Mortality in Chicago Attributed to the July 1995 Heat Wave

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ABSTRACT

Objectives. This study assessed mortality associated with the mid-July 1995 heat wave in Chicago.

Methods. Analyses focused on heat-related deaths, as designated by the medical examiner, and on the number of excess deaths.

Results. In July 1995, there were 514 heat-related deaths and 696 excess deaths. People 65 years of age or older were overrepresented and Hispanic people underrepresented. During the most intense heat (July 14 through 20), there were 485 heat-related deaths and 739 excess deaths.

Conclusions. The methods used here provide insight into the great impact of the Chicago heat wave on selected populations, but the lack of methodological standards makes comparisons across geographical areas problematic. (*Am J Public Health.* 1997;87:1515–1518)

Introduction

During July 1995, the midwestern United States experienced a severe heat wave. Media reports, based on information provided by the Cook County medical examiner (Edmund R. Donoghue), indicated that the number of deaths in Chicago resulting from the heat wave was among the highest in the history of the United States. The purpose of this paper is to examine mortality in Chicago associated with the heat wave.

Methods

Data Sources and Definitions

Weather data were obtained from the Midwestern Climate Center.[1] In addition to temperature, we used the heat index, also referred to as the "apparent temperature." This index is meant to be a measure of what a hot day feels like to the typical person. Its value may be obtained from a chart that combines the influences of temperature and relative humidity.[2] Death certificate data were obtained from Illinois vital records files.

The Cook County Medical Examiner's Office certifies a death as heat related if there was no history of trauma or evidence of fatal injury and the case met at least one of several criteria. First, the measured body temperature had to be 105°F (40.6°C) or higher before or immediately after death. Second, there had to be evidence of high environmental temperature at the scene of death, usually greater than 100°F (37.8°C). Finally, the body had to be decomposed, and investigation had to disclose that the person was last seen alive during the heat wave period and that the environmental temperature at the time would have been high.

Statistical Analyses

To calculate the number of expected deaths for a given day, we performed three different regression analyses for the months June through September for the 16 years between 1979 and 1994. All three models generated virtually identical estimates for these 64 months. Deviations from baseline (expected deaths) are referred to here as "excess deaths" (these values can, of course, be negative).

All death rates are for Chicago residents. Rates for years other than 1980 and 1990 were based on intercensal estimates and projections generated by the Epidemiology Program of the Chicago Department of Public Health. Using the direct method, we standardized age-adjusted death rates to the 1940 United States population. We performed significance tests on rate ratios employing a Taylor series expansion to generate 95% confidence intervals (CIs).[3]

Results

Heat-Related Deaths

Five hundred fourteen July 1995 deaths were heat related. The first 4 heat-related deaths occurred on July 13, and then, 2 days later, the daily number peaked at 181. Figure 1 presents the relationship between temperature, the

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This paper was accepted January 10, 1997.

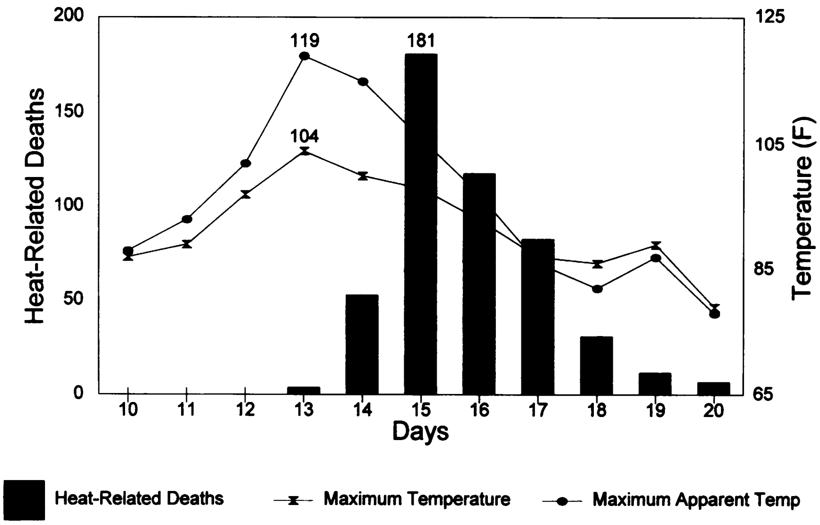

FIGURE 1—Heat-related deaths and temperatures: Chicago residents, July 10 through July 20, 1995.

TABLE 1—Age-Specific and Age-Adjusted Heat-Related Death Rates per 100 000 Population, by Race/Ethnicity: Chicago Residents, Mid-July Heat Wave, 1995

	Non-Hispanic White		Non-Hispanic Black		Total		
Age, y	No.	Rate	No.	Rate	No.	Rate	Ratio[a]
<55	27	4	42	5	73	3	1.3
55–64	19	31	44	57	69	38	1.8
65–74	62	75	62	83	125	68	1.1
75–84	87	119	63	176	153	126	1.5
>84	47	222	45	429	94	258	1.9
Total[b]	242	11	256	17	514	12	1.5

[a]Non-Hispanic Black to non-Hispanic White ratio.
[b]Standardized to the 1940 US population.

heat index, and heat-related mortality, which peaked 2 days after the maximum temperatures.

Table 1 illustrates the disproportionate impact that the heat wave had on mortality among the elderly. Race/ethnicity-specific rates increased monotonically with age. People 65 years of age and older accounted for 63% of all deaths in 1994 and 72% of the heat-related deaths due to the mid-July 1995 heat wave. The heat-related mortality rate ratio for people 65 years of age and older relative to people less than 65 years old was 14.55 ($P < .001$, 95% CI = 11.92, 17.77). The corresponding 1992 to 1994 rate ratio for all causes was 9.42 ($P < .001$, 95% CI = 9.18, 9.66). Males had a higher age-adjusted heat-related death rate (18 per 100 000 population) than females (7 per 100 000), resulting in a rate ratio of 2.53 ($P < .001$, 95% CI = 2.07, 3.08). The corresponding 1992 to 1994 rate ratio for all causes was 1.91 ($P < .001$, 95% CI = 1.85, 1.96).

Table 1 also shows the age and race/ethnicity distributions of the heat-related deaths attributed to the mid-July heat wave. The heat-related age-adjusted death rates were 11 per 100 000 population for non-Hispanic Whites and 17 per 100 000 for non-Hispanic Blacks, resulting in a rate ratio of 1.50 ($P < .001$, 95% CI = 1.22, 1.84). This was similar to the non-Hispanic Black to non-Hispanic White rate ratio of 1.36 for all causes for 1992 to 1994 combined ($P < .001$, 95% CI = 1.32, 1.40). For every age interval but the youngest, non-Hispanic Blacks had higher rates than non-Hispanic Whites, with the rate ratio being near 2 for people 85 years of age and older. The number of deaths for Hispanics (n = 12) and those of other races (n = 4) was too small to allow for age adjustment. However, it is essential to note that while Hispanics constitute about 23% of Chicago's population, they accounted for only 2% of the heat-related mortality.

From 1979 to 1994, there were a total of 149 heat-related deaths in Chicago. The maximum number to occur in a year was 60 in 1988, and the maximum number to occur in a month was 55 in August of 1988, only about one tenth of the number that occurred in July 1995.

Excess Deaths

We used a second measure of the impact that the heat wave had on Chicago mortality: the number of excess deaths. This was calculated by comparing the number of observed deaths with the baseline for each day in July of 1995 (72). During the period July 14 through July 20, there were 739 deaths in excess of baseline. Until July 10, daily death counts were distributed rather randomly around baseline, as they were after July 22. This relationship is displayed in Figure 2.

There were 696 excess deaths and 514 heat-related deaths in July. Thus, the heat wave appears to have contributed to 182 more deaths than were attributed by the Cook County Medical Examiner's Office. For the period July 14 through July 20, there were 739 excess deaths and 485 heat-related deaths. During this 7-day period, the heat wave appears to have contributed to 254 more deaths than were attributed by the Cook County Medical Examiner's Office.

Table 2 summarizes the findings of other studies that have used the concept of excess deaths due to heat. One way to make these diverse results comparable is to examine the proportion of excess deaths relative to the selected baseline, a technique that helps control for demographic characteristics of the population. In July 1995, Chicago experienced a 31% increase over baseline. This may be compared with a 65% increase for Kansas City[4] in 1980 and a 57% increase in St. Louis[5] during the same year. Chicago experienced more excess deaths during July and August of 1955 (885) than in July 1995 (696), but the percentage increase during 1955 was substantially lower.

When using this technique, the length of the time period under consideration is central. The bottom four rows of Table 2 provide an illustration. If, instead of July 1995, we look at the week of greatest mortality (July 14 through 20), we find a few more excess deaths (a total of 739 for this 7-day period) but a far larger proportionate increase of 147%. This increase may be compared with 9-day increases of 108% in 1939 and 122% in 1955 in Los Angeles[6] and a 7-day increase of 62% in 1972 in New York City.[7]

Discussion

Counts of heat-related deaths depend on the definitions and procedures used by the local medical examiner or coroner. These are not standardized, thus making it difficult to compare results across studies.[5,8,9] Excess deaths are more comparable than heat-related deaths but depend on the selected baseline. Baselines used in the literature include the corresponding month of the previous year,[4,10] the average of the previous 4 weeks,[11] surrounding days,[4] and statistics from more complicated long-term models.[12–14]

Employing excess mortality and the proportionate increase methodology described earlier allows us to place what happened in Chicago in the summer of 1995 into perspective. The number of deaths caused by the heat was not the highest ever, nor was the proportionate increase in mortality for a month the highest. However, the proportionate increase for a week was the highest we have been able to locate. This is consistent with the suddenness and brevity of the effect of the heat on mortality (see Figures 1 and 2), which, in turn, is consistent with a sudden increase in the high temperature and heat index.

One of the main questions that must be answered is why the heat killed so many people in Chicago during this heat wave. We examined some weather variables but failed to detect relationships between the weather and mortality that would explain what happened in July 1995 in Chicago. For example, we regressed, for every summer day for the past 16 years ($n = 1472$), all-age mortality and mortality for those more than 65 years of age on temperature and the heat index, and we did so lagging mortality by 0, 1, and 2 days. The most reasonable explanation of our inability to find notable relationships, and what appears to us to be the most valuable avenue for future investigation, comes from the work of Kalkstein and his colleagues. Employing what they call a "synoptic" analysis, Kalkstein and his colleagues have identified air masses that are functions of many weather variables, including cloud coverage, wind speed, wind direction, and so forth, all of which are measured several times a day.[15–17] These air masses do indeed show a stronger relationship to mortality than any we were able to detect in the analyses described above. However, they still leave a fair amount of variance in the mortality measure unexplained (L. S. Kalkstein, written communication, August 1995).

During the heat wave, it was questioned whether the criteria used by the medical examiner to certify heat-related deaths were too broad and whether the number of deaths due to the heat was overestimated. Examination of the excess mortality data indicates that neither of these was the case and that the criteria used by the Cook County Medical Examiner's Office, while yielding a record number of heat-related deaths, did not overestimate mortality due to the heat. A team of investigators from the Centers for Disease Control and Prevention sent to Chicago in the wake of the heat wave[18] reached the same conclusion.

The immediate determination of heat-related mortality by the Cook County Medical Examiner's Office focused attention on a severe public health problem at the time of its occurrence. The measure of excess mortality, taken later, is probably a better measure of the true impact of heat on mortality but necessarily could not be implemented in real time as a warning system.

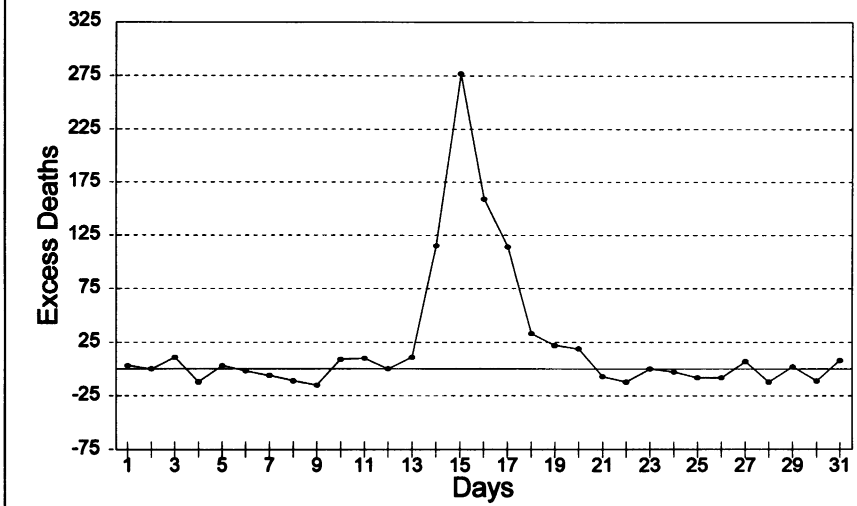

FIGURE 2—Estimated excess mortality: Chicago residents, July 1995.

TABLE 2—Comparison of Baseline Deaths and Excess Deaths for Selected Cities and Time Periods

Location	Month and Year	Baseline Deaths	Excess Deaths	% Increase
Chicago	July 1955	2840	514	18
Chicago	August 1955	2822	371	13
Memphis	July 1980	711	106	15
St. Louis	July 1980	542	308	57
Kansas City	July 1980	362	236	65
Chicago	July 1983	2449	208	8
Chicago	July 1986	2387	167	7
Chicago	August 1988	2356	294	12
Chicago	July 1995	2232	696	31
Los Angeles	September 1939 (9 days)	504	546	108
Los Angeles	September 1955 (9 days)	778	946	122
New York	July 1972 (7 days)	1428	891	62
Chicago	July 1995 (7 days)	504	739	147

It would be a major advance if the epidemiology of summer weather mortality could be standardized so that comparisons could be readily available. Even though we were able to locate many papers that reported on mortality associated with summer weather, only a few contained information that would allow comparisons. The following would seem to be a list of minimal epidemiological requirements for the analysis of summer mortality:

- An explicit definition of a heat-related death should be provided. Ideally, such a definition would be standardized and accepted by medical examiners and coroners.
- Heat-related deaths should be presented as rates and should be age adjusted according to a common standard.
- A common methodology for generating baseline estimates must be provided; otherwise, measures of excess deaths cannot be compared. Regression techniques, such as the ones used here, would appear to be appropriate.
- In examinations of age (or gender or race) disproportionality, comparisons with baseline experiences should be provided.
- Excess deaths, which cannot be age adjusted because they are not identified as individual cases, should be presented as proportionate increases over the baseline period.

Chicago, like most urban centers, is a prime target for heat mortality. It is well established that important risk factors for death from heat, other than the demographic variables discussed earlier, are living alone, living on the higher floors of buildings, living in poverty, living without air-conditioning, and using special and excessive medications.[9,19] These factors and many others have been examined in a case–control study of the Chicago heat wave.[20] Finally, there is the generalized impact of big cities, massive centers of heat-retaining concrete structures.[21–24] The risk factors for heat mortality suggest that the problem will worsen unless we learn to intervene effectively. □

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