis* 1963;16:249-62.
18. Yaglou CP. Temperature, humidity, and air movement in industries: the effective temperature index. *J Ind Hyg* 1927;9:297-309.
19. Steadman RG. The assessment of sultriness. 1. A temperature-humidity index based on human physiology and clothing science. *J Appl Meteorol* 1979;18:861-73.
20. *Idem*. The assessment of sultriness. 2. Effects of wind, extra radiation, and barometric pressure on apparent temperature. *J Appl Meteorol* 1979;18:874-85.
21. *Idem*. A universal scale of apparent temperature. *J Clim Appl Meteorol* 1984;23:1674-87.
22. Bar-Or O, Lundegren HM, Buskirk ER. Heat tolerance of exercising obese and lean women. *J Appl Physiol* 1969;26:403-9.
23. Haymes EM, McCormick RJ, Buskirk ER. Heat tolerance of exercising lean and obese prepubertal boys. *J Appl Physiol* 1975;39:457-61.
24. Kollias J, Bullard RW. The influence of chlorpromazine on physical and chemical mechanisms of temperature regulation in the rat. *J Pharmacol Exp Ther* 1964;145:373-81.
25. Gover M. Mortality during periods of excessive temperature. *Public Health Rep* 1938;53:122-43.
26. Schuman SH, Anderson CP, Oliver JT. Epidemiology of successive heat waves in Michigan in 1962 and 1963. *JAMA* 1964;189:733-8.
27. Bridger CA, Helfand LA. Mortality from heat during July 1966 in Illinois. *Int J Biometeorol* 1968;12:51-70.
28. Henschel A, Burton LL, Margolies L, Smith JE. An analysis of the heat deaths in St. Louis during July, 1966. *Am J Public Health* 1969;59:2232-42.
29. Ellis FP, Prince HP, Lovatt G, Whittington RM. Mortality and morbidity in Birmingham during the 1976 heatwave. *Q J Med* 1980;49:1-8.
30. Applegate WB, Runyan JW Jr, Brasfield L, Williams ML, Konigsberg C, Fouche C. Analysis of the 1980 heat wave in Memphis. *J Am Geriatr Soc* 1981;29:337-42.
31. Mortality public use computer data tapes for the years 1979-1991. Hyattsville, Md.: National Center for Health Statistics, 1992.