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U.S. Peak and Non-peak Hyperthermia: Who is at Risk?

Susan M. Macey*

Introduction

The above average temperatures across the United States during the summer of 1999 and the high mortality figures attributed to heat wave conditions provide vivid examples of the susceptibility of certain population subgroups to temperature extremes.¹ Over the last 20 years, there have been four peak years for heat-related deaths in the United States. The most recent peak occurred in 1995. Three additional years — 1980, 1983 and 1988 — were also exceptional for their high hyperthermia death rates. This study examines hyperthermia death rates in the United States from 1979 to 1996 to determine the relative risk of different demographic groups for peak years versus non-peak years. Attributes investigated include age, race and gender. The elderly (65 years old and older) and the very young (under five years old) are known to be particularly susceptible; death rates for these groups will be compared to rates for the rest of the population. As the objective is to compare those at risk under natural, rather than artificial environmental circumstances, all deaths for the International Classification of Diseases E900 code, excluding those attributable to occupational causes (E900.1), are used.²

Hyperthermia Characteristics — Who is at Risk?

Hyperthermia generally results from three major causes: thermoregulatory mechanisms being overwhelmed by excessive metabolic production of heat, excessive environmental heat or impaired heat dissipation.³ The word excessive is used in the official

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¹ Center for Disease Control, WONDER Web Page, updated on October 21, 1998, available at <http://wonder.cdc.gov/>.

² *Id.*

definition for deaths from heat-related causes, yet mortality for those at risk may be triggered by less than severe conditions. The fact that hyperthermia may be considered a preventable cause of death makes it more important to identify factors which would aid in targeting those at highest risk. While hyperthermia may claim victims of any age, the elderly are particularly at risk, with fatal conditions developing in a mere few hours.⁴ Indeed, the particular vulnerability of the elderly to hyperthermia has been noted by several authors and is routinely noted in the Center for Disease Control's Mortality and Morbidity Weekly Report.⁵ While the elderly is the most frequently cited group, they are by no means the only group at risk. The very young (under five years old), non-whites and persons with chronic illness or impaired mobility are other common risk groups cited.⁶

The question remains as to whether the attributes characterizing hyperthermia decedents hold for both peak and non-peak periods. Second, can a finer distinction be made in the demographic profile of those at risk so that warnings to reduce death rates can be more effectively targeted? Between 1979 and 1996, the period for which data are available on the Center for Disease Control WONDER web site, there were four peak years of hyperthermia mortality: 1980, 1983, 1988 and 1995.⁷ Frequently, in describing decedents, previous heat waves are alluded to, but only in the most generic terms. For example, Kellermann and Todd state: "As in other heat waves, the vast majority of victims were elderly inner-city residents."⁸ Similarly, official

³ Harry B. Simon, *Hyperthermia*, 329 *New Eng. J. of Med.* 483 (1993).

⁴ *Id.*

⁵ *Id.*; Harry T. Phillip, & Susan A. Gaylord, *Aging and Public Health* (1985); F.P. Ellis, *Mortality from Heat Illness and Heat-Aggravated Illness in the United States*, 5 *Envtl. Res.* 1 (1972); Center for Disease Control, *Heat-Related Deaths – Philadelphia and United States, 1993-1994*, 43 *Morbidity & Mortality Wkly. Rep.* 453 (1994); Center for Disease Control, *Heat-Related Illnesses and Deaths – United States, 1994-1995*, 44 *Morbidity & Mortality Wkly. Rep.* 465 (1995).

⁶ See Center for Disease Control, *supra* note 5. Center for Disease Control, *Extreme Heat: A Prevention Guide to Promote Your Personal Health and Safety* (1996); Laurence S. Kalkstein & Robert E. Davis, *Weather and Human Mortality: An Evaluation of Demographic and Inter-Regional Responses in the United States*, 79 *Annals of the Ass'n. of Am. Geographers* 44 (1989); Susan M. Macey & Dona F. Schneider, *Deaths from Excessive Heat and Excessive Cold Among the Elderly*, 33 *The Gerontologist* 497 (1993); Center for Disease Control, *Heat-Related Mortality – Chicago, July 1995*, 44 *Morbidity & Mortality Wkly. Rep.* 577 (1995).

⁷ See Center for Disease Control, *supra* note 1.

reports speak of age, race or gender groups, but rarely combine all three to give a more explicit picture of those at risk.⁹ The purpose of this study is to examine the demographic characteristics of hyperthermia decedents for both peak and non-peak periods in order to determine whether a more detailed profile can be developed.

Methodology

Mortality data for all cases attributed to excessive heat of non-manmade origin (International Classification of Diseases, code E900) were extracted from the Center for Disease Control and Prevention's (CDC) WONDER web page.¹⁰ Annual death rates per 100,000 population were extracted for several age groups: under one year-old, one to less than five years old, 5 to 64 years old and 65 years old and older. The elderly group was also subdivided into three segments. The three groups were 65 to 74 years old, 75 to 84 years old and 85 years old and older. For each age category, data for each race-gender combination were extracted. This breakdown allows comparison by age, race and gender over the eighteen-year period. Overall annual trends, as well as years in which peak mortality rates occurred, are described. Statistical associations between decedent characteristics including age, gender and race are assessed using simple nonparametric correlation techniques.¹¹ Cross-group statistical comparisons are made by age and peak versus non-peak year occurrence. Statistical significance levels reported are at the .05 level or greater.

The Demographics of Hyperthermia Deaths

During the period of study, 6,453 hyperthermia deaths were recorded. More than half of all hyperthermia decedents were elderly (51.4%). Those under one year-old accounted for only 1.05% of hyperthermia deaths, while decedents of one to five years-of-age accounted for 1.7%. Males outnumbered females (59.9% versus 40.1%, respectfully) and whites outnumbered blacks and other races

⁸ Arthur L. Kellermann & Knox H. Todd, *Killing Heat*, 335 *New Eng. J. of Med.* 126, 127 (1996).

⁹ See Center for Disease Control, *supra* note 6.

¹⁰ *Id.*

¹¹ Mariji J. Norusis/SPSS Inc., *SPSS Base Systems User's Guide* (1990).

(65.0%, 33.8% and 1.3%, respectively). In absolute numbers, the pattern for race held for all age groups. However, the pattern for gender did not. Females outnumbered males in the 65 years old and older group.

While absolute numbers may be used to characterize decedents, they do not portray relative risk. Death rates per 100,000 population are therefore used in the rest of this study to compensate for the absolute size of each subgroup. The "other races" category and the under one year-old age group were so small in size (81 and 68 decedents, respectively, for the eighteen-year period) that rates reported to two decimal places were often unreliable, therefore the "other race" category was dropped, while the under one year-old and the one to five year-old age groups were combined for the purpose of further analysis.

An examination of death rates for the period of study shows that the elderly have the highest rate, while males and blacks have higher rates than females and whites in each age group (Table 1). While the very young may be a high-risk group, the death rates for those less than five years old are lower than any other age group in the population. Overall, the results conform to the general image presented in the literature of the elderly with males and blacks being at highest risk. However, these broad characterizations mask important variations within age categories.

Taking age, race and gender into consideration, elderly black males as a group have the highest rate (2.74) followed closely by elderly black females (2.72). While the rate is much lower than for their elderly counterparts, the difference between black males and all other race-gender groups is more marked in the other two age categories. For all age groups, white females exhibit the lowest incidence. Rates for the elderly are higher than those for the rest of the population in every race-gender category. The under five year-old group tends to follow the same pattern in race-gender rates as the 5 to 64 year-old age group in all subcategories, although rates are significantly higher in the latter for males of both races.

Table 1
 Characteristics of Hyperthermia Decedents by Age Group, 1979-1996

<i>Age Group</i>	<i>Characteristic</i>	<i>Annual Average Death Rate</i>	
Less than 5 years		.05	
	Gender	Male	.06
		Female	.04
	Race	White	.04
		Black	.10
	Race/Gender	White male	.05
		White female	.04
		Black male	.12
Black female		.08	
5 to 64 years		.08	
	Gender	Male	.12
		Female	.04
	Race	White	.06
		Black	.21
	Race/Gender	White male	.10
		White female	.03
		Black male	.31
Black female		.12	
65 years and older		.62	
	Gender	Male	.71
		Female	.55
	Race	White	.43
		Black	2.73
	Race/Gender	White male	.54
		White female	.36
		Black male	2.74
Black female		2.72	

When the elderly age category is subdivided into subgroups, further variations become evident. Rates increase progressively for all race-gender groups with age (Table 2). The increase is particularly striking for black females between the 65 to 74 year-old age group and the 75 to 84 year-old age group where the rate almost triples. While rates are significantly higher, the 65 to 74 year-old age group race-gender pattern is the same as that of the under 65 year-old age group with black males having the highest rate. The pattern in the two oldest categories (75 to 84 years old and 85 years old and older) is for black females to have the highest rates followed by black males. Thus, based

on death rates, those at greatest risk are the 85 years old and older black females. Black males in the same age category are a close second. However, the rates for blacks in the other two elderly age groups also shows them to be at greater risk than the rest of the population. Rates for these groups are at least four times higher than that of their white counterparts. Rates for white males and white females increase with age, but overall rates are comparatively low.

Table 2
Characteristics of Elderly Hyperthermia Decedents, 1979-1996

<i>Age Group</i>	<i>Characteristic</i>	<i>Annual Average Death Rate</i>	
65 to 74 years		.40	
	Gender	Male	.51
		Female	.31
	Race	White	.27
		Black	1.77
	Race/Gender	White male	.37
		White female	.19
		Black male	2.03
Black female		1.60	
75 to 84 years		.86	
	Gender	Male	.98
		Female	.79
	Race	White	.58
		Black	4.31
	Race/Gender	White male	.74
		White female	.48
		Black male	3.92
Black female		4.56	
85 years and older		1.45	
	Gender	Male	1.83
		Female	1.30
	Race	White	1.07
		Black	6.38
	Race/Gender	White male	1.44
		White female	.92
		Black male	6.30
Black female		6.45	

Peak versus Non-peak Decedent Characteristics

Of the eighteen years examined, the greatest numbers of deaths were recorded in 1980, 1983, 1988 and 1995. Peak periods for hyperthermia deaths during the eighteen-year period were associated with widespread events occurring across a large region over the summer months in specific years. The summer of 1980 saw record heat across 21 mainly southern states.¹² In 1980, 1,668 people died of hyperthermia.¹³ The 1983 heat wave affected much of the Eastern, Central and Southern United States during the summer months.¹⁴ Similarly, record high temperatures were set in many parts of the United States as early as June of 1988.¹⁵ In 1983 and 1988, there were recorded peaks of 534 and 439 deaths respectively. The 1995 death count reached 682. In 1995, record high temperatures were recorded at approximately 70 locations across the United States, ranging from the Central and Northern Great Plains to the Atlantic Coast.¹⁶ The next highest counts were recorded in 1986 and 1987. With 334 and 315 deaths, respectively, these peaks were considerably smaller than those recorded in other years.

With the overall demographic characteristics of decedents established for the eighteen-year study period, the question arises whether these patterns differ between peak and non-peak years. As a general comparison, tests were performed to determine whether rates for peak years differed significantly from rates for non-peak years. White males and white females under five years old were the only groups to show no significant difference between peak and non-peak years. All other age-race-gender groups registered a significantly higher rate in peak years. Therefore, warnings of impending extreme conditions to the public are vital. However, given that almost all groups are at higher risk, can we determine who may need the most help?

¹² Center for Disease Control, *Heat Wave Related Mortality – United States*, 29 Morbidity & Mortality Wkly. Rep. 357 (1980).

¹³ See Center for Disease Control, *supra* note 1.

¹⁴ Center for Disease Control, *Illness and Death Due to Environmental Heat-Georgia and St. Louis, Missouri, 1983-1984*, 33 Morbidity & Mortality Wkly. Rep. 325 (1984).

¹⁵ Center for Disease Control, *Heat-Wave-Related Morbidity and Mortality*, 37 Morbidity & Mortality Wkly. Rep. 390 (1988).

¹⁶ Center for Disease Control, *Heat-Wave-Related Mortality – Milwaukee, Wisconsin, July 1995*, 45 Morbidity & Mortality Wkly. Rep. 505 (1996).

The age-race-gender group rates for years in which relatively extensive heat wave conditions were recorded — 1980, 1983, 1988 and 1995 — are set out in Table 3. The age-race-gender pattern for those 5 to 64 years old is the same for all years with black males recording the highest rate, followed by black females and white males. White females have the lowest rate. This pattern is consistent across peak years throughout the whole eighteen-year study period. The 65 to 74 year-old category also exhibits the same pattern as the 5 to 64 year-old age group across peak and non-peak years, with the exception of 1980. In this peak year, the black female rate was slightly higher than the black male rate.

Table 3
Association of Age-Race-Gender Groups by Period of Occurrence

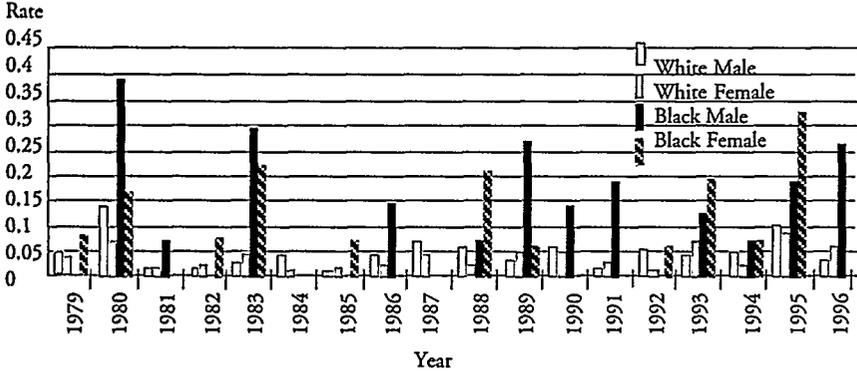
<i>Age-Race-Gender Group</i>	<i>1980</i>	<i>1983</i>	<i>Death Rate</i>		<i>Average 1979-1996</i>
			<i>1988</i>	<i>1995</i>	
Less than Five Years	.13	.06	.06	.11	.05
White male	.13	.02	.06	.10	.05
White female	.07	.04	.02	.09	.04
Black male	.39	.29	.07	.19	.12
Black female	.16	.22	.21	.32	.08
5 to 64 years	.33	.12	.09	.14	.08
White male	.30	.14	.12	.19	.10
White female	.12	.04	.03	.05	.03
Black male	1.52	.48	.40	.51	.31
Black female	.92	.24	.12	.19	.12
65 to 74 years	2.52	.67	.53	.57	.40
White male	1.91	.65	.56	.60	.37
White female	1.20	.38	.31	.27	.19
Black male	12.87	3.10	2.32	3.26	2.03
Black female	13.65	2.33	1.38	1.48	1.60
75 to 84 years	5.71	1.37	.87	1.23	.86
White male	4.03	.77	.70	1.34	.74
White female	2.67	.86	.52	.79	.48
Black male	28.95	6.08	4.42	4.30	3.92
Black female	41.93	9.16	4.01	4.36	4.56
85 years and older	8.83	2.22	1.87	2.75	1.45
White male	5.47	2.86	2.18	3.26	1.44
White female	5.69	1.33	1.20	1.84	.92
Black male	43.38	6.67	10.70	11.36	6.30
Black female	55.63	8.88	5.38	8.21	6.45

In other ways, 1980 was also exceptional. It was the only year when the white female rate exceeded the white male rate in any age category. Specifically, while only one-tenth of the black female rate, white females 85 years old and older outranked white males of the same age. While all elderly groups showed elevated rates, black female and black male rates were disproportionately high in 1980 compared with their levels in other peak years and their average rate over the eighteen-year period. Elderly black females fared the worst in 1980, with the highest rate for any group over the study period. The lower rates among all elderly groups in later peak years suggests that programs to assist the elderly have led to improved conditions.

In 1983, black females in the oldest-old category (75 years old and older) were still most susceptible to hyperthermia. In 1988 and 1995, this pattern was reversed with black males having generally higher rates than black females among the oldest-old group. Indeed, the relatively low rate for elderly black females in 1988 and 1995 compared to the previous two peak years was unexpected, but may evince more effective outreach to this group.

At the opposite end of the age spectrum, a reversal in gender is also apparent. However, in this case black males had the highest rate in 1980 and 1983, while the rate for black females surpassed that of black males in 1988 and 1995. The rate for black females under five years old in 1995 is also higher than the rate for any other under five year-old race-gender group, except black males in 1980. Indeed, the 1995 under five years old race-gender group rates are closer to the 1980 rates than for any other age group. The 1988 and 1995 rates for under five years old black females also surpassed the rate for 5 to 64 year-old black females in those years. The jump in death rates among black males and females less than five years old in peak years is particularly evident in Figure 1. For fifteen of the eighteen years, black infants have higher rates than their white counterparts. Individuals in this subcategory require close scrutiny, especially when a heat wave is expected.

Figure 1 Under Five Years Old Death Rates, 1979-1996



Death rates during the eighteen-year study period for the 5 to 64 year-old group are depicted in Figure 2. The higher rates for 5 to 64 year-old black males are clearly apparent. In peak years, the rate for black females increases to rival or surpass that of white males. In the 65 years old and older group (Figure 3), the vulnerability of black females and black males, especially during peak years, is evident. These two groups consistently have higher rates throughout the eighteen-year study period compared with white males and females. This graph also shows the dramatic increase during peak years.

Figure 2: Five to Sixty-four Years Old Death Rates, 1979-1996

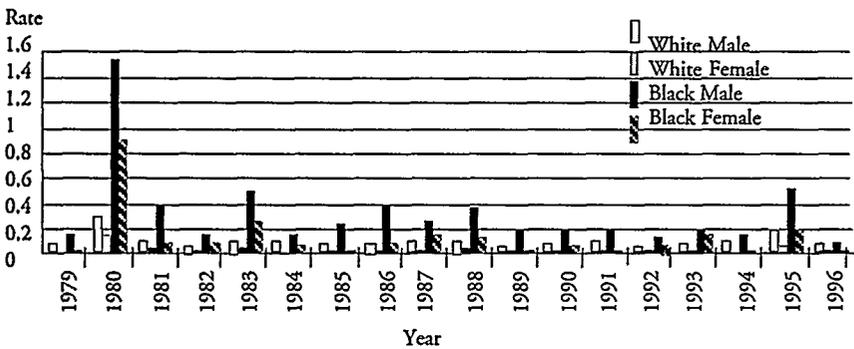
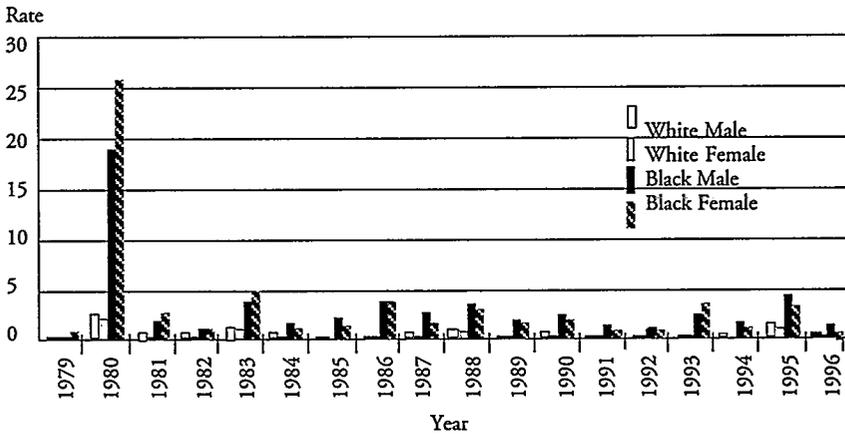


Figure 3: Sixty-five Years and Older Death Rates, 1979-1996



Targeting Those at Greatest Risk

Overall, a comparison of rates shows that the profile of hyperthermia decedents during peak periods parallels those for hyperthermia decedents in general. However, the relative risk for certain subgroups does vary from year to year. Elderly black males and females exhibit the highest rates, though the rates for all elderly are consistently higher than those for persons under 65 years old. Black males and females under five years old also exhibit disproportionately higher rates during peak periods. In the 5 to 64 year-old group, black males consistently record the highest rates. A logical conclusion would be to attribute this pattern to the generally lower income levels associated with minority groups and the elderly. Studies of the elderly show that even when individuals are aware of their inability to adequately judge the thermal environment, few employ remedial care measures. Some even consciously threaten their own health by trying to save money on utility bills.¹⁷ In particular, low income urban elderly have been found to engage in energy curtailment behaviors.¹⁸

¹⁷ Susan M. Macey, *Hypothermia and Energy Conservation: A Tradeoff for Elderly Persons?*, 29 *Int'l. J. of Aging Hum. Dev.* 151 (1989); Colleen K. Milcham & Jeanette A. Brandt, *Influence of Income on Energy Beliefs and Behaviors of Urban Elderly*, 6 *J. of Housing for the Elderly* 107 (1990).

¹⁸ Joseph M. Holtzman et al., *Symptoms and Self-Care in Old Age*, 5 *J. of Applied Gerontology* 183 (1986).

Numerous newspaper articles on the Chicago heat wave of 1995 spoke of elderly victims dying with their air conditioners unused because they were afraid of high electric bills. Programs need to be implemented to alleviate the fear of high utility bills. Many areas have budget billing where peak usage expenses can be spread over an annual billing cycle. In spite of common recognition of the problem, it appears that the vulnerability of the elderly, especially in urban core areas, is still present and remains underestimated.¹⁹

Along with greater efforts to enroll the elderly and minorities in such energy-related programs, individuals need to be impressed with the importance of seeking help when higher temperatures are forecast, and before heat becomes life threatening. Where the elderly and minorities of any age group do not have air conditioning, programs providing open local facilities and transportation to individuals may be the best remedy. Unfortunately, heat stroke frequently develops with little or no warning. A typical scenario in the 1980 heat wave was that a person went to bed, apparently well, and was discovered severely ill, unconscious or dead the next day.²⁰ Studies also attribute death rates to the social isolation in the 1995 Chicago heat wave.²¹ A network of centers and volunteers that could be rapidly brought into service when peak conditions are forecasted needs to be in place. While the effectiveness of such measures has yet to be documented, cities with heat preparedness plans including Philadelphia and St. Louis may serve as role models.²² In conjunction with established programs such as those providing utility bill assistance and fans in times of peak heat conditions, these contingency plans may further reduce hyperthermia death rates.



¹⁹ National Oceanographic & Atmospheric Administration, Nat. Disaster Surv. Rep. July 1995 Heat Wave (1995).

²⁰ T.S. Jones et al., *Morbidity and Mortality Associated with the July 1980 Heat Wave in St. Louis and Kansas City, MO.* 247 *J. of the Am. Med. Ass'n* 3327 (1982).

²¹ See Kellermann, *supra* note 8; Jan C. Semenza et al., *Heat-Related Deaths During the July 1995 Heat Wave in Chicago*, 335 *New Eng. J. of Med.* 84 (1996).

²² See National Oceanographic & Atmospheric Administration, *supra* note 19; Laurence S. Kalkstein et al., *The Philadelphia Hot Weather-Health Watch/Warning System: Development and Application, Summer 1995*, 77 *Bull. of the Am. Meteorological Soc'y* 1519 (1996).