

Heat-Related Fatalities in North Carolina

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We used medical examiner's records to identify heat-related fatalities (N = 161) that occurred during the period January 1, 1977, to December 31, 2001, in North Carolina. Estimates of the population at risk were derived from US census data. Annual fatality rates increased with increases in average summer temperature and with the number of days per year at 90°F or higher. Of the occupational heat-related fatalities (n = 40), 45% occurred among farm laborers, many of whom died unnoticed and without medical attention. (*Am J Public Health*. 2005; 95:635–637. doi:10.2105/AJPH.2004.042630)

In the southern United States, residents are presumably acclimatized to hot weather and high humidity. However, previous research has found that heat-related mortality has been an important cause of death among agricultural laborers, with most of these heat-related deaths occurring among young African Americans.¹ In recent years, many Latino workers have entered the agricultural industry. Although the consequences of this transition have not been systematically investigated, several heat-related deaths have been reported recently among Latino farm laborers in North Carolina,^{2,3} and these reports suggested that a description of heat-related mortality in the southern United States could improve our understanding of the hazard of heat stress in this population.

METHODS

We reviewed medical examiner's records for all deaths between January 1, 1977, and December 31, 2001, with heat-related primary or underlying causes of death (*International Classification of Diseases, Ninth Revision*,⁴ codes 692.71, 992.0–992.9, E900.0, E900.1, and E900.9). To determine the work-relatedness of each death, we abstracted information about decedents' locations and activities at the times the heat-related injuries occurred. Deaths occurring after heat-related injuries in the workplace or while traveling from the workplace were considered work-related fatalities. Decedents younger than 10 years and decedents for whom the cause of death directly involved manufactured sources of heat were excluded.

We used linear interpolation and extrapolation of the decennial censuses to derive annual estimates of the total and working populations of North Carolina.⁵ We obtained statewide temperature data for 1976 to 2002 from the National Climatic Data Center. Fatality rates were estimated with Poisson regression analysis.⁶

RESULTS

Of the 161 heat-related deaths, 40 were identified as having occurred on the job (Table 1). All decedents whose heat-related injuries occurred in occupational settings were men, and

TABLE 1—Demographic Characteristics, Health Conditions, Location at Time of Onset, and Timing of Natural Environmental Heat-Related Deaths: North Carolina, 1977–2001

	Decedents Aged ≥ 10 y (N = 161) No. (%)	Work-Related	
		No (n = 121) No. (%)	Yes (n = 40) No. (%)
Age, y			
10–19	4 (2)	4 (3)	0 (0)
20–29	9 (6)	2 (2)	7 (18)
30–39	22 (14)	9 (7)	13 (33)
40–49	25 (16)	13 (11)	12 (30)
50–59	30 (19)	23 (19)	7 (18)
60–69	37 (23)	36 (30)	1 (3)
≥ 70	34 (21)	34 (28)	0 (0)
Mean ±SD	56 ±18	61 ±17	42 ±11
Median	55	63	41
Range	11–92	11–92	21–63
Ethnicity			
Hispanic	4 (2)	0 (0)	4 (10)
Non-Hispanic/unknown	157 (98)	121 (100)	36 (90)
Race			
Black	93 (58)	70 (58)	23 (58)
White	62 (39)	48 (40)	14 (35)
Native American	3 (2)	2 (2)	1 (3)
Other or unknown	3 (2)	1 (1)	2 (5)
Gender			
Female	47 (29)	47 (39)	0 (0)
Male	114 (71)	74 (61)	40 (100)
Blood alcohol ^a			
Not screened	48 (30)	40 (33)	8 (20)
Screened, alcohol not detected	89 (55)	59 (49)	30 (75)
Screened, alcohol detected	24 (15)	22 (18)	2 (5)
Medical history			
Alcohol or drug abuse	25 (16)	17 (14)	8 (20)
Dementia	9 (6)	9 (7)	0 (0)
Depression	7 (4)	4 (3)	3 (8)
Physical disability ^b	4 (2)	4 (3)	0 (0)
Schizophrenia	8 (5)	7 (6)	1 (3)
Other psychiatric condition ^c	10 (6)	8 (7)	2 (5)
Location at time of heat injury			
Construction site	10 (6)	0 (0)	10 (25)
Farm or agricultural property	19 (12)	3 (2)	16 (40)
Home or residence	88 (55)	85 (70)	3 (8)
Sidewalk or public area	11 (7)	10 (8)	1 (3)
Sports area	6 (4)	5 (4)	1 (3)
Vehicle, while driving	4 (2)	3 (2)	1 (3)
Other or unknown	23 (14)	15 (12)	8 (20)
Year of death ^d			
1977–1981	35 (22)	22 (18)	13 (33)
1982–1986	39 (24)	31 (26)	8 (20)
1987–1991	31 (19)	26 (21)	5 (13)
1992–1996	24 (15)	18 (15)	6 (15)
1997–2001	32 (20)	24 (20)	8 (20)

^aBlood alcohol screen performed at time of autopsy.^bPhysical disability with restricted mobility.^cOther psychiatric health condition suggested by text in medical examiner's records.^dYear of death, in 5-year categories.

most were young adults. Although many deaths did not occur at work, all heat-related deaths among Hispanic men occurred on the job. Decedents for whom the work-related injuries caused by heat occurred away from the worksite either wandered away from the site (n = 1) or were returning to migrant labor camp at the end of the day (n = 2).

Information about decedents' medication and alcohol use was not consistently included in the medical examiner's files; however, indication in the medical examiner's reports of having a diagnosis or history of schizophrenia, dementia, alcohol abuse, or drug abuse suggested the possibility of use of substances known to affect thermoregulation (Table 1).^{7–9} Decedents for whom the fatal heat-related injury occurred at work were more likely to be screened for blood alcohol than were decedents who were not working at the time of the injury.

Peaks in the number of heat-related fatalities in North Carolina occurred in 1983, 1986, and 1999 (Figure 1). The overall rate of fatal heat-related injury was 0.11 per 100 000 per year, with the 5-year rate declining from 0.13 per 100 000 per year during the period 1977 through 1981 to 0.09 per 100 000 per year during the period 1997 through 2001. Eighteen (45%) work-related fatalities associated with heat occurred among farm workers (fatality rate = 1.52 per 100 000 per year). The heat-related fatality rate among farm workers in the agricultural industry was elevated compared with rates in the general population (rate ratio [RR] = 14.20; 95% confidence interval [CI] = 8.75, 23.06) and the working population (RR = 30.52; 95% CI = 17.50, 53.23).

Figure 1 illustrates the relation between average summer temperature and numbers of heat-related deaths. We estimated that for each 1°F increase in average summer temperature, the rate of heat-related death increased 59% in the total population (RR = 1.59; 95% CI = 1.36, 1.87) and 37% in the working population (RR = 1.37; 95% CI = 0.99, 1.90). The heat-related fatality rates in each population also increased with increasing number of days per year in which the temperature was 90°F or higher. In both populations, the rates increased 5% per additional day of temperature at 90°F or higher (total population: RR =

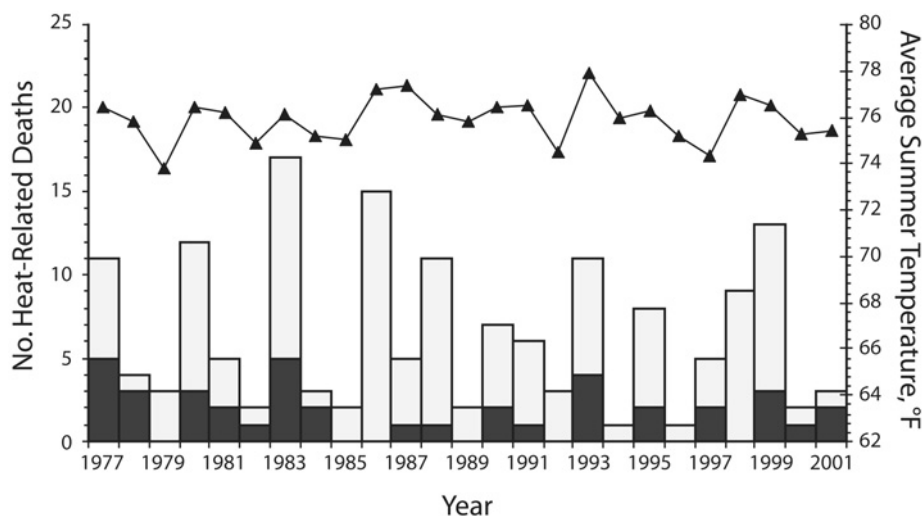


FIGURE 1—Occupational (black bars) and nonoccupational (white bars) heat-related deaths and average annual summer temperatures (°F, June–August, black triangles) in North Carolina, 1977–2001.

1.05; 95% CI=1.04, 1.07; working population: RR=1.05; 95% CI=1.02, 1.08).

DISCUSSION

Occupational deaths caused by heat should be viewed as sentinel events marking settings in which people work to the limits of human exhaustion. In places where farm laborers perform physically demanding tasks in hot and humid weather, heat-related illnesses and injuries are of particular concern.¹⁰ Notably, most occupational heat-related deaths occurred among younger adults, many of whom were African American laborers for whom narrative portions of the medical examiner's records described physical work, such as laying bricks or harvesting crops, in hot weather. Similar to findings in other regions,^{9,11} most nonoccupational heat-related deaths occurred among older adults, often with physical or psychiatric health conditions noted in the medical examiner's records. Only 4 decedents in this category, including 3 high-school athletes, appear to have experienced exertional heat-related injuries.

The data presented here likely underestimate the effect of heat stress on mortality¹²; these findings do not include cardiovascular or other natural causes of death exacerbated by the physiological stress of hot weather.

Also, we did not include other causes of death that might be attributable to heat exhaustion, such as falls, motor vehicle collisions, or injuries involving equipment. Nonetheless, these findings support a strong association between summer temperature and rates of heat-related death. ■

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Contributors

Both authors developed the study protocol, interpreted findings, and revised the article. M.C. Mirabelli extracted and analyzed the data and drafted the article. D.B. Richardson reviewed interim analyses and supervised the project.

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Human Participant Protection

The University of North Carolina at Chapel Hill Public Health institutional review board reviewed the protocol

for this study and determined that approval was not needed.

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