

Morbidity and mortality experience in St. Louis during the heat wave of July, 1966, present problems pertinent to general health care and to health care in enclosed spaces such as shelters.

AN ANALYSIS OF THE HEAT DEATHS IN ST. LOUIS DURING JULY, 1966

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Introduction

EXPOSURE to a combination of high environmental temperature and physical work that exceed the levels during the preceding few days has been considered the precipitating factor in heat stroke in many instances.^{9,12,13,15-18} It has also been observed that deaths from all causes increased during heat waves.^{1,2,4,5,10,11,14}

From these two series of reports it is concluded that in certain situations environmental heat can be a primary cause of death, but in others it may be only a contributing factor. The extent to which heat factors are responsible for the increased death rate associated with naturally occurring summer heat waves has not been fully documented.

The present study was undertaken as part of Work Order OCS-PS-64-126 between the Office of Civil Defense and the Division of Health Mobilization, U.S. Public Health Service. The objective of the study was to evaluate the effects of excessive environmental conditions upon deviations from normal experience of mortality and morbidity in which heat was an identifiable primary or contributing factor. Data are primarily from a study of the role of heat in the increased death rate during heat waves of July, 1966, in St. Louis, Mo.

Methods and Materials

The main sources of data were the death certificates and hospital records that were made available to us for review, and the July, 1966, Local Climatological Data compilation for Lambert Field in St. Louis which was obtained from the National Weather Records Center in Asheville, N. C. The pertinent items of information were abstracted from the records and entered on punched cards for computer analysis. In addition, on a map of the greater St. Louis area, the home address of each heat death was identified to show the residence-area distribution of heat-death cases.

Results and Discussion

The weather data for the periods before, during, and after the heat wave in July, 1966, are presented in Figure 1 and Table 1. The data were abstracted from the official Weather Bureau records for Lambert Field, the St. Louis Municipal Airport located a few miles northwest of the central core area of St. Louis. The maximum and minimum temperatures were probably higher in the high-density, central-core area than in the outlying suburbs where Lambert Field is located. Within the core area a horizontal and vertical variation in

temperatures would also be expected. Consequently, actual temperatures in many places may have been 2 to 5 degrees higher than those recorded by the Weather Bureau station at Lambert Field.

The temperatures each day were above 90° F from June 22 until July 20 except for July 7. During this period the maximum temperatures exceeded the normal for the date by 2 to 17 degrees. Maximum temperatures were consistently in the low to middle 90s, 2 to 7 degrees above normal, until July 9. For the next six days the maximum temperatures were above 100° F (101°-106° F) and were about 10 degrees

higher than during the preceding two weeks of hot weather and 12 to 17 degrees higher than normal. After July 14 temperatures were lower again and more nearly approximated the conditions that preceded the six-day heat wave.

The minimum temperatures for the nights were also 10 to 15 degrees higher during the July 9-14 heat wave than either before or after. The higher minimum temperatures would slow the rate of night-time cooling of the buildings and would, in effect, increase the total daily heat load. In addition, the high night temperatures would interfere with proper sleep, rest, and recuperation.

Figure 1—Daily temperature in °F at Lambert Field, St. Louis, Mo., during July, 1966

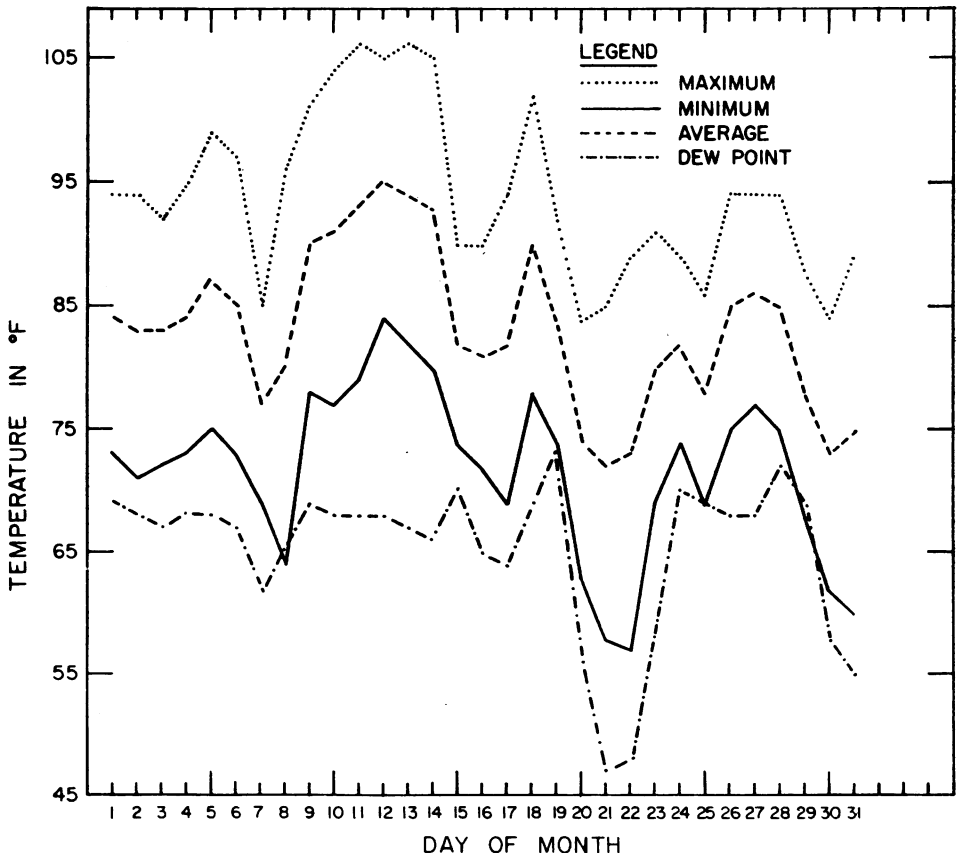


Table 1—Daily temperatures in °F at Lambert Field, St. Louis, during June-August, 1966

Date	Temperature, °F				Average dew point
	Maximum	Minimum	Average	± Normal	
June 24	93	67	80	3	59
25	95	73	84	7	60
26	94	73	84	7	64
27	94	72	83	6	67
28	91	72	82	5	65
29	92	69	81	4	64
30	94	70	82	5	66
July 1	94	73	84	7	69
2	94	71	83	5	68
3	93	72	83	5	67
4	95	73	84	6	68
5	99	75	87	9	68
6	97	73	85	7	67
7	85	69	77	-1	62
8	96	64	80	2	65
9	101	78	90	12	69
10	104	77	91	13	68
11	106	79	93	15	68
12	105	84	95	17	68
13	106	82	94	16	67
14	105	80	93	15	66
15	90	74	82	4	70
16	90	72	81	2	65
17	94	69	82	3	64
18	102	78	90	11	69
19	92	74	83	4	73
20	84	63	74	-5	56
21	85	58	72	-7	47
22	89	57	73	-5	48
23	91	69	80	2	58
24	89	74	82	4	70
25	86	69	78	0	69
26	94	75	85	7	68
27	94	77	86	8	68
28	94	75	85	7	72
29	88	68	78	0	69
30	84	62	73	-5	58
31	89	61	75	-3	55

We know that dew point temperatures express the amount of moisture in the air and are directly relatable to the vapor pressure of the moisture in the air. We also know that the amount of moisture that can be evaporated from the skin to keep the body from overheating is determined by the vapor pressure of the air (and can be readily calculated from dew point). However, relative hu-

midity is not a good indicator of the ease with which sweat can be evaporated. Even though humidity was moderately high for the six-week period shown in Table 1, the moisture conditions of the air that existed in St. Louis before, during, and after the heat wave should not have been a limiting factor in sweat evaporation.

Calculations employing various heat-

stress indexes show that the total heat load was high during the heat wave. The corrected effective temperature (ET) was between 83° and 85° F when based on the maximum daily temperatures and between 80° and 81° F when based on daily mean temperatures. According to the relative strain index (RSI),⁸ the conditions during the heat wave would be equal to an RSI of about 0.4 to 0.5. At that level of heat stress, nonacclimatized, middle-aged or older persons would be expected to exhibit distress and progressive inability to maintain normal thermal balance. The less heat-tolerant individuals would become heat casualties and, if relief were not forthcoming, some deaths would be expected.

Increase in Death Rates

A total of 1,428 death certificates for July were analyzed. Included were certificates for all deaths that occurred from July 1 through July 25. For the period of July 26-29, some of the death certificates were filed later and were not included on the original microfilm record used in making the study.

The distribution of deaths from all causes by sex and race is shown in Table 2. For total deaths, there were equal numbers of males and females and the proportion of Negro to Caucasian in each sex group was about the same.

Daily deaths by age groups for the month of July are given in Table 3. As expected, the total deaths increased with age; about half of the deaths occurred in the over-69-year age group. During the days of the heat wave, July 9-14, there was some increase in the number of deaths in each age group except the 1-19-year group. The increase was progressively more pronounced with increasing age. The average daily death rate was about the same for the days preceding as for those following the heat wave. There was not a lower-than-normal death rate after the heat wave which could compensate for the high rate during the heat. It did not appear, therefore, that only terminal cases were affected by the heat, and that all that the heat wave did was to hasten the deaths of those who were destined to die within a few days anyway.

Heat was listed as the primary cause of death on 246 of the 1,428 death certificates analyzed. On an additional 40, heat was listed as a contributing factor. The daily totals of deaths from all causes and from heat for July, 1966, are shown in Figure 2. The expected number of deaths in St. Louis based on the preceding five-year average is about 35 a day during July. The observed average daily number of deaths for the first nine days in July, 1966, was 41. By most standards, the weather preceding the heat wave would be considered hot. The

Table 2—St. Louis deaths for July, 1966

	All causes			Due to heat		
	Male	Female	Total	Male	Female	Total
Caucasian	525	514	1,039	69	87	156
Negro	186	201	387	32	56	88
Indian		1	1		1	1
Unknown		1	1		1	1
Totals	711	717	1,428	101	145	246

Table 3—Total daily deaths by age group, St. Louis, July, 1966

July	Under 1 yr	1-19	20-39	40-49	50-59	60-69	Over 69
Preheat wave							
1	1	0	3	6	7	8	18
2	4	0	1	1	4	14	11
3	4	1	0	1	2	10	29
4	2	3	1	3	2	2	25
5	1	1	0	2	8	14	26
6	1	1	0	3	3	10	21
7	0	0	3	3	5	8	19
8	1	1	1	0	6	10	11
Heat wave							
9	1	0	2	4	4	6	27
10	1	2	2	1	6	10	27
11	2	0	0	3	10	19	43
12	4	1	2	5	12	18	53
13	6	3	4	7	17	31	84
14	0	0	2	9	14	23	78
Post-heat wave							
15	3	1	3	5	14	22	49
16	3	0	1	1	4	11	29
17	1	2	4	3	10	9	24
18	2	0	1	0	4	7	25
19	1	1	0	1	4	10	19
20	0	0	2	1	3	5	16
21	1	0	3	2	5	6	12
22	1	0	3	2	6	7	22
23	0	0	4	3	0	7	13
24	2	3	1	3	4	3	26
25	0	1	2	3	9	5	22
26	0	0	2	4	3	6	8
27	2	0	1	1	2	8	12
28	2	0	1	0	4	4	11
29	0	0	0	1	1	3	5
Totals	46	21	49	78	173	296	765

above average death rate observed during these first days of July may reflect the higher than normal temperatures.

A striking increase in daily deaths occurred on July 11, 12, 13, 14, and 15. The beginning of the increase in death rate followed the start of the heat wave by a day or two and returned to normal on the second day after the heat wave broke. The delay of one to two days between the start of a heat wave and the appearance of the effects reflects the time required for heat to build up in the buildings in which people live and work

and the time required for the physiological reserve capacities of individuals to be overwhelmed.^{3,7,8}

The first of the 246 deaths certified as due to heat was reported on July 10, the second day of the heat wave. On July 11 there were 11 certified primary heat deaths, 35 on July 12, 73 on July 13, 61 on July 14, 31 on July 15, and 5 to 7 on each of the next four days (Figure 2). The remaining eight reported heat deaths occurred after July 19 when air temperatures were again down to levels of the period prior to

the heat wave. For the heat wave period, the 246 certified primary heat deaths accounted for about 65 per cent of the total excess deaths for the six days from July 10 to 15.

The incidence of certified primary heat deaths is presented by age and day in Table 4. Primary heat deaths occurred in all age groups except the 1-19-year category. The number of heat deaths increased with age as did the total number of deaths. The proportion of the total deaths that was attributable to heat did not show a consistent relationship to age. For the period July 10-19, 26 to 37 per cent of the total

deaths were primary heat deaths in individuals 20 years of age or older.

As seen in Table 2, more females than males were primary heat deaths even though there was no sex difference in total deaths for July. The proportion of heat deaths to total deaths was also greater for Negroes than for Caucasians. The same sex difference in the proportion of Negro heat deaths was observed. For total deaths, 26 per cent of the males and 28 per cent of the females were Negro. Among the certified heat deaths, 32 per cent of the males and 39 per cent of the females were Negro. The higher proportion of Negro to Caucasian heat

Figure 2—Daily deaths in St. Louis—July, 1966

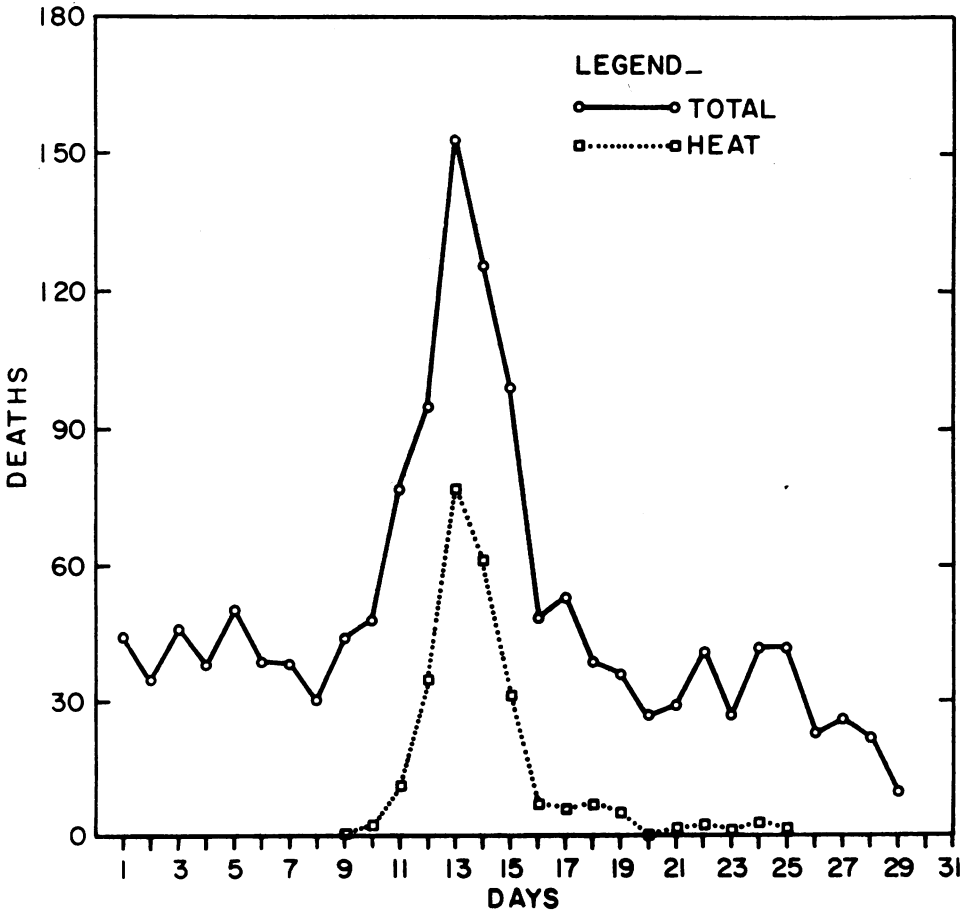


Table 4—Heat deaths by age—St. Louis, July, 1966

July	Under 1 yr	1-19	20-39	40-49	50-59	60-69	Over 69
Preheat wave							
8	0	0	0	0	0	0	0
Heat wave							
9	0	0	0	0	0	0	0
10	0	0	1	0	1	0	0
11	0	0	0	0	3	3	5
12	1	0	0	2	6	8	18
13	1	0	1	3	9	23	36
14	0	0	2	5	9	12	33
Post-heat wave							
15	1	0	1	0	5	7	17
16	0	0	0	0	1	0	6
17	1	0	0	0	0	2	3
18	0	0	0	0	0	0	7
19	0	0	0	0	0	1	4
20	0	0	0	0	0	0	0
21	0	0	0	0	0	0	1
22	0	0	0	0	1	0	1
23	0	0	0	0	0	0	1
24	0	0	0	0	0	0	3
25	0	0	0	0	0	0	1
26	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0
Totals	4	0	5	10	35	56	136

deaths could reflect the area of the city in which they lived and the general living conditions.

Location of Heat Casualties

The location within the greater St. Louis area where the 246 heat-death individuals lived at the time they became heat casualties is shown in Figure 3. It is obvious that the heat deaths were not randomly distributed throughout the area but were clustered within the city-core area. Many factors might account for fewer heat deaths occurring in the suburbs. The population density is lower in a suburban residential area. The more open areas with grass, trees, and so on, in the suburbs would tend to reduce the air temperature and accelerate radiative heat loss, particularly

at night. It is also likely that more air-conditioning is in use in the suburban homes.

The population estimate by census tracts for July 1, 1966, for the City of St. Louis was 724,000: 454,000 white and 270,000 nonwhite. These estimates do not include the suburban areas where the population is predominantly white. The ratio of white to nonwhite was calculated for each of the 26 census tracts in the City of St. Louis. In 15 of the census tracts, 0 to 25 per cent of the population was nonwhite (average 2.4%). These census tracts made up most of the southern and northern areas of the city from the river to the city limits on the west. The two census tracts with a nonwhite population of 26 to 50 per cent (average 36%) bordered on the east of Forest Park. Six census tracts

had a nonwhite majority of 51 to 75 per cent (average 54%). In the remaining three census tracts, more than 75 per cent of the inhabitants were nonwhite (92%).

Of the 246 certified heat deaths, 209 occurred within the City of St. Louis. The incidence of certified heat deaths for July 9-15, 1966, within the city limits was 25 per 100,000 in the predominantly white census tract areas, and 32 per 100,000 in the nine census tracts in which more than 50 per cent of the

population was nonwhite. The rate was 29 per 100,000 in the census tracts with 26 to 50 per cent (average 36%) nonwhite. These observations tend to substantiate the conclusion that the nonwhite population of the City of St. Louis contributed more than its proportionate share to the certified heat deaths. This does not constitute proof, however, that the nonwhite individual may be less tolerant to heat. Overcrowding, poorer housing conditions, lower economic status, and poorer general health might

Figure 3—Distribution of heat deaths, St. Louis, July, 1966



Table 5—Daily deaths by selected disease category, St. Louis, July, 1966

Day of mo	CV	Cer	Pul	Hep	Car	Hem	Endo	Renal	Acc	Heat	Post op	GI	Inf
Preheat wave													
1	15	7	10	0	2	4	1	1	2	0	0	0	1
2	18	3	5	0	1	0	0	0	1	0	0	2	4
3	24	7	5	0	4	0	0	1	1	0	0	0	4
4	20	4	5	0	1	1	0	1	2	0	0	1	2
5	23	10	5	3	5	1	2	0	0	0	0	0	1
6	22	8	4	0	1	0	0	1	2	0	0	0	1
7	16	2	10	1	4	0	0	2	1	0	2	0	0
8	7	7	4	0	7	1	0	2	0	0	0	0	1
Post-heat wave													
9	18	7	4	2	6	3	0	2	1	0	0	0	1
10	19	8	4	0	9	1	1	2	2	2	0	0	1
11	28	8	12	3	7	0	2	0	2	11	3	0	1
12	27	14	9	1	2	0	0	1	0	35	0	1	3
13	35	11	12	1	7	0	1	3	0	73	4	0	4
14	42	9	5	1	6	0	0	1	0	61	1	0	0
Post-heat wave													
15	45	7	7	1	2	0	0	0	1	31	0	1	2
16	18	6	8	1	3	1	1	1	1	7	1	0	1
17	18	6	8	1	3	1	0	1	4	6	1	0	0
18	13	4	4	0	5	1	2	2	1	7	0	0	0
19	15	1	7	0	3	2	0	0	0	5	0	0	1
20	16	2	3	0	1	1	0	1	2	0	0	0	0
21	9	2	2	0	6	1	0	3	0	1	0	2	1
22	14	4	3	2	5	0	1	4	1	2	2	1	1
23	10	4	5	0	3	0	0	1	3	1	0	0	0
24	12	6	4	0	7	1	0	0	4	3	0	0	1
25	14	5	8	1	5	0	1	1	3	1	0	0	0
26	8	1	5	0	7	1	0	0	0	0	0	0	0
27	5	3	4	0	5	1	2	1	2	0	0	2	1
28	6	3	5	1	4	0	0	0	1	0	0	0	2
29	5	1	1	0	1	0	0	1	0	0	0	0	0
Totals	522	160	168	19	122	21	14	33	37	246	14	10	34

also contribute to the observed differences.

Daily deaths listed by major disease categories are given in Table 5. The frequency of death from cardiovascular disease, from cerebral accidents, and to a less degree from pulmonary disorders, was increased during the heat wave as compared with the periods before and after.

Symptoms of Heat Stroke

Hospital records were reviewed for 200 of the 246 certified heat deaths during the heat wave. Of these 200, 80 were dead on arrival at the hospital. Almost all of those admitted to the hospital during the weeks of the heat wave had body (oral or rectal) temperatures from 103° to 106° F on admission. These

would appear to be heat-stroke cases. Many persons who died had been in a hospital for months; suddenly, with high environmental temperatures, they developed body temperatures of 103° F or above and died within a few days.

Laboratory data could be obtained on only about 50 per cent of the deceased patients whose charts were reviewed. In most cases normal plasma electrolyte (Na, K, Cl) values were found. Hyperkalemia has been reported as an important electrolyte alteration in heat stroke. Most of the liver function tests and enzymes (SGPT, SGOT, LDH) showed abnormally high values, indicating definite intracellular damage. Fasting blood sugars and blood urea nitrogens were also consistently above normal. Many gave abnormal reactions to blood tests, such as increased prothrombin times and bleeding problems manifested by guaiac positive stools, melena, and hemoptysis. Similar biochemical changes have been reported in fatal heat-stroke cases by others.^{8,17}

Only about one-third of the 200 certified heat-death cases whose hospital charts were reviewed had any previous hospital admissions or available medical histories. Most of the others were admitted either unconscious or were dead on arrival. Because of this, no information could be obtained concerning their previous diseases, medications taken, or general state of health.

For the persons with available hospital records, the main diseases were:

	No. of persons
Arteriosclerotic heart disease	19
Congestive heart failure	10
Diabetes	7
Hypertension	6
Syphilis	5
Cerebral vascular accidents (embolism and thrombosis)	5
Alcoholism	4
Emphysema	3
Cancer (uterus, lip, breast)	3

Four patients were described as extremely obese; one had multiple sclerosis; one, epilepsy. Eight were taking a digitalis preparation and seven were on diuretics. However, many of these persons had more than one disease, and over one-third of those with medical histories were over 65 years of age and had been chronically ill for years.

One interesting feature was that one hospital was divided into three main units: one was air-conditioned, and the other two were without air-conditioning. (Each patient was confined to one of the three units.) All 35 heat deaths in the hospital occurred in the two units without air-conditioning.

Conclusions

The morbidity and mortality experiences in St. Louis during the July, 1966, heat wave illustrate problems that are pertinent to general health care and to civil defense shelter management. In 12 to 36 hours, many individuals become heat casualties if the temperature within the shelter rises to about 95° F or above. The older and middle-aged groups are affected more than younger people. Particularly susceptible are those with acute or chronic cardiovascular and pulmonary disorders. Excessive heat can be a primary cause of death from typical heat stroke or a contributing cause in already ill patients. The high environmental temperatures in shelters will magnify the problems of health support and of shelter management. Of particular concern will be the hospitalization and medical care for the load of heat casualties that will develop.

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