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Cardiovascular Mortality — The Hidden Peril of Heat Waves

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Keywords: cardiovascular mortality; death certificates; heat-related mortality; heat waves; mortality files; prevention of heat-related mortality; rapid field assessment

Abbreviations:
ACME = automatic classification of medical entities
CI = 95% confidence interval
ICD-9 = International Classification of Diseases
RR = mortality rate ratio
SE = standard error

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Abstract

Objective *— Define the mortality associated with extremely hot weather during the 04 July through 14 July, 1993 heat wave that struck the northeastern United States.*

Methods*: Design — A rapid field assessment was used to compare mortality occurring during the heat wave to mortality occurring during a period in which there was no heat wave using copies of death certificates. The findings of the rapid field assessment were validated, and it was determined whether increases in mortality occurred in other metropolitan east-coast counties also affected by the heat wave, by reviewing computerized mortality files.*

Setting — Information was collected on all deaths occurring in Baltimore City, Maryland; Baltimore County, Maryland; Essex County, New Jersey; Newcastle County, Delaware; and Philadelphia County, Pennsylvania; during these specified study periods: 08–18 June (comparison period) and 06–16 July (heat wave study period), 1993.

Main Outcome Measures — Ratios for total mortality, cause-specific mortality, and variables such as age, sex, race, residence, and day and place of death, that were available from death certificates were calculated.

Results*: From the rapid field assessment, the following were observed: a 26% increase in total mortality and a 98% increase in cardiovascular mortality associated with the heat wave in Philadelphia. Data from the computerized mortality files showed an increase in total mortality in four of five counties examined and an increase in cardiovascular mortality in all five counties. The risk for death for those dying from cardiovascular disease increased significantly for people older than 64 years, for both sexes, and all races.*

Conclusion*: As initially indicated by the Philadelphia Medical Examiner, there was excess mortality associated with a heat wave in Philadelphia. All other nearby counties examined also experienced excess mortality associated with the heat wave, although this excess was not recognized by the local health officials. The true impact of a heat wave that causes excess preventable mortality must be appropriately and rapidly ascertained. Using a national standard to certify a death as heat-related will provide the needed information rapidly so that public health resources can be more effectively allocated and mobilized to prevent further heat-related illnesses and death.*

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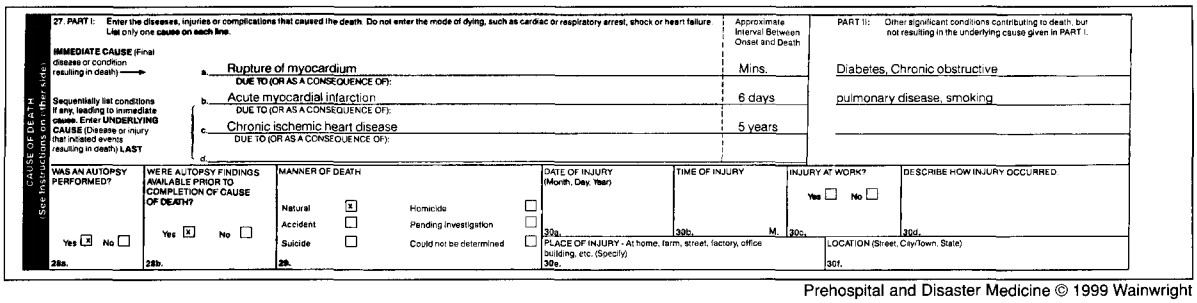
Introduction

The number of deaths occurring in a region can increase by more than 50% during a heat wave. [1–3] Although heatstroke is the most obvious cause of death, and although in 1980, a year in which a severe heat wave occurred, heatstroke accounted for 1,700 deaths, it accounted for only a portion of the excess mortality.[4,5] Deaths due to cardiovascular, cerebrovascular, and respiratory diseases may increase as much as 100% during heat waves[1,6,7] Yet, these deaths often are not reported as heat-related. An accurate classification and reporting of a death as heat-related during a heat wave is essential for understanding what risk factors are involved, and for allocating resources effectively in order to prevent heat-wave-related mortality.

A severe heat wave occurred in Philadelphia, Pennsylvania, from 04–14 July, 1993. The Philadelphia Medical Examiner, who is responsible for investigating sudden or unexplained deaths, initially reported that 118 deaths were related to this heat wave.[8] However, several other east-coast counties also affected by the heat wave, did not report many



27. PART I: Enter the diseases, injuries or complications that caused the death. Do not enter the mode of dying, such as cardiac or respiratory arrest, shock or heart failure. List only one cause on each line.

Approximate Interval Between Onset and Death

PART II: Other significant conditions contributing to death, but not resulting in the underlying cause given in PART I.

CAUSE OF DEATH (See instructions on reverse side)

IMMEDIATE CAUSE (Final disease or condition resulting in death) →
a. Rupture of myocardium — Mins.
DUE TO (OR AS A CONSEQUENCE OF):

Sequentially list conditions if any, leading to immediate cause. Enter UNDERLYING CAUSE (Disease or injury that initiated events resulting in death) LAST
b. Acute myocardial infarction — 6 days
DUE TO (OR AS A CONSEQUENCE OF):
c. Chronic ischemic heart disease — 5 years
DUE TO (OR AS A CONSEQUENCE OF):
d.

Diabetes, Chronic obstructive pulmonary disease, smoking

28a. WAS AN AUTOPSY PERFORMED?	28b. WERE AUTOPSY FINDINGS AVAILABLE PRIOR TO COMPLETION OF CAUSE OF DEATH?	29. MANNER OF DEATH	30a. DATE OF INJURY (Month, Day, Year)	30b. TIME OF INJURY	30c. INJURY AT WORK?	30d. DESCRIBE HOW INJURY OCCURRED
Yes [X] No [ ]	Yes [X] No [ ]	Natural [X] Homicide [ ]; Accident [ ] Pending investigation [ ]; Suicide [ ] Could not be determined [ ]		M.	Yes [ ] No [ ]	

30e. PLACE OF INJURY - At home, farm, street, factory, office building, etc. (Specify)

30f. LOCATION (Street, City/Town, State)

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Figure 1—Example of Part I and Part II of Pennsylvania's State death certificate

heat-related deaths. This disparity in reported heat-related deaths caused some public health officials and the media to dispute the findings of the Philadelphia Medical Examiner.[9] Three possible explanations for the difference are that: 1) a true increase in mortality as a result of the heat wave did not occur in Philadelphia, but that more cases were referred to the Medical Examiner; 2) Philadelphia County, Pennsylvania, was the only county that experienced a true increase in mortality as a result of the heat wave; or 3) different criteria may have been used to certify a death as heat-related in the different east-coast counties. Given these issues and the need to characterize the public health impact of the 1993 heat wave, the objectives of this study were to: 1) determine whether the numbers of deaths were greater than would be expected in Philadelphia and other counties on the east-coast affected by the July 1993 heat wave; 2) determine whether the criteria used by the Philadelphia Medical Examiners to certify a death as heat-related closely reflected an actual increase in mortality; and 3) identify risk factors that were associated with any excess mortality.

Methods

The study consisted of two phases. The first phase, a rapid field assessment, was conducted from 12 August through 02 September, 1993 in Philadelphia. Death certificates filed with the Pennsylvania Division of Vital Records for June and July 1993 were reviewed. Also, case files at the Philadelphia Medical Examiner's (ME) Office of people who died from 06–16 July, 1993, and whose deaths were classified by the Medical Examiner as due to excessive heat exposure related to the heat wave were examined. The second phase, the mortality-file review, consisted of an analysis of the completed, computerized mortality files for all deaths that occurred in Philadelphia and four other east-coast counties. This second phase allowed assessment of the validity of the rapid field assessment.

Weather Data

The daily maximum temperature and humidity data reported by first order stations (airport) for June, July, and August of 1988 through 1993 were obtained from the National Climatic Data Center.[10,11] The standard definition used by the National Weather Service was used: a heat wave occurs when the maximum air temperature for at least three consecutive days is ≥90.0°F (32.2°C) in a specific location.

Study Period

The July 1993 heat wave in Philadelphia, Pennsylvania, lasted from 04–14 July. Since mortality associated with heat waves generally is delayed for two to three days after the start of a heat wave, the period of 06 July through 16 July, 1993 was used to study mortality associated with the heat wave.[6] The period of 08–18 June, 1993, an 11-day period during which no heat wave occurred, was selected for comparison. The comparison period was begun on the same day of the week as the heat-wave study period in order to control for the normal variation in mortality by day of the week.[12,13] The same periods were used in the analysis of data for the four other counties included in the mortality-file review as well as in the evaluation of excess mortality for the preceding five years, 1988 through 1992.

Rapid Field Assessment

Copies of all death certificates filed with the Pennsylvania Division of Vital Records from 10 June through 13 August, 1993, for deaths that occurred in Philadelphia County were obtained. The beginning filing date of 10 June was selected because of archiving procedures used by the Division of Vital Records. To ensure approximately comparable ascertainment of deaths for each study period, death certificates that were filed from 10 June through 14 July for the comparison period were obtained, as were certificates filed from 15 July through 13 August.

Total mortality was determined by counting the number of deaths that occurred during the heat wave and the comparison periods. Since data from these death certificates had not yet been computerized or officially coded by the Pennsylvania Division of Vital Records using the Ninth Edition of the International Classification of Diseases (ICD-9),[14] and since the field staff was not trained in these registration procedures, only those death certificates that listed a single condition in Part I of the death certificate were included in the analysis of cause-specific mortality. Each death was classified according to the condition entered in Part I as due either to cardiovascular disease, cerebrovascular disease, hyperthermia, injury, respiratory disease, or "other" cause

(Figure 1).

Medical Examiners' (ME) Classification of Heat-related Mortality

Interview of Medical Examiners — To identify criteria that individual medical examiners used in determining whether or not to list a heat-related condition (e.g., hyperthermia, heat stroke, "found in a hot environment") on the death certificate, three of the seven Philadelphia Medical Examiners were interviewed. Reasons for listing a heat-related condition in Part I, Part II, or in the "describe how injury occurred" item on the death certificate were sought (Figure1).

Review of Medical Examiner Case Files — To determine the criteria used by Philadelphia Medical Examiners in designating a death as heat-related, the 118 Medical Examiner case files for people who died in July as a result of excessive heat exposure as determined by the Philadelphia Medical Examiner's Office were reviewed. Six people were excluded because the dates of their deaths were outside of the study period. Case files for 16 of the 112 decedents with the dates of their deaths within the study period could not be located at the time of the field assessment; thus, 96 case files were included in the review.

Each of the 96 case files contained a Death-Investigation Report and a Death Certificate. The Death-Investigation Report contained a detailed description of the circumstances of death, such as the temperature of the surroundings at the time of death and the adequacy of ventilation, and this description was used to obtain additional information on the heat-relatedness of, and risk factors for, the death.

Other Counties

On the basis of their proximity to Philadelphia County, four metropolitan east-coast counties in addition to Philadelphia County were selected for further evaluation of the impact of the July 1993 heat wave: 1) Baltimore City, Maryland; 2) Baltimore County, Maryland (these two counties are independent political units); 3) Essex County, New Jersey; and 4) Newcastle County, Delaware.

Computerized mortality data files for 1988 through 1993 were obtained for these counties and for Philadelphia County from their respective state office of vital statistics or vital records. The underlying cause of death, which had been selected by the Automated Classification of Medical Entities (ACME) from the ICD-9 codes corresponding to the conditions on the death certificate were grouped into the same categories used in the rapid field assessment: 1) cardiovascular disease (390.0–398.9, 402.0–402.9, 404.0–429.9, 440.0–448.9); 2) cerebrovascular disease (430.0–438.9); 3) hyperthermia (E900.0–E900.9); 4) injury (E800.0–E899.9, E901.0–E978.9); 5) respiratory disease (460.0–460.9, 480.0–487.9, 490.0–496.9); and 6) other cause (all other ICD-9 codes not previously listed).[15]

Also, computerized multiple-causes-of-mortality data were obtained from the Pennsylvania Division of Vital Records for all of the Philadelphia County deaths that occurred during the study periods and for all of the Baltimore City and Baltimore County deaths from the Maryland Division of Vital Records. These data consist of the ICD-9 codes for all of the conditions listed anywhere on each death certificate as well as the underlying cause of death. To identify all deaths with any mention of hyperthermia on the death certificate, these data were searched for the ICD-9 codes that correspond to "Deaths caused by excessive heat due to natural and environmental factors" E900.0 (due to weather conditions) and E900.9 (of unspecified origin). The code E900.1 (of man-made origin) was not included.[14]

Analysis

Total and cause-specific mortality-rate ratios (RRs) were estimated assuming that the populations at risk in each county during the heat wave and the comparison period were the same. The RRs were calculated by dividing the number of deaths during the heat-wave study period by the number of deaths during the comparison period. The 95% confidence intervals (CIs) were calculated for the RRs by taking the antilog of the following formula: The standard error (SE [ln RR]) was calculated as the

SE = square root of (1/heat wave deaths + 1/comparison period deaths) ln RR "1.96 SE (ln RR).[16]

The RRs and 95% CIs were calculated for mortality for each of the five preceding years for each county. The RRs were calculated by age, gender, and race for cardiovascular mortality. For the rapid field assessment, the place of death was abstracted from the death certificate and classified either as residence or non-residence. Non-residence included hospital (in-patient, Emergency Department, or dead on arrival) and nursing home. Using the residential address of the decedent as listed on the death certificate, the health district in which the decedent resided was identified. Neither the decedent's place of death nor residential address was available in the computerized mortality files for analysis in the mortality-file review. Total mortality rates and age-adjusted mortality rates were computed on the basis of the 1990 census using the direct method and the 1960 U.S. standard million population.[17,18] For all five counties, the RRs for cardiovascular mortality also were calculated for 1993 and the previous five years for their respective periods of 06 July through 16 July compared with 08 June through 18 June.

Comparison of Rapid Field Assessment and Mortality - File Review

Using the file number, which is listed on each death certificate and is also contained in the Pennsylvania mortality files, the death certificates used in the rapid field assessment were matched with their corresponding data in the Pennsylvania mortality files.

Results

The maximum daily temperatures were similar in each

	No heat wave	Heat wave	RR (*)	95% CI (**)
Total Mortality (n =1135)	503	632	1.26	1.12,1.42
Death certificates excluded	200	193		
Cause-specific mortality				
Cardiovascular disease	112	222	1.98	1.58,2.48
Cerebrovascular disease	15	13	0.87	0.47,1.82
Hyperthermia	0	23	undefined	5.76, infinity
Injury	32	38	1.19	0.74,1.90
Respiratory disease	20	25	1.25	0.69,2.25
Other cause	124	118	1.05	0.82,1.35
Total	303	439	1.45	1.34,1.56

Table 1—Total and cause-specific mortality during a heat-wave study period (July 6 through July 16, 1993) and during a comparison period (08 June through 18 July, 1993), as determined by a review of death certificates during the 1993 rapid field assessment, Philadelphia, Pennsylvania. Deaths were excluded from the cause-specific analysis if Part I of the death certificate contained more than one condition

* Rate ratio (RR) is the number of deaths during the heat wave divided by the number of deaths during the comparison period when there was no heat wave

** 95% Confidence Interval[9]

	No heat wave	Heat wave	RR (*)	95% CI (**)
Cardiovascular mortality	112	222	1.98	1.58,2.49
Age group				
0–44 years	9	6	0.66	0.24,1.87
45–64 years	15	40	2.67	1.48,4.82
>64 years	88	176	2.00	1.55,2.58
Sex				
Female	70	125	1.78	1.33,2.38
Male	42	97	2.31	1.61,3.31
Race				
White	77	131	1.70	1.28,2.25
Other than white	35	91	2.60	1.76,3.84
Place of death				
Residence	28	135	4.82	3.22,7.27
Not a residence ***	84	86	1.02	0.76,1.38
Unknown	0	1		

Table 2—Cardiovascular mortality * by sex, race, age group, and place of death, during a heat wave study period (July 06 through 16 July, 1993) and during a comparison period (08 June through 18 June, 1993), as determined by a review of death certificates during the rapid field assessment, Philadelphia, Pennsylvania. Deaths were excluded from this analysis if Part I of the death certificate contained more than one cause of death

* Rate ratio (RR) is the number of deaths during the heat wave divided by the number of deaths during the comparison period when there was no heat wave

** 95% Confidence Interval[9]

*** Includes nursing homes, hospitals, emergency departments, and dead on arrival

county during the summer of 1993. Among the five counties, Essex County reported the highest maximum daily temperature (105.0°F [40.6°C]) from 04 July through 14 July, and Newcastle County reported the lowest maximum daily temperature (85.0°F [29.4°C]). From 03 July through 14 July, 1993, temperatures remained above 90.0°F (32.2°C) for 7, 8, 11, and 12 consecutive days in Essex County, Newcastle County, Philadelphia County, and Baltimore (City and County), respectively. During the comparison period in June, the maximum daily temperature exceeded 90.0°F (32.2 °C) in each county for no more than two days.

Rapid Field Assessment

From 10 June through 13 August, 1993, 1,135 death certificates were filed with the Pennsylvania Division of Vital Records for deaths occurring in Philadelphia County during the two study periods. For deaths occurring during the heat-wave period, 632 death certificates were filed, and 503 were filed during the comparison period (RR = 1.26; 95% CI: 1.12, 1.42) (Table 1). A total of 439 deaths during the heat wave and 302 during the comparison period

	County					
	Philadelphia	Essex	Baltimore City	Baltimore	Newcastle	Total
Total mortality (n)	1335	530	764	343	221	3,193
No heat wave	621	245	330	163	110	1,469
Heat wave	714	285	434	180	111	1,724
RR	1.15	1.16	1.32	1.10	1.01	1.17
95% CI	1.03,1.28	0.98,1.38	1.14,1.52	0.89,1.36	0.78,1.31	1.09,1.26
Cause-specific mortality						
Cardiovascular disease (n)	458	53	229	97	70	1,007
No heat wave	171	61	76	45	31	384
Heat wave	287	92	153	52	39	623
RR	1.68	1.51	2.01	1.16	1.26	1.62
95% CI	1.39,2.03	1.09,2.08	1.53,2.65	0.78,1.72	0.79,2.02	1.43,1.84
Cerebrovascular disease (n)	56	30	46	21	6	159
No heat wave	37	16	18	10	4	85
Heat wave	19	14	28	11	2	74
RR	0.51	0.88	1.56	1.10	0.50	0.87
95% CI	0.30,0.89	0.43,1.79	0.86,2.81	0.47,2.59	0.09,2.73	0.64,1.19
Hyperthermia (n)	7	8	1	1	0	17
No heat wave	0	0	0	0	0	0
Heat wave	7	8	1	1	0	17
RR	undefined	undefined	undefined	undefined	-	undefined
95% CI	2.85, infinity	1.70, infinity	0.39, infinity	0.39, infinity	-	3.85, infinity
Injury (n)	107	32	54	8	26	227
No heat wave	48	16	26	3	17	110
Heat wave	59	16	28	5	9	117
RR	1.23	1.00	1.08	1.67	0.53	1.06
95% CI	0.84, 1.80	0.50, 2.00	0.63, 1.84	0.40, 6.97	0.24, 1.19	0.82, 1.38
Respiratory disease (n)	71	27	38	20	13	169
No heat wave	36	11	18	10	6	8
Heat wave	35	16	20	10	7	88
RR	0.97	1.45	1.11	1.00	1.17	1.09
95% CI	0.61, 1.55	0.68, 3.13	0.59, 2.10	0.42, 2.40	0.39, 3.47	0.80, 1.47
Other cause (n)	636	280	396	196	106	1,614
No heat wave	329	141	192	95	52	809
Heat wave	307	139	204	101	54	805
RR	0.93	0.99	1.06	1.06	1.04	1.00
95% CI	0.80, 1.09	0.78, 1.25	0.87, 1.29	0.80, 1.41	0.71, 1.52	0.90, 1.10

Table 3—Total and cause-specific mortality during a heat-wave study period (06 through 16 July, 1993) and during a comparison period (08 June through 18 June, 1993), in five metropolitan east-coast counties (n = number of patients; RR = rate ratio; CI = confidence interval).

were identified in the cause-specific analysis. The rate for deaths from cardiovascular disease was 1.98 times higher (95% CI: 1.58, 2.48) during the heat-wave than during the comparison period. Deaths from hyperthermia also were significantly elevated during the heat wave (23 deaths vs. no deaths). Deaths from injury (RR = 1.19; 95% CI: 0.74, 1.90) and respiratory disease (RR = 1.25; 95% CI: 0.69, 2.25) showed increases in the respective RRs, but confidence intervals included 1.0. No other cause of death showed an increase. Since a greater proportion of death certificates for the comparison period (41%) were excluded from the cause-specific analysis than for the heat-wave period (31%), the overall rate ratio for the cause-specific analysis (RR = 1.45) was greater than was the rate ratio for total mortality (RR = 1.25).

Significant increases in number of deaths due to cardiovascular disease occurred during the heat wave among people in the 45–64 year age group, as well as among those >64 years of age (Table 2). Mortality rates for cardiovascular disease increased for both genders and for all races during the heat wave, and were higher for males and for races other than whites.

There was a striking increase in the number of deaths due to cardiovascular disease occurring at residential locations during the heat wave. This increase was so great that it reversed the normal pattern, as indicated by the pattern during the comparison period in which the majority of deaths occur in non-residential locations (Table 2). Using location of the residential address of those who died due to cardiovascular disease to identify the health district in which the residence was located, all of the health districts experienced increased mortality. However, there was substantial variation in the degree of increased mortality by health district, with RRs ranging from 1.40 to 7.33.

Medical Examiners' Classification

Interview of medical examiners — The three Philadelphia

Cardiovascular Mortality	County				
	Philadelphia	Essex	Baltimore City	Baltimore	Newcastle
	1.68	1.51	2.01	1.16	1.26
Age group					
0–44 years					
RR *	1.00	3.00	undefined	0.00	0.67
95% CI **	0.32, 3.10	0.31, 28.70	0.39, infinity	0.14, 7.09	0.11, 3.99
45-64 years					
RR	2.30	1.50	1.65	0.50	2.66
95% CI	1.41, 3.75	0.72, 3.11	0.90, 3.00	0.13, 2.00	0.70, 10.10
> 64 years					
RR	1.60	1.48	2.10	1.26	1.16
95% CI	1.30, 1.97	1.03, 2.13	1.54, 2.86	0.83, 1.92	0.65, 1.92
Sex					
Female					
RR	1.50	1.85	1.71	1.60	0.93
95% CI	1.17, 1.93	1.16, 2.95	1.18, 2.46	0.92, 2.80	0.44, 1.97
Male					
RR	1.94	1.24	2.45	0.80	1.53
95% CI	1.45, 2.60	0.79, 1.95	1.55, 3.87	0.44, 1.42	0.83, 2.80
Race					
White					
RR	1.49	1.66	1.93	1.07	1.18
95% CI	1.18, 1.89	1.13, 2.44	1.34, 2.79	0.71, 1.61	0.71, 1.96
All other					
RR	2.05	1.20	2.12	5.00	1.75
95% CI	1.50, 2.80	0.38, 1.46	1.40, 3.20	0.59, 42.5	0.51, 5.98

Table 4—Rate ratio (RR) for cardiovascular mortality during a heat wave study period (06 through 16 July, 1993) to the rate for a comparison period (08 June through 18 June, 1993) by sex, race, and age group in five metropolitan counties

(* Rate ratio (RR) is the number of deaths during the heat wave divided by the number of deaths during the coparison period when there was no heat wave

** 95% Confidence Interval[9])

Medical Examiners interviewed confirmed that, if a person's body temperature was 105.0 F (40.6°C) or higher, they would use the strict medical definition to rule the cause of death as hyperthermia, and would list "heatstroke" or "hyperthermia" in Part I of the death certificate. If the medical examiners found circumstantial evidence of a hot environment associated with a death, they would classify it as "heat-related," and list "hyperthermia" under Part II, even if core body temperature had not been obtained.

Review of case files — Eighty (83%) of the death certificates in the 96 case files reviewed listed "cardiovascular disease" as the cause of death under Part I; 14 listed "heatstroke" or "hyperthermia," and two listed "obesity." Of the 14 decedents for whom heatstroke or hyperthermia was listed under Part I, 10 had a documented core body temperature greater than 105.0°F (40.6°C). Of the 80 death certificates for which cardiovascular disease was listed as the cause of death under Part I, 79 (99%) listed hyperthermia as the cause of death under Part II, and one listed "obesity" as the cause of death under Part II. An unusually "hot and non-ventilated environment" was mentioned in the "Describe How Injury Occurred" box on all 80 death certificates. Additional review of the 80 matching death investigation reports in each case file indicated adequacy of ventilation as follows: 16 (20%) reports noted fans or air conditioners as not working properly, and 32 (40%) mentioned sealed, closed, or slightly cracked windows.

Computerized mortality files — Total mortality in all five metropolitan east-coast counties combined increased 17%, from 1,469 deaths during the comparison period to 1,724 during the heat wave, an increase of 255 (Table 3). Mortality was increased by at least 10% in all counties except for Newcastle County, which experienced essentially no change in mortality during the heat wave. Mortality from cardiovascular causes was increased in all five counties (RR = 1.16 to 2.01). Hyperthermia deaths occurred during the heat wave in Baltimore City, Baltimore County, Essex County, and Philadelphia County. No hyperthermia deaths were reported during the comparison period in any of the counties studied. Cardiovascular mortality was increased for most age categories, both genders, and all races for each of the five

	County				
	Philadelphia	Essex	Baltimore City	Baltimore	Newcastle
1993 Mortality					
(Average age-adjusted)					
08-18 June	2.5	2.5	3.3	1.6	2.2
06-16 July	2.9	2.8	4.3	1.7	2.0
1988-1992 Mortality					
(Average age-adjusted)					
08-18 June	2.6	2.3	2.9	1.4	2.0
(Range)	(2.2–2.8)	(2.0–2.6)	(2.4–3.4)	(1.3–1.5)	(1.8–2.2)
06-16 July	2.8	2.5	3.2	1.4	2.1
(Range)	(2.6-3.1)	(2.2-2.6)	(3.0-3.4)	(1.1-1.6)	(1.8-2.3)
Population (1990)	1,585,577	778,206	736,014	692,134	441,946
Population density	11,745	6,176	9,087	1,155	1,037

Table 5—Average age-adjusted daily mortality rates (per 100,000 population) for five metropolitan east-coast counties during a heat-wave study period (06 July through 16 July, 1993) and during a comparison period with no heat wave (08 June through 18 June, 1993) and for 1988–1992 for the same study periods, including their respective population and population density (people per square mile)

counties (Table 4).

Average age-adjusted daily mortality rates calculated for the five counties were higher during the heat-wave period than they were during the comparison period in Philadelphia County, Essex County, Baltimore City, and Baltimore County; this rate was highest in Baltimore City (Table 5). The average age-adjusted daily mortality rates during June 1993 were similar to those for June 1988–1992, except for Baltimore County, where the rate was above the range for the previous five years. The average age-adjusted daily mortality rates during the 1993 heat-wave period were higher than were those for the same July period from 1988–1992 (Table 5), except for Philadelphia County, which was at the top end of the range for the previous five years, and for Newcastle County. The counties with the three highest average age-adjusted daily mortality rates for the heat-wave study period also had the three largest populations and highest population densities (Table 5). The calculated RRs for cardiovascular mortality for 1993 and the previous five years (1988–1992) for the periods of 06 July through 16 July compared with 08 June through 18 June for all five counties showed that the only RRs that were elevated significantly were in 1993 for three counties: Philadelphia County, Essex County, and Baltimore City.

Philadelphia Rapid Field Assessment and Mortality File Review — For the rapid field assessment in Philadelphia County, 1,135 (85%) of the 1,335 death certificates that were filed with Pennsylvania's Division of Vital Records (Tables 1, 3) were obtained. Agreement between the general classification of the cause of death for the rapid field assessment with that of the computerized mortality files was greater than 92% (heat wave agreement = 88%; comparison agreement = 94%); with the exception of deaths from hyperthermia and cerebrovascular diseases during the heat wave and from respiratory diseases in both the heat wave and the comparison periods (Table 6). All of the findings of the rapid field assessment were confirmed using the computerized mortality files, although the rate ratios derived from the mortality review (with only two exceptions) moved closer to 1.00 (Tables 1–4).

Heat-related illness or a hot environment was mentioned on 111 death certificates included in the rapid field assessment. The ultimate determination of the underlying cause of death on these death certificates is rather remarkable. At the time of the field study, 23 death certificates listed hyperthermia or heat stroke as the only cause of death on Part I of the certificate. Follow-up indicated the following: the underlying cause of death assigned in the computerized mortality file was hyperthermia (ICD-9: E900) for two certificates, cardiovascular disease (ICD-9: 429) for 12, pyrexia of unknown origin (ICD-9: 780.6) for five, and "miscellaneous causes" for the remaining four. A recent review of these 23 certificates indicated that 10 were amended by the Medical Examiner's Office after the rapid field assessment, and that hyperthermia no longer was listed in Part I when the certificate was sent to the Pennsylvania Division of Vital Records. Ultimately, only 13 death certificates listed only hyperthermia in Part I.

On 82 death certificates listing hyperthermia either with other conditions in Part I or in Part II only, the underlying cause of death was ICD-9 coded at the Pennsylvania Division of Vital Records by the ACME program as hyperthermia (ICD-9: E900) on two, cardiovascular disease (ICD-9: 429) on 76, and other causes for the remaining four. The remaining six certificates mentioned a hot environment and were assigned an underlying cause of cardiovascular disease (ICD-9: 429.2). Thus, the ACME program assigned an ICD-9: code of E900.0 or E900.9 for the underlying cause of death — reflecting "deaths caused by excessive heat due to natural and environmental factors" — to only four (4%) of the 111 death certificates identified from the rapid field assessment as mentioning a heat-related condition or a hot environment.

Cause of death	Deaths in RFA	Agreement of RFA cause with mortality file agreement n	(%)
Heat wave study period			
Cause-specific mortality			
Cardiovascular disease	222	210	(95)
Cerebrovascular disease	13 *	9	(69)
Hyperthermia	23	2	(9)
Injury	38	38	(100)
Respiratory disease	25	14	(56)
Other cause	118	112	(95)
Total	439	385	(88)
Comparison period			
Cause-specific mortality			
Cardiovascular disease	112	107	(96)
Cerebrovascular disease	15	14	(93)
Hyperthermia	0	0	(100)
Injury	32	32	(100)
Respiratory disease	20	12	(60)
Other cause	123	120	(98)
Total	302	285	(94)

Table 6—Comparison of the classification of the cause of death in the rapid field assessment (RFA) with the classification in the computerized mortality file, Philadelphia, Pennsylvania, 1993. (* One of the death certificates in the RFA could not be located in the computerized mortality file.)

Since the ICD-9 coded underlying cause of death did not reflect the contribution of heat to the excess mortality associated with the 1993 heat wave, multiple-cause mortality data for Philadelphia County and Baltimore City were analyzed. For Philadelphia County, the multiple-cause data for the heat-wave study period contained 117 records with an ICD-9 code of either E900.0 or E900.9. Of these 117 records, 108 (92%) corresponded to deaths identified by the Philadelphia Medical Examiners as heat-related. Six of the records that did not correspond were pending at the time of the field assessment and were not included in the Medical Examiners' list of heat-related deaths; the other three were not Medical Examiner cases. The 117 records identified using the Philadelphia County multiple-cause data, approximates the 112 deaths that occurred during the heat-wave study period that were identified by the Philadelphia Medical Examiner's Office as heat-related. Two of the four deaths identified by the Medical Examiner did not correspond to any record in the multiple-cause file; the other two were coded as E900.1, "man-made environmental heat," and 780.6, "hyperpyrexia" in the multiple-cause file. Although Baltimore City had a similar increase in total mortality associated with the heat wave, the Baltimore City multiple-cause mortality files contained only two records with an ICD-9 code of either E900.0 or E900.9; the underlying cause of death of one of these was E900.9.

Discussion

Excess mortality occurred in association with the July 1993 heat wave. The number of excess deaths varied by county, but was consistent across four of the five counties examined, and accounted for 255 excess deaths. The cause of virtually all of this excess was increase in the number of deaths due to cardiovascular disease. Because the heat wave extended beyond the study area, it can be assumed that excess deaths occurred during the same period in other counties that were affected by the heat wave.

The excess mortality first identified was for Philadelphia County by the Philadelphia Medical Examiner. The Medical Examiner recognized the excess deaths as heat-related, and the number of deaths that were reported as heat-related was virtually identical to both the excess in total and in cardiovascular mortality for Philadelphia County and to the number of heat-related deaths noted in Philadelphia County using their multiple-cause mortality files. In contrast, the excess in total and cardiovascular mortality seen in three of the other four counties far exceeded that reported at the time of the heat wave[9] as well as that noted in Baltimore City using its multiple-cause mortality file. These findings suggest that: 1) there is a need to develop standardized criteria for determining that a death is heat-related; 2) these criteria should allow for circumstantial (e.g., decedent found in a room without air conditioning, all windows closed, and a high ambient temperature) as well as medical evidence, similar to the criteria used by the Philadelphia Medical Examiner's Office;[8] 3) the people who certify deaths need to note the contribution of heat on the death certificate; 4) the use of the underlying

cause of death, as determined by the ACME system, to identify heat-related deaths greatly underestimates the mortality associated with a heat wave; and 5) the use of computerized, multiple-cause data files can be a reliable and accurate method for identifying most heat-related deaths during a heat wave, if the certifier of each heat-related death would list a heat-related condition or the presence of a hot environment somewhere on the death certificate. Although the presence of an underlying, chronic condition in the decedent increased his or her susceptibility to heat could not be determined, presence of such a condition also should be considered when determining whether a death was heat-related.

A public health emergency like that of the 1993 July heat wave and the 1995 Midwest United States heat wave, requires rapid recognition and response in order to prevent further morbidity and mortality, as well as the collection of accurate, complete data for subsequent analyses.[8,20] Through the use of vital records, rapid field assessment provided a quick (within five days), accurate, and population-based assessment of deaths that occurred during the heat wave, and facilitated quicker responses to concerns raised by the media and health officials regarding excess mortality from the heat wave. The study confirms the increases in mortality reported by the Philadelphia Medical Examiner, and demonstrated the value of Medical Examiner-based surveillance as the most timely and accurate measure of heat-related mortality available during a heat wave required to alert appropriately the public and local officials .[8, 20] Medical examiner and vital records data, however, are not sufficient to evaluate many of the risk factors described above. For this purpose, targeted epidemiological studies are needed. Although multiple-cause mortality files are not available rapidly enough to be useful in emergency assessments during a heat wave, the use of the Mortality Medical Indexing, Classification, and Retrieval System@ (MICAR), a recently developed computer program for entering and coding conditions listed on a death certificate, could facilitate future rapid field assessments in the days following a heat wave.[21]

Conclusion

Many of the findings of this study, including those concerning the factors that place people at increased risk for death during a heat wave, are similar to those of previous studies: the three counties with the largest populations and highest population densities had the highest risk; the elderly were at increased risk; and those who died were most likely to die from cardiovascular disease.[1,2,5,6,22–24] As has been demonstrated in several previous studies, in Philadelphia County, the association of deaths from cardiovascular disease with place of death and the variation in risk across the county suggest that environmental and sociologic factors played a strong role in mortality risk.[1,5,6,25–27] In contrast to previous studies, there was an excess of cardiovascular deaths among people in the 45- to 64-year old age group in Philadelphia County. Finally, this study is the first to characterize risk factors for people who died of cardiovascular disease during a heat wave.

Severe heat waves will continue to occur. Since many of the severe illnesses and deaths associated with heat waves are preventable, we need to accurately forecast the occurrence of future heat waves, and must rapidly implement effective strategies to prevent their adverse effects. These preventive strategies will require collaboration between medical examiners, weather forecasters, the news media, public health and emergency response agencies, and community organizations to notify and assist those at risk.

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References

1. 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;247:3327–3331.
2. Ellis FP: Mortality from heat illness and heat-aggravated illness in the United States. *Environ Res* 1972;5:1–58.
3. Hodge WT: Weather-related variations in U.S. daily mortality. *Conference on Agriculture & Forest Meteorology*, 2–6 April, 1979, Minneapolis, MN. American Meteorological Society, Boston, MA. 1979;294–297.
4. National Center for Health Statistics: *Public Use Data Tape Documentation for the Compressed Mortality File (CMF).* U.S. Centers for Disease Control and Prevention. National Center for Health Statistics, 1979–1991. Washington DC.
5. U.S. Centers for Disease Control and Prevention: Heat-related illnesses and deaths—United States, 1994-1995. *MMWR* 1995;44:465-468.
6. Kilbourne EM: Heat Waves. In: Gregg MB, (ed.), *The Public Health Consequences of Disasters* 1989. U.S. DHHS/U.S. Centers for Disease Control and Prevention, Public Health Service, September 1989; pp 51–61.
7. Yarbrough BE, Hubbard RW: Heat-related illnesses. In: Auerbach PS, Geehr EC, (eds.) *Management of wilderness and environmental emergencies.* 2nd ed. St. Louis: C.V. Mosby Company, 1989; pp 131–132.
8. Centers for Disease Control and Prevention: Heat-related deaths—Philadelphia and United States, 1993-1994. *MMWR* 1994;43:453–455.
9. Marder D: Philadelphia takes some heat over death statistics. *Philadelphia Inquirer* 1993 Jul:1(col 1).
10. National Climatic Data Center, National Environmental Satellite Data and Information Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce: *Hourly Surface Airways Observations.* Asheville, North Carolina. TD-3280. 1992–1993.

11. EarthInfo's National Climatic Data Center: *Surface Airways*. Boulder, Colorado, EarthInfo, Inc. 1988–1991.
12. National Center for Health Statistics: *Vital Statistics of the United States*, 1990, Vol II, Mortality, Part A. Washington, DC: Public Health Service. 1994. U.S. DHHS Pub. No. (PHS) 95–1101:383.
13. National Center for Health Statistics. *The Advanced Report of Final Mortality Statistics, 1979. Monthly Vital Statistics Report*, vol 31 no 6, suppl (9). Hyattsville, Maryland: Public Health Service.
14. World Health Organization: *Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death, Based on the Recommendations of the Ninth Revision Conference, 1975*. Geneva: World Health Organization. 1977.
15. National Center for Health Statistics: *Vital statistics, ICD-9 Automated Classification of Medical Entities (ACME) Decision Tables for Classifying Underlying Causes of Death*. Instruction Manual; Part 2c. Hyattsville, Maryland: Public Health Service. 1981.
16. Lilienfeld AM, Lilienfeld DE: *Foundations of Epidemiology*. New York: Oxford University Press, 1980; pp 344–346.
17. Kochanek KD, Hudson BL: *Advance Report of Final Mortality Statistics, 1992*. Monthly Vital Statistics Report, 1995; Vol 43 No 6, suppl. Hyattsville, Maryland: National Center for Health Statistics; pp 71–72.
18. U.S. Bureau of the Census: *U.S. Population and Housing (CPH), 1990*: Public Law 94-171 Data on the CD-ROM/ prepared by the Bureau of the Census. Washington, D.C.: U.S. Bureau of the Census, 1991.
19. National Association of Medical Examiners: Development of criteria for certifying a death as heat-related. *NAME News*. St. Louis, MO, 1995;3:3.
20. Centers for Disease Control and Prevention: Heat-related-mortality—Chicago, July 1995. *MMWR* 1995;44:577–579.
21. National Center for Health Statistics: *Mortality Medical Indexing, Classification, and Retrieval System (MICAR)*. Instruction Manual, Part 2h. National Center for Health Statistics. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention. 1991.
22. Clarke JF: Some climatological aspects of heat waves in the contiguous United States. *Environ Res* 1972; 5:76–84.
23. Buechley RW, Van Bruggen J, Truppi LE: Heat island = death island? *Environ Res* 1972;5:85–92.
24. Clarke JF: Some effects of the urban structure on heat mortality. *Environ Res* 1972;5:93–104.
25. Kilbourne EM, Choi K, Jones TS, Thacker SB, and the Field Investigation Team: Risk factors for heatstroke: A case-control study. *JAMA* 1982;247:3332–3336.
26. Martinez BF, Annest JL, Kilbourne EM, *et al.*:Geographic distribution of heat-related deaths among elderly persons. *JAMA* 1989;262:2246–2250.
27. 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.