# Twenty-five year occupational homicide mortality trends in North Carolina: 1992–2017

Chelsea L Martin ,[1,2] David Richardson,[3] Morgan Richey,[4] Maryalice Nocera,[5] John Cantrell,[6] Elizabeth S McClure,[2,6] Amelia T Martin,[6] Stephen W Marshall ,[7,8] Shabbar Ranapurwala [9]

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/ip-2023-044991).

For numbered affiliations see end of article.

**Correspondence to**
Dr Chelsea L Martin, Department of Epidemiology, Gillings School of Global Public Health, UNC-Chapel Hill, Chapel Hill, NC 27599, USA; martinlc@unc.edu

Received 28 May 2023
Accepted 2 December 2023
Published Online First 14 February 2024

## ABSTRACT

**Introduction** Determining industry of decedents and victim–perpetrator relationships is crucial to inform and evaluate occupational homicide prevention strategies. In this study, we examine occupational homicide rates in North Carolina (NC) by victim characteristics, industry and victim–perpetrator relationship from 1992 to 2017.

**Methods** Occupational homicides were identified from records of the NC Office of the Chief Medical Examiner system and the NC death certificates. Sex, age, race, ethnicity, class of worker, manner of death, victim–perpetrator relationship and industry were abstracted. Crude and age-standardised homicide rates were calculated as the number of homicides that occurred at work divided by an estimate of worker-years (w-y). Rate ratios and 95% CIs were calculated, and trends over calendar time in occupational homicide rates were examined overall and by industry.

**Results** 456 homicides over 111 573 049 w-y were observed. Occupational homicide rates decreased from 0.82 per 100 000 w-y for the period 1992–1995 to 0.21 per 100 000 w-y for the period 2011–2015, but increased to 0.32 per 100 000 w-y in the period 2016–2017. Fifty-five per cent (252) of homicides were perpetrated by strangers. Taxi drivers experienced an occupational homicide rate that was 110 times (95% CI 76.52 to 160.19) the overall occupational homicide rate in NC; however, this rate declined by 76.5% between 1992 and 2017. Disparities were observed among workers 65+ years old, racially and ethnically minoritised workers and self-employed workers.

**Conclusion** Our findings identify industries and worker demographics that experienced high occupational homicide fatality rates. Targeted and tailored mitigation strategies among vulnerable industries and workers are recommended.

### WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Previous literature provided a robust description of the epidemiology of occupational homicides in North Carolina between 1977 and 1991, highlighting vulnerable industries and victim characteristics.

### WHAT THIS STUDY ADDS

⇒ North Carolina has seen profound changes in economic and demographic factors that influence worker safety, including workplace violence initiatives. This study demonstrated a decline in occupational homicide until the period 2016–2017, indicating a need for continued monitoring. This study highlights industries and vulnerable populations who are still vulnerable to occupational homicide in the state of North Carolina.

### HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study aids in targeting and tailoring mitigation programmes among specific industries, older workers, racially and ethnically minoritised workers and self-employed workers.

## INTRODUCTION

Workplace violence resulting in worker fatalities imposes significant social, economic, healthcare and litigation costs.[1] The National Safe Workplace Initiative suggests that workplace violence leads to an approximately US$4 billion expenditure each year,[2] which does not account for the negative psychological impact on surviving employees, victims' families and communities. Approximately 9%–14% of all occupational fatalities at work are due to homicides,[3 4] second only to motor vehicle crashes.[5]

Epidemiological studies from North Carolina (NC) have previously reported occupational homicides by industry,[1] employee class of worker (ie, self, private or government employed)[6] and racial disparities[7] among workers between 1978 and 1991. Prior studies did not examine circumstantial information, including victim–perpetrator (v–p) relationship and firearm use among occupational homicide cases, which are important to target prevention programmes for the most vulnerable workers.[8] Since the last descriptive epidemiological study by industry in NC, major economic and demographic shifts have occurred. Industries have shifted away from manufacturing jobs to service industries. Additionally, the state population has increased from 6.6 to 10.4 million people, with an annual growth rate of 8.8% in Hispanic residents between 1990 and 2020.[9] Due to these changes, an updated epidemiological profile of occupational homicides by industry, worker and v–p relationship was undertaken.

The purpose of this study is to examine occupational homicide rates in NC by victim characteristics, industry and v–p relationship between 1992 and 2017. This epidemiological study will provide

Check for updates



**To cite:** Martin CL, Richardson D, Richey M, *et al*. *Inj Prev* 2024;**30**:283–289.

an update to previous literature to inform workplace policy and safety intervention programmes in a state with changing demographics and industries.

## METHODS

### Study design and data

We conducted a retrospective cohort study to examine trends of occupational homicide deaths in NC using data abstracted from the NC Office of the Chief Medical Examiner (OCME) system from 1992 to 2017. All subjects in the study were deceased so informed consent was not necessary following review by the University of North Carolina Office of Human Research Ethics. Occupational homicides were defined as intentional fatality that occurred as a result of an assault on an NC worker engaged in legal work for pay. OCME data consist of medical examiner (ME) investigative reports of fatal injuries that occur in NC's 100 counties. MEs identify the cause and circumstances of each death, determine if the fatality occurred 'on the job', and fill out the official death certificate. To increase sensitivity, we combined the NC death certificate data from the NC State Center for Health Statistics along with the OCME data. The death certificate data also include an 'at work' flag. Any death that was either flagged 'on the job' in the OCME data or 'at work' on the death certificate and had a cause of death listed as homicide on the death certificate was eligible. In addition, we sought out news reports, court transcripts and publicly available information about the deaths. If a fatality was 'flagged' as occupational in either database, the case was eligible for review. Cases where only one of the two flags was present were adjudicated by at least two study investigators and the project manager before making a determination of 'occupational' death. We excluded deaths among active-duty military members.

### Patient and public involvement

No patients were involved in setting the research question or design. Study results are shared with the US National Institute for Occupational Safety and Health Administration (OSHA), NC OCME, and the Injury and Violence Prevention Branch of the Division of Public Health in the NC Department of Health and Human Services, who engage with employers, representatives, members of the public and advocacy groups. Findings are communicated with advisory bodies to inform patients and public materials.

### Variables

#### Victim characteristics

Sex was classified as male and female. Age was abstracted in integer years and subsequently categorised as 18–24, 25–34, 35–44, 45–54, 55–64 and 65+ years old. Race (white, black/African American, American Indian or Alaska Native, Asian and Pacific Islander and other race), and Ethnicity (Hispanic, Non-Hispanic) were originally abstracted as separate variables and subsequently reclassified as Hispanic, non-Hispanic black, non-Hispanic white and a combined group of non-Hispanic, non-black, non-white to avoid cross-classification of Hispanic victims by race in accordance with recommendations[10] and to allow robust interpretation of estimates from groups with small number of outcomes. The class of workers consisted of self-employed, privately employed or government employed. The industry of employment at the time of the fatal injury of the victim was abstracted and coded according to the US Census year 2000 guidelines.[11]

#### v–p relationship

Information on the v–p relationship was abstracted from OCME case files and supplemental sources and classified as 'stranger', 'customer or client', 'coworker', 'personal relation' or 'unknown.'[12] If the v–p relationship included two categories (eg, a coworker and a personal relation), these cases were classified into the category deemed the closest degree of relationship (eg, a case listed as 'customer or client' and 'stranger' was classified as a customer or client).

#### Population at risk

Annual estimates of the NC workforce were derived from the 1990, 2000 and 2010 decennial US Census. Estimates were calculated for age group, sex (male, female), race (white, black or other), ethnicity (Hispanic, non-Hispanic) and industry groups (51 groups based on census codes). These population estimates were used to approximate worker-years (w-y) at risk in each stratum overall and by calendar year.

### Statistical analyses

Data were assessed for missingness prior to analyses, with no missingness observed for all variables. Homicides by demographics, firearm use and time frame (1992–1995, 1996–2000, 2001–2005, 2006–2010, 2011–2015 and 2016–2017) were reported as counts and percentages.

Homicide rates were calculated for categories of sex, age group, race/ethnicity and class of worker, where the rate was defined as the number of occupational homicides observed in that group divided by an estimate of the w-y at risk, expressed as events per 100 000 worker years. For analyses stratified by industry, crude and age-standardised homicide rates were calculated as the number of homicides at work divided by an estimate of the NC population employed in the particular industry per 100 000 worker years. Rate ratios and 95% CIs were calculated for the specified industry compared with all industries. Strata that included less than five cases were suppressed in the tables to ensure results were not identifiable. v–p relationship was reported as count and percentages by industry. All data management and statistical analyses were performed in SAS V.9.4 (SAS Institute). The Strengthening the Reporting of Observational Studies in Epidemiology guidelines were used for reporting.[13]

## RESULTS

Between 1992 and 2017, 456 homicide deaths occurred over 111 573 049 w-y. Occupational homicide rates decreased over the study period, from 0.82 per 100 000 w-y during 1992–1995 to 0.21 per 100 000 w-y during 2011–2015, but increased to 0.32 per 100 000 w-y during 2016–2017. The largest numbers of homicides were observed among males (378, 83%), people aged 35–44 years (125, 27%), non-Hispanic white (289, 63%) and privately employed (263, 58%) (table 1). However, the highest homicide rates were among self-employed workers (1.22 per 100 000 w-y) and workers 65 years and older (0.90 per 100 000 w-y) (table 1). All racially and ethnically minoritised groups demonstrated higher rates of homicide compared with white non-Hispanic workers (Hispanic: 0.70 per 100 000 w-y; non-Hispanic black: 0.53 per 100 000 w-y; non-Hispanic, non-white, non-black: 0.60 per 100 000 w-y, white non-Hispanic workers: 0.36 per 100 000 w-y), with Hispanic workers experiencing nearly two times the rate of occupational homicide compared with non-Hispanic white workers (1.94, 95% CI 0.95 to 3.96) (table 1). Firearm use was reported in 81% (369) of all occupational homicide deaths (online supplemental table 1).

**Table 1** Victim characteristics of occupational homicide deaths in North Carolina, 1992–2017

| Characteristic | N (%) | Worker-years | Rate per 100K worker-years | Rate ratio (95% CI) |
|---|---|---|---|---|
| Calendar period | | | | |
| 1992–1995 | 115 (25) | 13 940 991 | 0.82 | 1.0 |
| 1996–2000 | 99 (22) | 18 696 593 | 0.53 | 0.63 (0.48 to 0.82) |
| 2001–2005 | 80 (18) | 20 408 833 | 0.39 | 0.47 (0.35 to 0.63) |
| 2006–2010 | 76 (17) | 22 609 774 | 0.34 | 0.40 (0.30 to 0.54) |
| 2011–2015 | 53 (12) | 25 125 266 | 0.21 | 0.25 (0.18 to 0.35) |
| 2016–2017 | 35 (8) | 10 791 592 | 0.32 | 0.38 (0.26 to 0.56) |
| Sex | | | | |
| Male | 378 (83) | 58 257 318 | 0.65 | 1.0 |
| Female | 78 (17) | 51 207 112 | 0.15 | 0.23 (0.18 to 0.30) |
| Age | | | | |
| <25 years | 44 (10) | 13 575 189 | 0.32 | 1.0 |
| 25–34 years | 92 (21) | 25 579 298 | 0.36 | 1.11 (1.04 to 1.18) |
| 35–44 years | 125 (27) | 29 157 868 | 0.43 | 1.32 (1.25 to 1.40) |
| 45–54 years | 87 (19) | 25 436 509 | 0.34 | 1.06 (0.99 to 1.12) |
| 55–64 years | 72 (16) | 11 719 994 | 0.61 | 1.90 (1.81 to 1.98) |
| 65+years | 36 (8) | 3 995 572 | 0.90 | 2.78 (2.67 to 2.89) |
| Race and ethnicity | | | | |
| Non-Hispanic white | 289 (63) | 79 850 257 | 0.36 | 1.0 |
| Non-Hispanic black | 106 (23) | 20 169 998 | 0.53 | 1.45 (1.16 to 1.82) |
| Hispanic | 31 (6) | 4 424 975 | 0.70 | 1.94 (0.95 to 3.96) |
| Non-Hispanic, non-white, non-black | 30 (7) | 5 019 200 | 0.60 | 1.65 (1.07 to 2.56) |
| Native American* | 5 | – | – | |
| Asian* | 25 | – | – | |
| Class of worker | | | | |
| Privately employed | 263 (58) | 82 352 763 | 0.32 | 1.0 |
| Government employed | 56 (12) | 15 926 684 | 0.35 | 1.10 (0.81 to 1.50) |
| Self employed | 137 (30) | 11 184 983 | 1.22 | 3.8 (3.17 to 4.64) |

*Population estimates for the denominator (worker-years) were not available for Native American, Asian individuals.

### Homicide by industry

The occupational homicide rate experienced in the taxi industry (crude: 39.7 per 100 000 w-y; industry standardised: 46.12 per 100 000 w-y) was over 110 times (95% CI 76.52 to 160.19) the overall occupational homicide rate in NC (table 2); however, this rate declined markedly over the study period by 76.5% (figure 1). Homicide rates were also relatively high among gasoline service station workers (crude: 18.5 per 100 000 w-y; age standardised: 20.0 per 100 000 w-y; standardised RR 48.0, 95% CI 35.2 to 65.4) and workers in grocery, dairy and food store industries (crude: 3.4 per 100 000 w-y; age standardised: 3.7 per 100 000 w-y; age-standardised RR 8.8, 95% CI 6.9 to 11.3). Gasoline service station workers demonstrated a minimal reduction of occupational homicide rates (12.9%), whereas grocery, dairy and food store workers saw an 88.8% decline over the study time frame (figure 1). Workers 65 years and older experienced a high incidence of occupational homicide in the grocery, dairy and food store industry (5.8 per 100 000 w-y) or in the general retail trade industry (2.79 per 100 000 w-y) (online supplemental table 2). Crude homicide rates among self-employed gasoline service station workers (self-employed: 48.7 per 100 000 w-y; privately employed: 14.8 per 100 000 w-y) and self-employed workers in grocery, dairy and food store industries (self-employed: 28.6 per 100 000 w-y; privately employed: 1.87 per 100 000 w-y) were higher than privately employed workers (online supplemental table 3). Table 2 provides further occupational homicide rate comparisons by industry.

### v–p relationship

Across all industries, most occupational homicides were perpetrated by strangers (252, 55%), followed by customers or clients (12%), personal acquaintances (10%) and coworkers (9%) (online supplemental table 5). This was consistent among the industries with the highest incidence rates (grocery, dairy and food store workers: 59, 79% stranger v–p relationship; gasoline service station workers: 39, 89%) with the exception of taxi drivers where customers or clients were most common (11, 37%), followed by strangers (10, 33%) (online supplemental table 5). In approximately 13% of occupational homicides, there was insufficient information to classify the victim-perpetrator relationship.

## DISCUSSION

In NC between 1992 and 2017, occupational homicide rates declined from 0.82 per 100 000 w-y in 1992–1995 to 0.21 per 100 000 w-y during 2011–2015, before an upwards trend was observed, increasing to 0.32 per 100 000 w-y during 2016–2017. Despite this decline, individuals employed in the taxi, gas station, grocery, dairy and food store industries are still experiencing high rates of homicides compared with combined industry rates. Workers over the age of 65 years old and racially and ethnically minoritised workers, had the highest rates of occupational homicides. Further disparities are noted among self-employed workers, particularly workers employed in the gas station, and

**Table 2** Incidence of homicide by industry

| Industry | n | Worker-years (w-y) | Crude rate | Standardised rate (95% CI) | Standardised RR (95% CI) |
|---|---|---|---|---|---|
| Grocery, dairy and food stores—retail | 75 | 2 204 413 | 3.4 | 3.68 (2.81 to 4.54) | 8.82 (6.91 to 11.27) |
| Eating and drinking places—retail | 56 | 4 724 083 | 1.19 | 1.61 (1.15 to 2.07) | 3.87 (2.93 to 5.11) |
| Justice, public order and Safety | 47 | 1 936 155 | 2.43 | 2.61 (1.80 to 3.43) | 6.28 (4.65 to 8.48) |
| General retail trade | 46 | 8 016 534 | 0.57 | 0.54 (0.38 to 0.70) | 1.3 (0.96 to 1.76) |
| Gasoline service stations—retail | 44 | 238 521 | 18.45 | 19.99 (13.93 to 26.06) | 48 (35.23 to 65.40) |
| Transport—taxi | 30 | 75 555 | 39.71 | 46.12 (28.64 to 63.61) | 110.71 (76.52 to 160.19) |
| Finance, insurance and real estate | 21 | 6 374 051 | 0.33 | 0.34 (0.19 to 0.46) | 0.81 (0.53 to 1.26) |
| Construction | 12 | 9 283 708 | 0.13 | 0.13 (0.06 to 0.21) | 0.31 (0.18 to 0.56) |
| Auto sales and services—retail and repair | 12 | 2 265 559 | 0.53 | 0.52 (0.22 to 0.82) | 1.25 (0.71 to 2.22) |
| Personal services | 11 | 2 094 897 | 0.53 | 0.57 (0.23 to 0.90) | 1.36 (0.78 to 2.47) |
| Professional and related services | 11 | 27 125 926 | 0.04 | 0.04 (0.02 to 0.07) | 0.1 (0.05 to 0.18) |
| Wholesale trade | 9 | 3 595 792 | 0.25 | 0.24 (0.08 to 0.40) | 0.58 (0.30 to 1.13) |
| Entertainment and recreation services | 9 | 1 174 008 | 0.77 | 0.98 (0.32 to 1.64) | 2.34 (1.21 to 4.53) |
| Lodging services | 8 | 943 037 | 0.85 | 0.98 (0.29 to 1.66) | 2.34 (1.16 to 4.71) |
| Business and repair services | 7 | 4 026 242 | 0.17 | 0.17 (0.04 to 0.30) | 0.41 (0.19 to 0.86) |
| Warehouse, storage and transport services | 6 | 816 021 | 0.74 | 0.75 (0.15 to 1.35) | 1.8 (0.80 to 4.03) |
| Agriculture | 5 | 1 218 537 | 0.41 | 0.43 (0.05 to 0.81) | 1.04 (0.43 to 2.51) |
| Printing and publishing | 5 | 1 061 344 | 0.47 | 0.48 (0.05 to 0.91) | 1.15 (0.48 to 2.78) |
| Detective and protective services | 5 | 387 203 | 1.29 | 1.38 (0.16 to 2.59) | 3.31 (1.37 to 7.98) |

Age-standardised RR=select industry standardised RR/standardised RR combined industries.
*Agriculture services, fishing, hunting and trapping, mining and oil, tobacco manufactures, apparel and finished rextile prod-MFG, paper and allied prod-MFG, sawmills planing and misc wood prod-MFG, wood buildings and mobile homes—MFG, primary metal-MFG, computer, medical, electronic, equipment-MFG, transport-railroad, water, air, auto repair and related services: 0 occupational homicides over 9 493 493 w-y.
MFG, manufacturing; Misc, miscellaneous; Prod, production; RR, rate ratio.

grocery, dairy, and food store industries compared with privately employed workers in the same industry.

## Overall homicide trends

Previous findings of occupational homicide rates in NC demonstrated 0.83 homicides per 100 000 w-y between 1977 and 1991.[1] This is similar to the incidence rate noted between 1992 and 1995 (0.81 per 100 000 w-y), but by 2011–2015, occupational homicide rates reached the lowest observed rate at 0.21 per 100 000 w-y. Similar trends were observed nationally by the Bureau of Justice Statistics, which observed the period 1992–2019 and reported that peak occupational homicide rates occurred in 1994 with 1080 homicides, but dropped 58% by 2019.[14] However, the current study demonstrated a slight increase in occupational homicides during 2016–2017, similar to national trends that have found an 11% increase in occupational

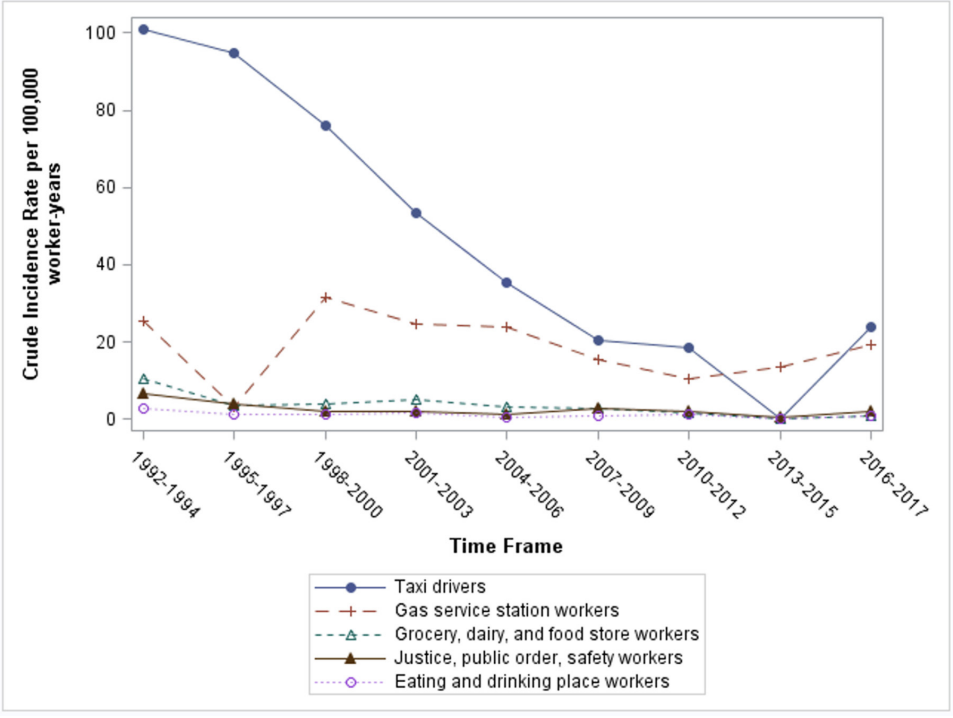


**Figure 1** Occupational homicide mortality trends among top five most vulnerable industries.

homicides from 2014 to 2019.[14] Firearm use continues to be the lethal weapon used in more than 80% of occupational homicides with over half of these crimes committed by a stranger. Previous literature suggests that workplace homicides with a firearm have increased 16.4% between 2014 and 2015, and an additional 11.4% between 2015 and 2016.[8] These workplace homicides committed by a stranger may be the result of robberies.[8] Additionally, a 21% budget reduction for the Department of Labor in 2017, and the elimination of OSHA's worker safety and health training program in March 2017 was observed.[8] Furthermore, the general public's access to firearms has increased since the mid-1990s.[8] From 1994 to 1998, employers in NC that permitted employees to carry a firearm demonstrated five times the odds of an occupational homicide event.[15] Other potential contributors that have been documented include increased substance use,[16] and economic challenges contributing to income inequality.[17] Thus, the combination of budgetary cuts for health and worker safety, increased access to firearms, substance use and economic challenges may in part explain the increase in occupational homicide during the 2016–2017 time frame. Due to these factors, continued monitoring is needed to determine if occupational homicides trend down or will continue to rise to inform policy.

### Homicide rate by industry

Although an overall decline in occupational homicides was noted across the study time frame, disparities between industries persisted. Taxi drivers experienced a lower crude (39.7 per 100 000 w-y) and standardised (46.12 per 100 000 w-y) rate of occupational homicide compared with previous reported incidence rates between 1979 and 1991 (66.1 per 100 000 w-y),[1] but still experience 110 times the rate of homicides compared with all industries in NC. However, this rate declined by 76.5% over the study time frame. Similar nationwide declines were observed between 1993 and 2002.[3] NIOSH and OSHA have provided non-mandatory recommendations to minimise homicides among taxi drivers, including maintaining a well-lit interior, removing unneeded signage, minimising cash exchange, and bullet-resistant barrier and camera installation.[18] Previous studies that investigated camera system installation mandates saw a significant reduction in homicides.[19] Although NC does not have any laws mandating the use of a camera system,[20] individual taxi companies[21] and local municipalities[22] adopted camera systems during the study time frame, which may have influenced the decline, along with possible adoption of NIOSH And OSHA recommendations.

Gas station worker homicide rates remain elevated compared with previous national estimates between 1980 and 1989, (1980–1989: 5.56 per 100 000 w-y; 1991–2017: 20.0 per 100 000 w-y).[23] In contrast, although grocery, dairy and food store workers are vulnerable to homicides, the rate appears to be declined by 88.8% over the study time frame. In both industries, 79%–89% of homicides were committed by strangers, despite declines in homicides committed by a stranger in previous literature across aggregate industry data.[3] Self-employed persons in these industries are at a higher risk of violent crime.[24] Other risk factors identified in this worker population include limited entrance visibility, cash availability, violent incident history, and no bullet-resistant shielding, security cameras, or robbery prevention employee training.[24 25] Compared with larger, privately owned businesses, self-employed businesses may have less access to prevention programmes and suffer larger personal financial losses when violent acts occur. However, intervention programmes aimed at self-employed liquor stores in California that addressed these risk factors demonstrated a 20%–87.1% reduction of all types of crime pre–post intervention.[25] Other interventions that have led to a reduction in crime include de-escalation training for employees, increased visibility of storefronts and surveillance camera installation.[26] Given higher stranger-perpetrated homicide rates among self-employed workers in the gas station and grocery, food, and dairy store industries, researchers and policy-makers should consider the aforementioned strategies that target these subsectors of workers.

### Occupational homicide and age

Workers 65 years or older demonstrated the highest rate of occupational homicide by age group. Previous literature has demonstrated a higher occurrence of injuries among older workers across various industries.[27 28] Although this group makes up a small proportion of the working population, these workers may be more vulnerable to workplace violence.[27 28] The proportion of older workers have gradually increased overtime in NC.[29] Older workers who experienced negative financial implications (ie, shifting industries from previous trades, applying for a secondary job due to financial losses) may be predisposed to workplace violence with re-entry into the workplace. Furthermore, the older workers may enter industries that are vulnerable to occupational homicides.[27 28] In particular, this study demonstrated a high rate of occupational homicide among grocery, dairy and food store workers (5.8 per 100 000 w-y). Continued data monitoring is needed to determine if the current industry trends continue, or if further age disparities across other industries arise.

### Occupational homicide and race, ethnicity

Racially and ethnically minoritised workers, particularly Hispanic workers, experienced the highest rate of occupational homicide, with nearly two times the rate of homicide compared with non-Hispanic white workers. Black and Hispanic individuals have historically worked in riskier work environments, with higher rates of fatal occupational injury in NC from 2000 to 2017.[30] Similarly, the US Bureau of Labor Statistics found that Hispanic and black workers have the highest fatality rates compared with non-Hispanic white workers.[31–33] These workplace deaths most commonly occur among jobs deemed to be the most physically demanding, such as construction and agriculture.[30 31] However, these physically demanding jobs were not among the industries most vulnerable to occupational homicides. Yet, Hispanic workers were still more vulnerable to homicides on the job compared with non-Hispanic white workers. Similarly, non-Hispanic black workers, and those representing minoritised racial groups had higher workplace homicide rates than non-Hispanic whites in NC. Future research is needed to determine which specific industries demonstrate racial disparities to better target prevention policies among racial minority groups.

### Limitations

Our study has limitations. First, this surveillance data are limited to information abstracted from administrative data, and therefore, cannot be used to make inferences about multiple factors that may contribute to occupational homicide risk (ie, employee access to firearms). Second, documentation bias may be present in the ME's documentation of race and ethnicity.[34] Those from minoritised racial and ethnic backgrounds may

be under-represented or misclassified. Third, due to the low numbers of homicides across industries (ie, less than five homicides), some industries, age groups, and races and ethnicities by industry strata were not reported to ensure deidentification is maintained. Fourth, for the strata of industry where low numbers of occupational homicide occurred with large census estimates, wide CIs were observed. CIs were estimated using standardised methods for observational studies, but these methods are based on methods that assume a probability sample, such as simple random sampling. Our population count data represent a full census of workers, but out counts of observed homicides come from a separate source (OCME system). Thus, the statistical imprecision in these estimates does not reflect uncertainty in the number of occupational homicides observed.

## CONCLUSION

This study documented that occupational homicide rates declined between 1992 and 2017, though an increase was noted in the 2016–2017 time frame. This increase from 2016 to 2017 suggests further monitoring is needed as policy around firearms, substance use and economic factors evolve. Specific industries and worker demographics, including self-employed, older and racialised minority workers, experienced high occupational homicide fatality rates compared with privately employed, non-Hispanic white and younger counterparts. Targeted and tailored mitigation strategies among vulnerable workers are recommended.

**Author affiliations**
[1]Department of Epidemiology, Gillings School of Global Public Health, UNC-Chapel Hill, Chapel Hill, North Carolina, USA
[2]Injury Prevention Research Center, The University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA
[3]Susan and Henry Samueli College of Health Sciences, University of California Irvine, Irvine, California, USA
[4]National Foundation for the Centers for Disease Control and Prevention Inc, Atlanta, Georgia, USA
[5]University of North Carolina Injury Prevention Research Center, Chapel Hill, North Carolina, USA
[6]Department of Epidemiology, Gillings School of Global Public Health, The University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA
[7]Epidemiology, UNC Gillings School of Global Public Health, Chapel Hill, North Carolina, USA
[8]Injury Prevention Research Center, The University of North Carolina at Chapel Hill Injury Prevention Research Center, Chapel Hill, North Carolina, USA
[9]Epidemiology, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA

**Acknowledgements** This study was supported by award R01 OH011256-01A1 from the National Institute for Occupational Safety and Health. The University of North Carolina Injury Prevention Research Center is partially supported by award R49/CE002479 from the National Center for Injury Prevention and Control, Centers for Disease Control and Prevention.The authors would like to thank the Office of the Chief Medical Examiner, the North Carolina Department of Health and Human Services and the State Center for Health Statistics for providing mortality data.

**Contributors** CLM is the guarantor. CLM: Conceptualization, methodology, formal analysis, investigation, writing. MR: Methodology, investigation, writing. DBR: Conceptualization, methodology, investigation, project administration, funding acquisition, writing, resources, supervision. MN: Conceptualization, methodology, visualization, project administration, funding acquisition, writing. JC: Conceptualization, investigation, data management, formal analysis. ESM: Conceptualization, methodology, formal analysis, investigation, writing. ATM: Conceptualization, methodology, investigation, writing. SWM: Conceptualization, methodology, investigation, project administration, funding acquisition, writing, resources. SIR: Conceptualization, methodology, investigation, project administration, funding acquisition, writing, resources, supervision.

**Funding** This study was supported by awards T42 OH008673 and R01 OH011256 from the National Institute for Occupational Safety and Health. The University of North Carolina Injury Prevention Research Center is partially supported by award R49/CE002479 from the National Center for Injury Prevention and Control, Centers for Disease Control and Prevention. Mortality data were provided by the Office of the Chief Medical Examiner, North Carolina Department of Health and Human Services. Author ATM is supported additionally by NIOSH T42OH008673.

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

**Patient consent for publication** Not applicable.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data may be obtained from a third party and are not publicly available. Fatality data may be available from the North Carolina Office of the Chief Medical Examiner (ocme.data.request@dhhs.nc.gov) or from the North Carolina State Center for Health Statistics (SCHS) (schs.info@dhhs.nc.gov).



**ORCID iDs**
Chelsea L Martin http://orcid.org/0000-0002-9152-9000
Stephen W Marshall http://orcid.org/0000-0002-2664-9233
Shabbar Ranapurwala http://orcid.org/0000-0002-3944-3912

## REFERENCES

1 Moracco KE, Runyan CW, Loomis DP, *et al*. Killed on the clock: a population-based study of workplace homicide, 1977–1991. *Am J Ind Med* 2000;37:629–36.
2 Office of Justice Programs. Breaking point: the workplace violence epidemic and what to do about it. Available: https://www.ojp.gov/ncjrs/virtual-library/abstracts/breaking-point-workplace-violence-epidemic-and-what-do-about-it [Accessed 18 Mar 2023].
3 Hendricks SA, Jenkins EL, Anderson KR. Trends in workplace homicides in the U.S., 1993-2002: a decade of decline. *Am J Ind Med* 2007;50:316–25.
4 Homicides and other workplace assaults by gender in 2019: the economics daily: U.S. Bureau of labor statistics. Available: https://www.bls.gov/opub/ted/2021/homicides-and-other-workplace-assaults-by-gender-in-2019.htm [Accessed 18 Mar 2023].
5 Census of Fatal Occupational Injuries (CFOI). Current and revised data: U.S. Bureau of labor statistics. Available: https://www.bls.gov/iif/fatal-injuries-tables.htm [Accessed 18 Mar 2023].
6 Mirabelli MC, Loomis D, Richardson DB. Fatal occupational injuries among self-employed workers in North Carolina. *Am J Ind Med* 2003;44:182–90.
7 Loomis D, Richardson D. Race and the risk of fatal injury at work. *Am J Public Health* 1998;88:40–4.
8 Doucette ML, Bulzacchelli MT, Frattaroli S, *et al*. Workplace homicides committed by firearm: recent trends and narrative text analysis. *Inj Epidemiol* 2019;6:5.
9 North Carolina population by year, county, race, & more | Usafacts. Available: https://usafacts.org/data/topics/people-society/population-and-demographics/our-changing-population/state/north-carolina?endDate=2020-01-01&startDate=1990-01-01 [Accessed 18 Mar 2023].
10 Bonham VL, Green ED, Pérez-Stable EJ. Examining how race, ethnicity, and ancestry data are used in biomedical research. *JAMA* 2018;320:1533–4.
11 IPUMS USA | 2000 occupation codes (OCC). Available: https://usa.ipums.org/usa/volii/occ2000.shtml [Accessed 08 May 2023].
12 Workplace violence prevention strategies and research needs. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health; 2006.
13 Elm E von, Altman DG, Egger M, *et al*. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ* 2007;335:806–8.
14 Office of Justice Programs. Archived | joint study on workplace violence. Available: https://www.ojp.gov/files/archives/pressreleases/2022/joint-study-workplace-violence [Accessed 15 Mar 2023].
15 Loomis D, Marshall SW, Ta ML. Employer policies toward guns and the risk of homicide in the workplace. *Am J Public Health* 2005;95:830–2.
16 Trends in substance use disorders among adults aged 18 or older. Available: https://www.samhsa.gov/data/sites/default/files/report_2790/ShortReport-2790.html [Accessed 16 May 2023].
17 Williams KR. Economic sources of Homicide: reestimating the effects of poverty and inequality. *Am Sociol Rev* 1984;49:283–9.

18 NIOSH fast facts: taxi drivers - how to prevent robbery and violence. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health; 2019.
19 Menéndez CC, Amandus H, Damadi P, *et al*. Cities with camera-equipped taxicabs experience reduced taxicab driver homicide rates: United States, 1996-2010. *Crime Sci* 2014;3:4.
20 SECTION 1. Chapter 20 of the general statutes is amended by adding a new;
21 WSOC TV. Charlotte taxi company installs video cameras inside cabs. Available: https://www.wsoctv.com/news/local/charlotte-taxi-company-installs-video-cameras-insi/335035408/ [Accessed 16 Mar 2023].
22 Raleigh cab drivers face changes. Available: https://www.wral.com/news/local/story/6359313/ [Accessed 16 Mar 2023].
23 Castillo DN, Jenkins EL. Industries and occupations at high risk for work-related homicide. *J Occup Med* 1994;36:125–32.
24 Hendricks SA, Landsittel DP, Amandus HE, *et al*. A matched case-control study of convenience store robbery risk factors. *J Occup Environ Med* 1999;41:995–1004.
25 Casteel C, Peek-Asa C, Howard J, *et al*. Effectiveness of crime prevention through environmental design in reducing criminal activity in liquor stores: a pilot study. *J Occup Environ Med* 2004;46:450–8.
26 Davis J, Casteel C, Menéndez CC. Impact of a crime prevention ordinance for small retail establishments. *Am J Ind Med* 2021;64:488–95.
27 Jeong BY. Occupational deaths and injuries in the construction industry. *Appl Ergon* 1998;29:355–60.
28 Chi C-F, Wu M-L. Fatal occupational injuries in Taiwan — relationship between fatality rate and age. *Saf Sci* 1997;27:1–17.
29 Richey MM, Golightly Y, Marshall SW, *et al*. Trends in fatal occupational injury rates among older workers before and after the great recession of 2008. *Occup Environ Med* 2023;80:154–9.
30 Richey MM, Golightly Y, Marshall SW, *et al*. Trends in fatal occupational injuries in Latino/a workers relative to other groups, North Carolina 2000-2017. *Am J Ind Med* 2022;65:242–7.
31 Census of fatal occupational injuries summary, 2021 - 2021 A01 results. Available: https://www.bls.gov/news.release/cfoi.nr0.htm [Accessed 31 Mar 2023].
32 Orrenius PM, Zavodny M. Do immigrants work in riskier jobs *Demography* 2009;46:535–51.
33 Richardson DB, Loomis D, Bena J, *et al*. Fatal occupational injury rates in southern and non-Southern states, by race and Hispanic Ethnicity. *Am J Public Health* 2004;94:1756–61.
34 McClure ES, Gartner DR, Bell RA, *et al*. Challenges with misclassification of American Indian/Alaska native race and hispanic ethnicity on death records in North Carolina occupational fatalities surveillance. *Front Epidemiol* 2022;2.