Morbidity and Mortality Associated With the July 1980 Heat Wave in St Louis and Kansas City, Mo

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• **The morbidity and mortality associated with the 1980 heat wave in St Louis and Kansas City, Mo, were assessed retrospectively. Heat-related illness and deaths were identified by review of death certificates and hospital, emergency room, and medical examiners' records in the two cities. Data from the July 1980 heat wave were compared with data from July 1978 and 1979, when there were no heat waves. Deaths from all causes in July 1980 increased by 57% and 64% in St Louis and Kansas City, respectively, but only 10% in the predominantly rural areas of Missouri. About one of every 1,000 residents of the two cities was hospitalized for or died of heat-related illness. Incidence rates (per 100,000) of heatstroke, defined as severe heat illness with documented hyperthermia, were 26.5 and 17.6 for St Louis and Kansas City, respectively. No heatstroke cases occurred in July 1979. Heatstroke rates were ten to 12 times higher for persons aged 65 years or older than for those younger than 65 years. The ratios of age-adjusted heatstroke rates were approximately 3:1 for nonwhite *v* white persons and about 6:1 for low *v* high socioeconomic status. Public health preventive measures in future heat waves should be directed toward the urban poor, the elderly, and persons of other-than-white races.**

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HOT WEATHER can affect human health adversely. High environmental temperatures are a well-known hazard to military recruits,[1] athletes,[2] and to persons in certain occupations. When unusually high temperatures for a geographic area and population continue for several days, rates of mortality for all causes can increase dramatically.[3-6] Mortality increases because of deaths directly attributable to the heat (eg, heatstroke) and also because of an increase in deaths for causes not apparently caused by the heat (eg, heart disease, cerebrovascular accidents).[7] Most studies of the health effects of heat waves are reports on mortality indices or of patients seen at a single medical-care institution.[8] There are few heat wave morbidity investigations and few population-based studies.[9]

See also pp 3332 and 3354.

The 1980 heat wave provided an opportunity to study the effects of hot weather on human health. We obtained population-based data on the health effects of the heat wave in Missouri—one of the most severely affected states in the country.[10] In addition to assessing mortality through review of death records, we were able to estimate heat effects on morbidity in both cities.

METHODS

St Louis weather data were obtained from the National Weather Service station at Lambert Field (19.2 km from downtown St Louis) and from the Department of Earth and Atmospheric Sciences of St Louis University. Kansas City weather data were obtained from the National Weather Service stations at the two Kansas City airports, one located near downtown and the other 27.2 km from the center of the city.

Illnesses or deaths that were attributed to heat by attending medical personnel in hospital or death records were defined as heat related. This category includes the classic heat-induced syndromes—heatstroke, heat exhaustion, and heat cramps—as well as diagnoses such as angina pectoris exacerbated by heat. Heatstroke was defined as a heat-related illness with a documented antemortem or postmortem body temperature of 41.1 °C or greater, or a documented antemortem temperature of 40.6 °C or greater, with warm, dry skin (anhidrosis), altered mental status, or both.

Cases were identified by three methods: review of records of 14 St Louis and 17 Kansas City acute-care hospitals; review of medical examiners' records; and review of death certificates. To estimate overall health effects of the heat wave, total hospital admissions, emergency room (ER) visits, and deaths from all causes were collected for June and July 1980 and compared with the same periods in 1978 and 1979, both non-heat-wave years. Cases and deaths of heatstroke and heat-related illness were identified from information in

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hospital and medical examiner records.

During a case-control study of heatstroke, 156 patients, or informants for them, were asked the number of days of illness before hospitalization or being discovered dead.[11]

For St Louis, we used estimates of the 1979 midyear population (500,484) based on projections from the 1970 US Census from the city's Division of Vital Records and Biostatistics. Sex distribution was estimated using proportions of the 1970 census. For Kansas City, the 1980 census preliminary estimate of 426,000 was used for the total population. Since 1980 census data for age, sex, and race were not available, they were estimated by using the proportions found in the 1970 census. Age adjustment was by the direct method using these data.

Census tracts were ranked by socioeconomic status in quartiles: high, high-middle, low-middle, and low. Socioeconomic classification of census tracts was done using three indicators obtained from the 1970 census: median school years completed by persons aged 25 years or older, proportion of housing units with 1.01 or more persons per room, and proportion of families below poverty level.[12]

Statistical significance was tested by the χ^2 test for independence of factors.

RESULTS

In Kansas City, there were 17 consecutive days with maximum temperatures of 38.9 °C or greater, including ten days when the temperature reached 42.2 °C or above. In St Louis, the maximum temperature was 37.8 °C or greater for 16 days, with new all-time high records established on four days. Air temperatures recorded at the Kansas City downtown airport (KCDA) for the period July 6 to 21, 1980, were higher than those recorded at the suburban Kansas City International Airport. The daily maximum temperature averaged 2.5 °C and the daily minimum temperature averaged 4.1 °C higher at the KCDA.

In both St Louis and Kansas City, deaths from all causes increased in July 1980 compared with July 1978 and July 1979 (Figs 1 and 2). In St Louis, there were 850 resident deaths in July 1980, compared with 542 deaths in July 1979, a 56.8% increase. In Kansas City, there were 598 deaths in 1980 and 362 in 1979, a 65.2% increase for 1980. Deaths for the remainder of Missouri, which is predominantly rural, increased only 9.5% for July 1980 (3,210) compared with July 1979 (2,932) (Fig 3).

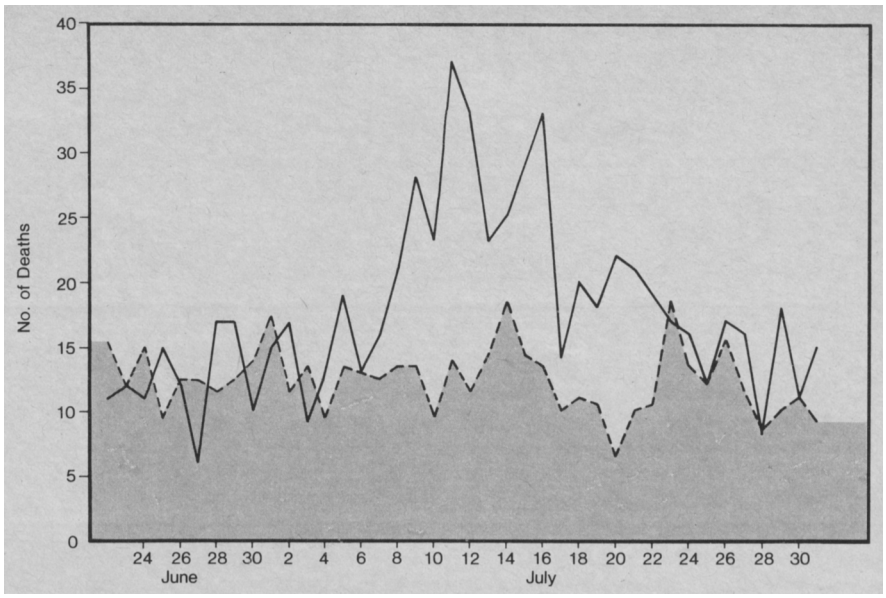

Fig 1.—Deaths, by date of occurrence, Kansas City, Mo, residents, June 1978 to July 1979 and 1980. Dotted line indicates mean values for 1978 to 1979 period; solid line, 1980.

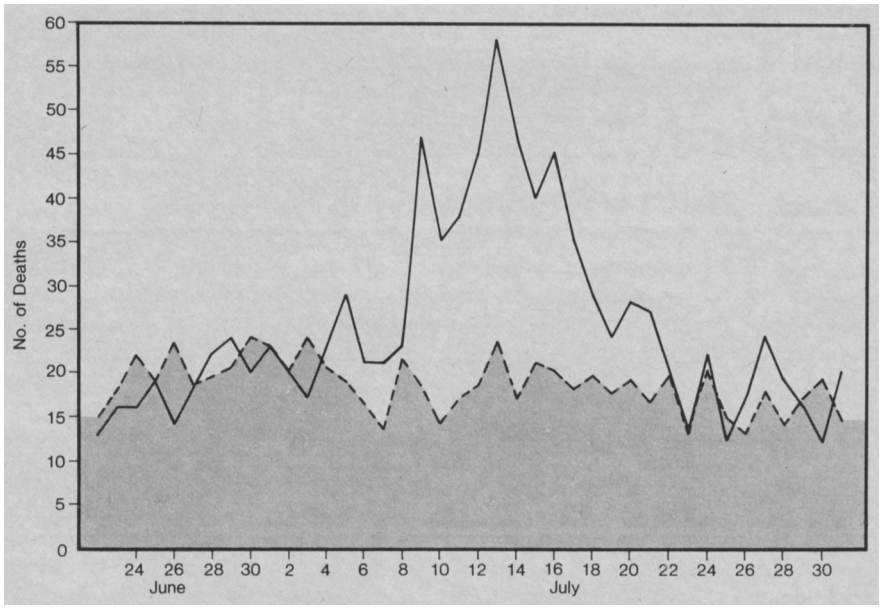

Fig 2.—Deaths, by date of occurrence, St Louis, Mo, residents, June 1978 to July 1979 and 1980. Dotted line indicates mean values for 1978 to 1979 period; solid line, 1980.

The total number of deaths reported by medical examiners was much greater for July 1980 than for July 1979 because of increased numbers of deaths not attended by physicians. In Kansas City, there were 255 deaths reported by medical examiners for July 1980 compared with 93 deaths for July 1979, a 174% increase. In St Louis, there were 512 deaths reported for July 1980, 273 (114%) more than the 1979 total of 239. The St Louis medical examiner classified 113 (22%) of all July 1980 deaths as heat related, while the Kansas City medical examiner similarly designated 133 (52%). The designation of deaths as heat-related was based on the circumstances in which the body was found, body temperature, and other factors.

In St Louis, the number of daily ER visits for all causes during July 1979 and July 1980 was available for ten hospitals representing 79.2% of the city's adult, acute-care beds. There were 27,641 ER visits in 1980 compared with 24,173 ER visits in 1979, an increase of 3,468 (14.3%). Daily ER visits peaked in mid-July 1980 during the period of maximum temperatures.

A similar increase was found for Kansas City, where information was available for 14 hospitals, representing 93% of the city's acute-care beds. There were 20,903 ER visits in 1980 compared with 19,431 visits in 1979, a 7.6% increase. Of the July 1980 ER visits in Kansas City, 179 were designated by attending medical personnel as heat related, whereas none were so listed during July 1979.

Hospital admissions for all causes increased slightly for July 1980. Data for 11 St Louis hospitals (89.9% of the city's acute-care beds) showed 17,423 admissions in July 1980 compared with 16,576 admissions for July 1979, a 5.1% increase. In Kansas City, 14 hospitals reported 12,885 admissions for July 1980 compared with 12,690 admissions for July 1979, an increase of 1.5%.

In St Louis, a total of 351 heat-related hospital admissions and deaths was found; in Kansas City, the number was 433 (Table 1). In both St Louis and Kansas City, the incidence peaked in mid-July, and began to decline before the end of the heat wave (Figs 1, 2, and 4).

The city-wide heatstroke rates (per 100,000 of the population at risk) were 26.5 for St Louis and 17.6 for Kansas City. In both cities, higher heatstroke rates were found for three subpopulations: the elderly, the poor, and nonwhites. Although persons aged 65 years or older constituted approximately 15% of the population, about 71% of the heatstroke cases occurred in this age group, giving rates ten to 15 times higher than those for the remainder of the population (Table 2). Age-adjusted heatstroke rates were three to six times higher for nonwhites than for whites (Table 3). The age-adjusted heatstroke rates for men and women were similar: 26.6 for men and 25.0 for women in St Louis, and 16.4 for men and 18.7 for women in Kansas City. Age-adjusted heatstroke rates were about six times higher for persons residing in census tracts in the lowest socioeconomic quartile compared with the highest socioeconomic areas (Table 4). Heatstroke incidence increased with age, independent of both race and socioeconomic status ($P<.05$). Our data were not sufficient to demonstrate independent contributions of race or socioeconomic status. Review of medi-

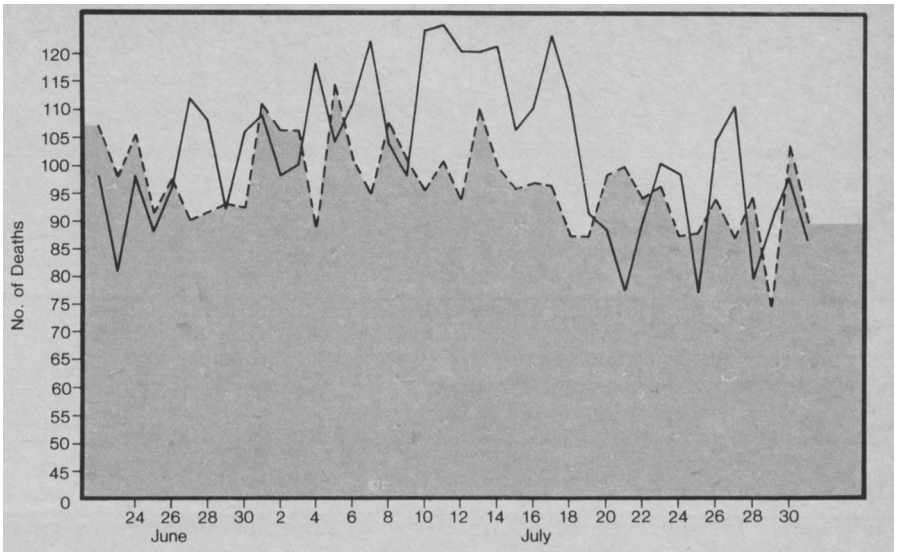

Fig 3.—Deaths, by date of occurrence, in Missouri residents, excluding residents of St Louis and Kansas City, June 1978 to July 1979 and 1980. Dotted line indicates mean values for 1978 to 1979 period; solid line, 1980.

Table 1.—Heat-Related Illness Cases, by Category, Found Among Medical Examiners' and Hospital Admission Records, St Louis (SL) and Kansas City (KC), Mo, July 1980

	Dead on Arrival		Hospitalized				Total	
			Died		Survived			
	SL	KC	SL	KC	SL	KC	SL	KC
Heatstroke (HS)	43	2	19	15	71	58	133	75
Non-HS, heat related	50	127	10	13	158	218	218	358
Total, Heat Related	93	129	29	28	229	276	351	433

Fig 4.—Heat-related illness by date of onset and daily maximum temperatures, St Louis, Mo, July 1980.

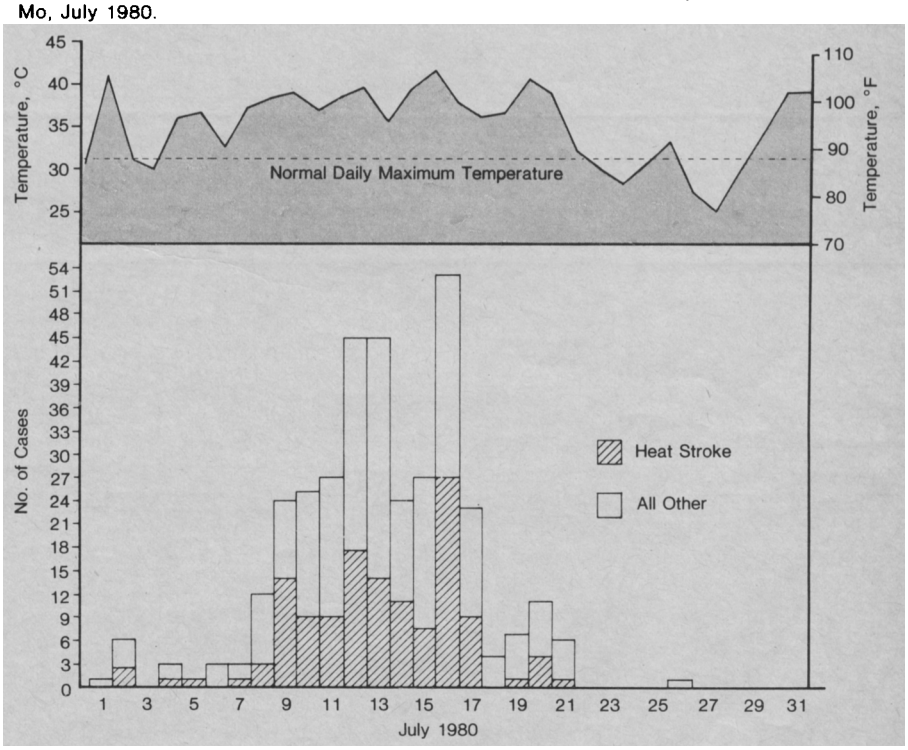

Table 2.—Heatstroke Rates, by Age Group, St Louis and Kansas City, Mo, July 1980

Age, Group, yr	Rate per 100,000 Persons	
	St Louis	Kansas City
0-18	0.0	0.0
19-44	3.4	2.1
45-64	28.5	23.6
≥65	121.0	102.0

Table 3.—Age-Adjusted Heatstroke, by Race, St Louis and Kansas City, Mo, July 1980

Race	Age-Adjusted Rate per 100,000 Persons	
	St Louis	Kansas City
White	15.1	9.3
Nonwhite	43.2	60.7

Table 4.—Age-Adjusted Heatstroke Rates, by Socioeconomic Status of Census Tract of Residence, St Louis and Kansas City, Mo, July 1980

Socioeconomic Status	Age-Adjusted Rate per 100,000 Persons	
	St Louis	Kansas City
High	8.1	6.5
High-middle	19.6	5.3
Low-middle	44.5	23.0
Low	55.8	36.5

Table 5.—Number of Days Between Reported Onset of Symptoms and Hospitalization or Being Found Dead, 156 Heatstroke Cases, Kansas City and St Louis, Mo, July 1980

No. of Days	No. (%) of Heatstroke Cases	Cumulative Percentage
<1	80(61)	...
1	16(12)	74
2	12(9)	83
3-4	9(7)	90
≥5	13(10)	100
Total Known	**130(99)**	...
Unknown	26	...

cal records at children's hospitals during this study identified only five cases of heat-related illness in infants and no cases of heatstroke.

Based on information from interviews of heatstroke survivors or family and friends of persons who died, heatstroke illness appeared abruptly (Table 5). Almost two thirds of the 130 cases for whom data are available were reported to have had less than one day of symptomatic illness before hospitalization or being found dead. Nearly three fourths had symptoms for one day or less before the onset of heatstroke.

COMMENT

This study documented the marked adverse effects of the 1980 heat wave on the health of large numbers of St Louis and Kansas City residents. During July 1980, about one of every 1,000 residents of St Louis (1/1,425) and Kansas City (1/984) was hospitalized or died because of heat-related illness. Approximately one of every 5,600 residents of Kansas City and one of 3,800 residents of St Louis met the rigorous criteria for heatstroke used in this study. Rates of illness were similar for the two cities. Compared with a similar time period in the non-heat-wave year of 1979, overall morbidity and mortality increased dramatically as did the classic heat-induced syndromes. The morbidity figures are minimum estimates of the impact of the heat wave on health, since persons with heat-related illnesses treated as outpatients by private physicians, at some public clinics, and by self care at home are not included.

Not unexpectedly, heatstroke was found to be a greater problem among the elderly,[3,8,13] the poor,[14] nonwhites,[5,7] and city-dwellers.[4,5,6,15] Heat casualties among the aged might be explained, in part, by impaired physiological responses to heat stress. Persons older than 65 years are less likely to have the capacity to increase cardiac output adequately and decrease systemic vascular resistance during hot weather.[16] Similarly, the efficiency of sweating declines with increasing age.[17,18] Acclimatization to hot weather may also be impaired among elderly persons, particularly those who do not live in hot climates year-round.[19,20] Finally, the elderly are more likely to have underlying diseases or to be receiving medications (anticholinergics, major tranquilizers, diuretics) that have been reported to increase the risk of heatstroke.

Our data show that, in the 1980 heat wave, residents of low socioeconomic status (SES) census tracts—independent of age and race ($P<.05$)—had higher rates of heat-related illness, particularly heatstroke. One factor that could account for high rates of heat-related illness among the poor is their relative lack of air-conditioning or other cooling devices. In the 1970 St Louis census, only about one fifth (19%) of the residences in the lowest quartile SES census tracts had air conditioning, while about two thirds (66%) were so equipped in the highest quartile census tracts. Other factors may contribute to the higher rates of heat-related illness among the poor, such as higher prevalence of chronic disease and delays in seeking care.[21,22]

The findings of other studies regarding a possible racial predilection for heatstroke are inconsistent. Some investigators[5,7] have found higher rates of heat-related illness and mortality among persons of races other than whites, while others[23,24] have shown no differences. Our study found higher rates of heatstroke in nonwhites, but the effect of race on heatstroke could not be dissociated from the potentially confounding effect of low socioeconomic status.

This investigation documented greater increases in mortality for all causes comparing July 1980 with July 1979 in the cities of Kansas City (+65%) and St Louis (+57%) than in the predominantly rural remainder of Missouri (+10%). Part of the explanation is higher temperatures in cities compared with surrounding suburban and rural areas (heat-island effect).[25,26] The higher temperatures in cities have been attributed to a variety of factors, including increased retention of solar heat by buildings and pavement[26]; increased heat production by higher concentrations of people, motor vehicles, and factories; and decreased heat loss due to the lower average wind velocities. In addition, other unidentified economic and social differences between city and rural residents may contribute to the larger increases in death rates in cities.

Some population groups fared better in the 1980 heat wave than in those that occurred earlier in this century. During earlier heat waves, infants were at relatively higher risk of death.[27] Hyperthermia during extreme hot weather was found to be particularly likely to develop in infants with diarrhea, respiratory tract infections, or neurological de-

fects.[23] The lack of severe heat-related illness and death among young children in 1980 paralleled the 1966 findings of Schuman.[14] Likewise, early in the 20th century, deaths from heatstroke were common among men 20 to 60 years old engaged in physically demanding manual labor. As a result, death rates from heatstroke were higher for men than women for all age groups.[4] This study found similar age-adjusted rates of heatstroke and other heat-related illness for men and women.

Heatstroke frequently developed with little or no warning. Almost two thirds of persons with heatstroke were reported to have been ill less than one day before being hospitalized or found dead. A typical history was that a person went to bed, apparently well, and was discovered severely ill, unconscious, or dead the next day. Therefore, even frequent observation of persons at high risk may yield little opportunity for therapeutic intervention in the majority of severe cases.

Major heat waves with the potential for causing increased mortality and morbidity will occur in the future, and public health measures should be aimed at preventing heat-related illness and death primarily among the poor, the elderly, and nonwhite persons.

High temperature, the number of days the temperature is elevated, the amount the temperature is in excess of normal, high humidity, and lower wind velocity have all been reported to be associated with increased heat stress in humans.[7,26,28,29] Although the use of one weather measurement, the wet-bulb globe temperature, has reduced heat casualties among military recruits,[1] specific weather conditions that constitute health threats for the general population need to be established and assessed for use in preventing heat-related illness.

Another possibility for the early detection of heat disasters is surveillance for heat-induced illness. The beginning of serious adverse health effects of a heat wave are signaled by the occurrence of heatstroke cases and by dramatic increases in the daily total of medical examiners' cases.[30] In both St Louis and Kansas City, the largest number of heatstroke cases were seen at the public municipal hospitals, which serve the high-risk poor, elderly, and persons other than whites. When the temperatures are high, daily surveillance of heatstroke hospital admissions, particularly at the hospitals that serve the high-risk populations, and daily surveillance of deaths recorded by the medical examiner may detect early increases in morbidity and mortality, so that prevention efforts can be intensified.

Weather hot enough to cause dramatic increases in deaths is a recurrent phenomenon in the United States.[6] During the last 50 years, major heat waves associated with increases in deaths have affected large areas of the country during at least six summers—the mid-1930s (1934, 1936), the 1950s (1952, 1954), 1966, and 1980. Although infants fared better in the 1980 heat wave, the pattern of relatively high morbidity and mortality among the elderly, the poor, and nonwhites was similar to previous heat waves. The 1966 heat wave in St Louis caused increases in general morbidity, deaths recorded by the medical examiner, and heatstroke deaths, comparable with those reported in this study.[5,14,30]

Unless a coordinated community effort is mounted during the next major heat wave, the remarkable loss of life in 1980 and previous major heat waves will be repeated.

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