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BRIEF REPORT

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Heat-related fatalities in North Carolina 1999–2017

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Abstract

Objectives: Research shows the highest rates of occupational heat-related fatalities among farm laborers and among Black and Hispanic workers in North Carolina (NC). The Hispanic population and workforce in NC have grown substantially in the past 20 years. We describe the epidemiology of heat-related fatal injuries in the general population and among workers in NC.

Methods: We reviewed North Carolina death records and records of the North Carolina Office of the Chief Medical Examiner to identify heat-related deaths (primary International Classification of Diseases, Tenth Revision diagnosis code: X30 or T67.0-T67.9) that occurred between January 1, 1999, and December 31, 2017. Decedent age, sex, race, and ethnicity were extracted from both the death certificate and the medical examiner's report as well as determinations of whether the death occurred at work.

Results: In NC between 1999 and 2017, there were 225 deaths from heat-related injuries, and 25 occurred at work. The rates of occupational heat-related deaths were highest among males, workers of Hispanic ethnicity, workers of Black, multiple, or unknown race, and in workers aged 55–64. The highest rate of occupational heat-related deaths occurred in the agricultural industry.

Conclusions: Since the last report (2001), the number of heat-related fatalities has increased, but fewer were identified as workplace fatalities. Rates of occupational heat-related deaths are highest among Hispanic workers. NC residents identifying as Black are disproportionately burdened by heat-related fatalities in general, with a wider apparent disparity in occupational deaths.

KEYWORDS
climate change, health disparities, heat-related fatalities, occupational epidemiology

1 | INTRODUCTION

In North Carolina (NC), heat and weather conditions are important occupational hazards, particularly in the agricultural industry. Research has found a disproportionate burden of occupational heat-related fatalities among farm laborers and among Black and Hispanic workers.[1,2] Over the last two decades, the Hispanic workforce in NC has grown dramatically.[3] Hispanic, immigrant, and migrant workers are more likely to be assigned hazardous jobs or tasks than their White, domestic counterparts,[4] and given the increasing concern about heat-related fatal injuries on the job in the United States overall,[5] and in NC in particular,[6,7] we report here on the descriptive epidemiology of heat-related fatal injuries in the general population and workforce of NC.

2 | METHODS

We reviewed North Carolina death records as well as records maintained by the North Carolina Office of the Chief Medical Examiner (described elsewhere)[1,8] for deaths that occurred between January 1, 1999, and December 31, 2017. Access to data for years subsequent to 2017 was prohibited because these more contemporary records are kept onsite at the NC Office of the Chief Medical Examiner (OCME), and their offices have been restricted since the pandemic began. We included deaths among civilian noninstitutionalized NC residents with heat-related primary or underlying causes of death (International Classification of Diseases, Tenth Revision, codes X30: "exposure to excessive natural heat—hyperthermia," and T67.0 through T67.9: "effects of heat and light." We excluded decedents younger than 10 years. Occupational heat-related fatalities were those that were flagged as "at work" on the North Carolina death certificate or indicated as a death that occurred on-the-job according to the records of the OCME. We identified 19 fatal occupational heat-related deaths that were flagged as occurring at work/on-the-job in both data systems. We identified an additional four deaths that were flagged as having occurred on the job in the OCME database but were not flagged as "at work" on the NC death certificate; these cases were reviewed and adjudicated to be workplace deaths based on review of the records. We also identified two deaths that were flagged as "at work" on the death certificate but were coded as "natural" deaths in the medical examiner's report; these cases were reviewed and adjudicated to be workplace heat-related fatal injuries.

We abstracted age, sex, race, and ethnicity of decedents from both the death certificate and the OCME report. We classified decedents as either Hispanic or non-Hispanic ethnicity and American Indian/Alaska Native, Asian, Black, Native Hawaiian/Pacific Islander, White, or a combined category representing more than one or unknown race.[9] Ethnicity and race were available from death records, and not self-reported. We estimated the North Carolina workforce and general population from the 1990, 2000, and 2010 decennial US Census[10] tabulated in strata defined by categories of age, sex, race, ethnicity, and industry sector. Annual estimates of the populations in intercensal years were estimated using a linear interpolation and the estimated numbers of individuals in each stratum were summed to obtain estimates of person-years at risk. These estimates of the worker and general populations were used to approximate the number of person-years at risk in each stratum and calendar year. Rates of heat fatalities were calculated per 1,000,000 person-years at risk; the number of deaths upon which a rate estimate is based is reported to provide an indication of the stability of the estimate, noting that events are not a sample from the target population but rather based on enumeration of all identified deaths over the study period.

3 | RESULTS

Table 1 shows that in North Carolina between 1999 and 2017, there were 225 deaths from heat-related injuries, of which 25 occurred on the job. In this descriptive comparison of data sets, the rates of nonoccupational heat-related deaths were higher than rates of occupational heat-related deaths. The vast majority of occupational heat-related deaths occurred among males (96%), but 65% of nonoccupational heat-related deaths occurred among males. The rates of occupational and nonoccupational heat-related deaths were higher among males than females. While 36% of occupational heat-related deaths occurred among Hispanic workers, only 4% of nonoccupational heat-related deaths occurred among Hispanic workers. Most occupational heat decedents were between 35 and 54 years old, but most nonoccupational heat decedents were 55 years or older at the time of death. A greater proportion of decedents of occupational heat injuries were Black, and a smaller proportion were White, compared to decedents of nonoccupational heat injuries. Occupational heat death rates were highest among workers aged 55–64, Hispanic workers, and non-White workers. nonoccupational heat death rates were highest among people aged 65 and older and non-Hispanic, American Indian/Alaska Native, and Black individuals. The observed rate of occupational heat-related deaths among Black workers was over four times that of White workers, wider than the Black/White disparity in nonoccupational heat death rates. The apparent disparity was even wider between the Hispanic and non-Hispanic workforce. The observed rate of occupational heat-related deaths among Hispanic workers (2.21 per 1,000,000 person-years) was over 11 times that of non-Hispanic workers, while the rate of nonoccupational heat-related deaths was higher among non-Hispanic than Hispanic members of the general population. Rates of occupational heat death were highest in the agricultural production industry, and there was a high rate in the landscape and horticultural services industry albeit based on a single death.

Figure 1 shows recent trends in heat-related fatality rates among the general population of North Carolina and the occupational heat-related deaths among the NC workforce. Rates of heat-related fatalities have remained fairly steady from 1999 through 2017, with a peak in nonworkplace fatalities in 2008. Rates of heat-related fatalities in the general population are higher than in the workforce.

4 | DISCUSSION

Occupational heat-related deaths indicate settings where workers likely reached their physiological limits. In industries like construction and agriculture, where workers perform physically demanding tasks outdoors in hot weather, heat-related injuries are of specific concern. In NC, the Hispanic workforce is overrepresented relative to the general population in the agricultural industry.[11] The highest rates of occupational heat-related deaths occurred in this industry. It is worth noting that the rate among decedents categorized as "more than one race or unknown race" was highest, and this group may include White decedents. However, misclassification of race on death records is more common among non-White than White decedents.[12–16] Disparities in heat-related deaths can be explained by several mechanisms. For occupational heat-related deaths, the literature demonstrates that racial/ethnic disparities in occupational injuries

TABLE 1 Characteristics of North Carolina heat death decedents, 1999–2017.

	Occupational $N = 25$		Nonoccupational $N = 200$	
	n (%)	Rate per 1,000,000 person-years	*n* (%)	Rate per 1,000,000 person-years
Sex, *n* (%)				
Male	24 (96)	0.51	130 (65)	1.52
Female	1 (4)	0.03	70 (35)	0.79
Age group, *n* (%)				
<18	0 (0)	0	29 (15)	0.78
18–24	1 (4)	0.05	6 (3)	0.49
25–34	4 (16)	0.17	12 (6)	0.52
35–44	7 (28)	0.34	18 (9)	0.80
45–54	9 (36)	0.97	30 (15)	1.37
55–64	4 (16)	1.58	31 (16)	1.40
65+	0 (0)	0	74 (37)	2.44
Ethnicity, *n* (%)				
Hispanic	9 (36)	2.21	8 (4)	0.44
Non-Hispanic	16 (64)	0.19	192 (96)	1.23
Race, *n* (%)				
American Indian/Alaska Native	0 (0)	0	5 (3)	1.80
Asian	0 (0)	0	3 (2)	0.48
Black	10 (40)	0.62	69 (35)	1.79
White	9 (36)	0.14	120 (60)	0.99
More than one or unknown race	6 (24)	0.89	3 (2)	0.66
Industry, *n* (%)				
Agricultural production	6 (24)	6.94	–	–
Auto and home supply stores	1 (4)	0.56	–	–
Construction	9 (36)	1.22	–	–
Electric light and power	1 (4)	1.61	–	–
Justice, public order, and safety	4 (16)	2.56	–	–
Landscape and horticultural services	1 (4)	15.04	–	–
Miscellaneous repair services	1 (4)	1.26	–	–
Unknown	2 (8)	–	–	–

have little to do with individual biology and behaviors but, rather, structural factors, like segregation, systematically sorting Workers of Color into more dangerous work conditions than their White counterparts.[17,18] Structural factors are similarly the major drivers of racial/ethnic health disparities in nonoccupational settings as well. For example, residential segregation, access to social services, and discriminatory policies are key mechanisms for health disparities like heat-related deaths.[19,20]

Our study drew upon information from both the NC death certificate and the NC OCME system. While there was substantial concordance between these two systems (76% of occupational heat-related deaths and injuries were identified in both systems), the two systems helped to identify a substantial number of events that would have been missed in an analysis that was restricted to reliance solely on death certificate-based information. The differences in coding of deaths we identified between the two data sources used show the benefits of individual case review. Common issues in using death certificate data for analytical purposes have been widely documented,[15,21,22] and there is no gold standard for collection of analytical data on heat-related deaths. The data

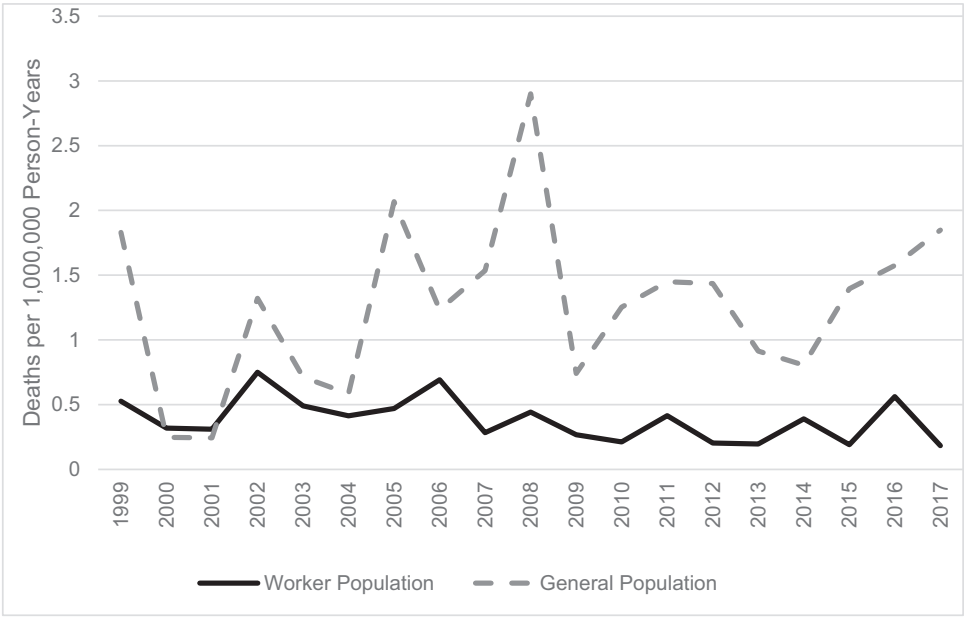

FIGURE 1 Trends in North Carolina heat-related fatality rates, 1999–2017.

included in this analysis likely underestimate the burden of heat-related mortality in NC, because these findings do not include causes of death exacerbated by hot weather (e.g., cardiovascular disease) or causes of death that might be attributable to heat exhaustion (e.g., falls or heavy equipment and motor vehicle accidents). These findings also likely underestimate fatalities among Hispanic workers, as there is bias in collection of ethnicity data on death certificates[16] and migrant workers are less likely to be documented for inclusions in the occupational fatalities database. Research on climate change-related mortality in other US jurisdictions and countries calls for improved surveillance and investigation of potentially heat-related deaths to mitigate this type of underestimation,[23,24] which is particularly prevalent in minoritized populations.[25]

AUTHOR CONTRIBUTIONS

Elizabeth S. McClure designed the study, drafted the initial manuscript, analyzed the data, created the tables and figures, assisted with the literature review synthesis, and approved the final manuscript as submitted. Shabbar I. Ranapurwala assisted in conceptual and analytic design, advised on the analytic strategy, provided commentary on the analysis, contributed to editing of the manuscript, and approved the final manuscript as submitted. Maryalice Nocera provided content to the analysis, assisted with the literature review, contributed to editing of the manuscript, and approved the final manuscript as submitted. David B. Richardson conceptualized the study, advised on the analytic strategy, provided commentary on the analysis, contributed to editing of the manuscript, and approved the final manuscript as submitted.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS APPROVAL AND INFORMED CONSENT

Because this study uses existing data, and there was no contact with human subjects, the University of North Carolina Office of Human Research Ethics considered this as non-human-subject research.

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