Original research

Fatal occupational injuries in North Carolina, 1992–2017

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ABSTRACT

Objectives After declining for several decades, fatal occupational injury rates have stagnated in the USA since 2009. To revive advancements in workplace safety, interventions targeting at-risk worker groups must be implemented. Our study aims to identify these at-risk populations by evaluating disparities in unintentional occupational fatalities occurring in North Carolina (NC) from 1992 to 2017.

Methods Our retrospective cohort study drew on both the NC Office of the Chief Medical Examiner system and the NC death certificate data system to identify unintentional fatal occupational injuries occurring from 1992 to 2017. Unintentional fatal occupational injury rates were reported across industries, occupations and demographic groups, and rate ratios were calculated to assess disparities.

Results Among those aged 18 and older, 2645 unintentional fatal occupational injuries were identified. Fatal occupational injury rates declined by 0.82 injuries/100 000 person-years over this period, falling consistently from 2004 to 2009 and increasing from 2009 to 2017. Fatal injury rates were highest among Hispanic workers, who experienced 2.75 times the fatal injury rate of non-Hispanic White workers (95% CI 2.42 to 3.11) and self-employed workers, who experienced 1.44 times the fatal injury rate of private workers (95% CI 1.29 to 1.60). We also observed that fatal injury rates increased with age group and were higher among male relative to female workers even after adjustment for differential distributions across occupations.

Conclusions The decline in unintentional fatal occupational injury rates over this period is encouraging, but the increase in injury rate after 2009 and the large disparities between occupations, industries and demographic groups highlight the need for additional targeted safety interventions.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ North Carolina has experienced dramatic economic and demographic transitions over the last 25 years, and it is not known how these transitions have impacted fatal occupational injury distributions across industries, occupations and populations, hindering the implementation of targeted safety interventions.

WHAT THIS STUDY ADDS

⇒ This study found that in North Carolina unintentional fatal occupational injury rates were highest within the Hispanic workforce relative to both the non-Hispanic white and non-Hispanic black workforces, even after adjustment for differential age and occupational distributions. Self-employed workers were found to be at higher risk for occupational fatal injury relative to private and government workers, in part because self-employed workers were on average older and employed in more dangerous occupations than the overall workforce. Additionally, the greatest fatal injury burden was attributable to the construction, transport, agriculture and forestry and logging industries and occupations.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The results of this study can be used to efficiently implement safety interventions targeting workforce groups at high risk for occupational fatal injury, thereby reducing occupational mortality and improving worker health.

INTRODUCTION

Occupational injuries place a substantial burden on public health in the USA. According to the Bureau of Labor Statistics (BLS), about 2.8 million occupational injuries were reported among US workers in 2021, of which 5190 were fatal.[1 2] While the rate of non-fatal occupational injury in the USA has declined steadily over the last 10 years, the rate of fatal occupational injury has remained relatively consistent since 2009, suggesting that the efficacy of occupational safety initiatives may have stagnated in recent years.[1–7] For example, this lack of progress may indicate that current safety efforts do not adequately address the needs of older workers, who have been shown to be at high risk for fatal injury and who make up an increasing portion of the US workforce.[8–10] Fatal injury trends within the construction and agriculture industries are also of particular concern, as workers in these fields have been found to be at high risk for fatal injury both globally and in the USA.[11–16] In the USA, self-employed and Hispanic workers have also been shown to be at increased risk for occupational fatal injury.[8 12 17] As the US' economy transitions and workforce expands, ages and diversifies, it is vital to benchmark fatal occupational injury rates and document the disparities therein to identify high-risk populations and facilitate the allocation of resources towards at-risk workforce groups.

We focus on unintentional fatal occupational injury rates in North Carolina (NC), which in 2021

had the ninth largest workforce and the sixth highest number of occupational fatal injuries in the nation.[18 19] This study reports on the epidemiology of fatal occupational injury in NC from 1992 to 2017, focusing on unintentional injury deaths, with the goal of identifying areas for research and injury prevention. This study builds on a prior study carried out by our team, examining occupational fatal injury disparities and trends in NC from 1977 to 1991.[20]

METHODS

The NC Medical Examiner system retrieves, codes and reports data maintained by the Office of the Chief Medical Examiner (OCME). The OCME obtains fatal injury data from local medical examiners (MEs) in each of the counties in NC. All injury-related deaths in NC are investigated by the OCME. Each ME determines the causes of and circumstances surrounding deaths in their jurisdiction, including whether the injuries that led to death occurred at work. The NC ME system has previously been shown to be a reliable source of occupational injury and fatality data for epidemiological studies.[21–24]

Data on occupational deaths occurring in NC between 1 January 1992 and 31 December 2017 were collected using the NC ME system and the NC State Center for Health Statistics (SCHS) death certificate data system. An occupational fatal injury was defined as any injury leading to death within 30 days that was sustained by an individual in NC engaged in legal work for pay or engaged in work for their personal or family-owned business. Military deaths were excluded from this analysis as these deaths are incompletely reported to the OCME. This report is restricted to unintentional fatal injuries, meaning that the manner of death was determined to be an 'accident'. Homicides, suicides and fatalities for which the manner of death was undetermined, were not included.

Deaths during the study period that were flagged as 'at work' in the SCHS death certificate data system or 'on the job' in the OCME data system were eligible for inclusion. Data were abstracted from the OCME records, including the ME reports, official death certificates, autopsy results and toxicology results. A review of the circumstances surrounding each death was then conducted. Complex cases, defined as cases in which there was discordance between the 'at work' flag on the death certificate and the 'on the job' flag in the OCME record, were adjudicated by trained investigators using information abstracted from supplemental sources, such as family interviews, witness and police statements, news clippings, court transcripts and crime scene reports, to make a final determination of 'at work status' for purposes of inclusion.

Information on the means of death, age, sex, race and ethnicity of decedents was abstracted from the death certificate and the ME report. Race was coded as 'white', 'black', 'American Indian or Alaska Native' (AI/AN), 'Asian and Pacific Islander' (API), and 'other race', and ethnicity was categorised as 'Hispanic' or 'non-Hispanic'. In analyses stratified by race and ethnicity, decedents were grouped as 'Hispanic', 'non-Hispanic white', and 'non-Hispanic black'. Non-Hispanic decedents who were classified as 'AI/AN', 'API' and 'other race' were excluded from race and ethnicity-stratified analyses due to limitations in workforce estimate data. Causes of injury were examined using information on the means of death, which was assigned by the ME using International Classification of Diseases, 9th revision (ICD-9) and 10th revision (ICD-10) codes. Information on occupation and industry at time of fatal injury was abstracted from the ME report and coded to align with US Census industry and occupation groups using the National Institute for Occupational Safety and Health (NIOSH) Industry and Occupation Computerised Coding System.[25]

Estimates of workforce size stratified by age, sex, race/ethnicity, class of worker, occupation and industry were derived from the 1990, 2000 and 2010 decennial US censuses of the population; worker populations in intercensal years were estimated by linear interpolation and extrapolation methods that assumed within-stratum linear changes in labour force participation between each decennial census.[26] The observed deaths and population data were used to estimate rates of fatal occupational injury per 100 000 person-years.

We calculated and plotted the overall fatal injury rate for each year in the study period and smoothed the data using a locally weighted scatterplot smoothing curve. We examined fatal occupational injury rates by age, sex, race/ethnicity, class of worker, occupation and industry, calculating crude, occupation-adjusted and age-adjusted fatal injury rates for each of these groups. Occupation-adjusted rates were calculated to determine to what extent disparities were attributable to differential workforce distribution in high-risk occupations. Occupation-adjusted rates were derived by standardising rates to the occupation distribution of the total NC workforce over the study period. Age-adjusted rates were derived by standardising rates to the age distribution of the total NC workforce over the study period. Rate ratios (RRs) and 95% CIs were calculated to compare rates between different demographic groups. Population attributable risks (PARs) for each occupation and industry were calculated to determine the absolute fatal injury burden contributed by each occupation and industry, respectively.[27]

RESULTS

During the study period, 2663 civilian deaths from unintentional occupational injuries were identified. Eighteen of these fatal injuries occurred among workers younger than 18 years of age, with the youngest decedent being 14 years of age. For fatal injuries among these younger workers, the leading industries were agriculture and construction, and the leading occupations were farm worker and construction worker. The leading means of death were machinery-related accidents, followed by falls/jumps and motor vehicle (MV) accidents. The remainder of this analysis focuses on the 2645 decedents aged 18 years and older, due to a lack of workforce estimate data for workers under 18 years of age (table 1).

The average NC fatal injury rate for workers aged 18+ years over the period 1992–2017 was 2.42 injuries/100 000 person-years. From 1992 to 2017, the overall fatal injury rate declined by 0.82 injuries/100 000 person-years. Over this period, the average annual fatal injury rate remained relatively stable from 1992 to 2004, declined from 2004 to 2009 and subsequently increased from 2009 to 2017 (figure 1). Over the study period, the estimated size of the NC workforce increased by 64% (online supplemental table 3). Fatal occupational injury rates increased consistently with age (table 2). Relative to individuals aged 18–24 years, the fatal injury rate among those aged 65–74 was 3.41 times as high (95% CI 2.79 to 4.17), and the rate among those aged 75+ was 6.06 times as high (95% CI 4.68 to 7.85).

The largest number of fatal injuries occurred in the construction occupation, followed by the MV transport and farm worker occupations (table 3, online supplemental table 1). The occupations with the highest fatal injury rates were the forestry and logging, fishing, hunting, and trapping, extractive, rail transport, and farm worker occupations (table 3). Fatal injury rates

Table 1 Descriptive characteristics of occupational fatality decedents in NC (1992–2017)

	Fatal injuries	%	Person-years
Sex			
Male	2541	96.07	58 257 437
Female	104	3.93	51 207 119
Age			
18–24 years	217	8.20	13 575 204
25–34 years	531	20.08	25 579 317
35–44 years	623	23.55	29 157 885
45–54 years	583	22.04	25 436 534
55–64 years	439	16.60	11 720 011
65–74 years	174	6.58	3 190 334
75+ years	78	2.95	805 271
Race and ethnicity			
Hispanic	280	10.59	4 424 999
NH white	1840	69.57	79 850 325
NH black	466	17.62	20 170 017
NH American Indian or Alaska Native	34	1.29	
NH Asian and Pacific Islander	23	0.87	
NH other race	2	0.08	
Class of work			
Self employed	399	15.09	11 185 004
Privately employed	2044	77.28	82 352 858
Government employed	202	7.64	15 926 694
Total	2645		109 464 556

NC, North Carolina; NH, non-Hispanic.

were low in the precision woodworking, food preparation and services, health services, other services, and sales and administrative support occupations.

The MV transport occupation had the highest PAR (17.34%), reflecting the moderately high fatal injury rate and large number of workers in this occupation (table 3). Additionally, high PARs were associated with the construction (17.01%), farm worker (6.40%), other agricultural (5.06%), and forestry and logging (5.00%) occupations. The managerial and professional specialty occupation had the lowest PAR (−29.55%), followed by the sales and administrative support occupation (−25.76%), indicating that the low fatal injury rates in these occupations contributed to reducing the state's overall average fatal injury rate.

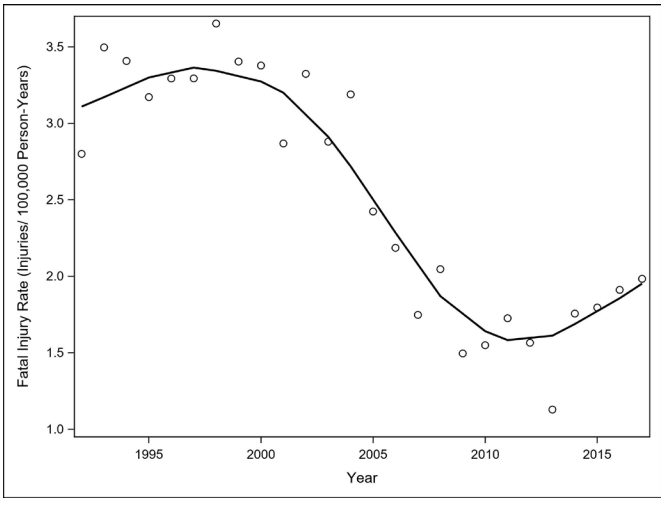

Figure 1 Overall fatal injury rate trend in North Carolina (1992–2017). Fatal injury rates in North Carolina were calculated for each year between 1992 and 2017. The data were smoothed using a LOWESS curve. LOWESS, locally weighted scatterplot smoothing.

When examined by industry, the largest number of unintentional fatal injuries occurred in the construction industry, followed by the bus, trolley and truck transport industry and agriculture industry (table 4, online supplemental table 2). The highest crude unintentional fatal injury rates were observed in the forestry and logging, fishing, hunting, and trapping, agriculture, agricultural services, and bus, trolley, and truck transport industries.

The construction industry had the highest PAR (20.44%), reflecting the moderately high death rate and large number of workers in this industry (table 4). Additionally, high PARs were associated with the bus, trolley, and truck transport (8.83%), agriculture (7.06%), agricultural services (5.22%), and forestry and logging (5.11%) industries. The professional and related services industry had the lowest PAR (−29.28%), indicating that the low fatal injury rate in this industry contributed to reducing the state's overall average fatal injury rate.

Most unintentional occupational fatal injuries occurred among workers employed in the private sector (table 1). However, the average fatal injury rate was highest among self-employed workers relative to private and civilian government workers (table 2). Relative to private workers, the fatal injury rate among self-employed workers was 1.44 times as high (95% CI 1.29 to 1.60) and the rate among government workers was 0.51 times as high (95% CI 0.44 to 0.59). The age-adjusted fatal injury rate among self-employed workers was 1.13 times that among private workers (95% CI 1.00 to 1.27), and the occupation-adjusted fatal injury rate among self-employed workers was 0.95 times that among private workers (95% CI 0.82 to 1.09). While age and occupation-adjustment substantially shifted injury rates among self-employed workers, crude and adjusted rates for private and government workers remained relatively consistent.

Among men, the crude fatal injury rate was 4.36/100 000 person-years; among women, the crude fatal injury rate was 0.20/100 000 person-years (table 2). After adjusting for age, the relative rate comparing men to women was 21.26 (95% CI 17.47 to 25.87). After adjusting for occupation, the fatal injury rate among men was 7.66 times the rate of women (95% CI 5.69 to 10.33).

Most fatal occupational injuries occurred among non-Hispanic white workers (1840 deaths), followed by non-Hispanic black workers (466 deaths) and Hispanic workers (280 deaths) (table 1). The crude fatal injury rate was 6.33/100 000 person-years among Hispanic workers, 2.31/100 000 person-years among non-Hispanic black workers and 2.30/100 000 person-years among non-Hispanic white workers (table 2). The crude fatal injury rate among Hispanic workers was 2.75 times that of non-Hispanic white workers (95% CI 2.42 to 3.11) and the crude fatal injury rate among non-Hispanic black workers was 1.00 times that of non-Hispanic white workers (95% CI 0.91 to 1.11). The age-adjusted fatal injury rate among Hispanic workers was 3.96 times that of non-Hispanic white workers (95% CI 3.36 to 4.66) and the occupation-adjusted fatal injury rate among Hispanic workers was 1.40 times that of non-Hispanic white workers (95% CI 1.15 to 1.71). While age and occupation-adjustment substantially shifted injury rates among Hispanic workers, crude and adjusted rates for non-Hispanic white and black workers remained relatively consistent.

Table 2 Occupational fatal injury rates by demographic groups (NC, 1992–2017)

	N	Crude rate*	Age-adj. rate*	Occ.-adj. rate*	Crude RR (95% CI)†	Age-adj. RR (95% CI)†	Occ.-adj. RR (95% CI)†
Overall	2645	2.42					
Sex							
Male	2541	4.36	4.34	3.05	21.48 (17.65 to 26.13)	21.26 (17.47 to 25.87)	7.66 (5.69 to 10.33)
Female	104	0.20	0.20	0.40	Ref.	Ref.	Ref.
Race/ethnicity							
Hispanic	280	6.33	8.93	3.40	2.75 (2.42 to 3.11)	3.96 (3.36 to 4.66)	1.40 (1.15 to 1.71)
NH white	1840	2.30	2.26	2.43	Ref.	Ref.	Ref.
NH black	466	2.31	2.42	2.38	1.00 (0.91 to 1.11)	1.07 (0.97 to 1.19)	0.98 (0.88 to 1.10)
Class of work							
Self employed	399	3.57	2.87	2.44	1.44 (1.29 to 1.60)	1.13 (1.00 to 1.27)	0.95 (0.82 to 1.09)
Privately employed	2044	2.48	2.54	2.58	Ref.	Ref.	Ref.
Government employed	202	1.27	1.31	1.46	0.51 (0.44 to 0.59)	0.52 (0.45 to 0.60)	0.57 (0.47 to 0.69)
Age group							
18–24	217	1.60		1.56	Ref.		Ref.
25–34	531	2.08		2.00	1.30 (1.11 to 1.52)		1.28 (1.09 to 1.51)
35–44	623	2.14		2.13	1.34 (1.15 to 1.56)		1.36 (1.16 to 1.60)
45–54	583	2.29		2.52	1.43 (1.23 to 1.68)		1.61 (1.37 to 1.90)
55–64	439	3.75		3.86	2.34 (1.99 to 2.76)		2.47 (2.09 to 2.94)
65–74	174	5.45		4.78	3.41 (2.79 to 4.17)		3.06 (2.46 to 3.81)
75+	78	9.69		8.89	6.06 (4.68 to 7.85)		5.70 (4.09 to 7.94)

*Fatal injuries/100 000 person-years.
†RR and 95% CI.
NC, North Carolina; NH, non-Hispanic; RR, rate ratio.

The overall decline in fatal injury rate from 2004 to 2009 and increase from 2009 to 2017 corresponded closely to trends within high-PAR occupations and industries, specifically the construction occupation and industry, the forestry and logging occupation and industry, the MV transport occupation, and the bus, trolley, and truck transport industry (online supplemental table 5). We also found that the overall fatal injury rate decline and subsequent increase paralleled trends within every race/ethnicity group, with the decline from 2004 to 2009 being most pronounce within the Hispanic workforce, and the increase after 2009 being pronounce within both the Hispanic and non-Hispanic black workforces (online supplemental table 6). Similar trends were also observed within all age groups and among all worker classes, most apparently among privately employed workers. These trends were not observed when we restricted to female workers.

Overall, MV accident was the most common means of unintentional occupational fatal injury, accounting for one-third of all injuries. Other leading means of fatal occupational injury included falling/jumping, machinery-related accident, blunt force and electrocution (online supplemental table 4). Rates of fatal MV accidents, machinery-related accidents and electrocutions fell consistently between about 2000 and 2009. Rates of electrocution then stagnated, while fatal MV and machinery-related accident rates increased consistently until 2017. Rates of accidents involving blunt force fell sharply between 2003 and 2006, and then remained relatively consistent until 2017. Rates of fatal injury resulting from falling/jumping did not show substantial change over the period of study.

DISCUSSION

In this surveillance of fatal occupational injuries in NC from 1992 to 2017, we found that the overall fatal injury rate among those aged 18 and older declined by 0.82 injuries/100 000 person-years over this period, but that the fatal injury rate increased from 2009 to 2017. This is consistent with data from the BLS, which show that national fatal occupational injury rates declined steadily between the early 1980s and early 2000s, but have either stagnated or increased since 2009.[2 6 7 28–30] While this recent increase was only observed among men in our study, it was observed consistently across race/ethnicity, class and age groups, suggesting that this trend reversal is indicative of industry and occupation-wide shortcomings in safety that impact a wide range of workers. Rates of fatal injury due to MV and machinery-related accidents increased consistently after 2009, as did fatal injury rates within the construction, forestry and logging, and MV transport industries and occupations. These findings align with literature reporting that, globally, road accidents are the leading means of occupational fatality, and that little progress has been made in recent years to reduce MV transport and machinery-related accidents or to reduce injury rates in the construction industry.[8 11 22 31–34]

We found that fatal injury rates were higher among men than among women and that this disparity was attenuated, but not eliminated, after adjustment for occupation. This may suggest that men are more likely to be employed in high-risk industries and occupations and that, within the same occupations, men generally carry out more dangerous tasks compared with women. This is consistent with literature that indicates that occupation and job-activity segregation remained commonplace over our period of study, with men working in more physically strenuous and dangerous jobs on average compared with women.[35–37] Additionally, this disparity may be indicative of differences between men and women regarding how occupational safety is generally perceived and approached.

Table 3 Occupational fatal injury rates by occupation (NC, 1992–2017)

Occupation	Fatal injuries	Crude rate*	Age-adj. rate*	PAR (%)†
Forestry and logging	137	67.56	70.66	5.00
Fishing, hunting and trapping	40	58.55	61.20	1.45
Extractive	5	23.86	38.54	0.17
Rail transport	10	21.15	21.94	0.34
Farm worker	192	19.05	15.76	6.40
Other material moving equipment operator	61	14.28	14.63	1.92
Other agricultural	162	13.23	14.06	5.06
Motor vehicle transport	545	12.59	12.16	17.34
Water transport	<5	9.76	8.21	0.11
Construction	603	7.90	8.32	17.01
Protective services	96	4.92	4.93	1.88
Material moving equipment (nontruck) operator	<5	4.63	4.85	0.07
Material handlers, helpers and labourers	100	4.22	4.48	1.65
Nonauto machinery mechanic/repairer	45	3.51	3.44	0.54
Auto mechanic/ repairer	47	3.22	3.47	0.45
Other mechanic/ repairer	51	2.92	2.90	0.34
Other machine operator	114	1.84	1.85	–1.43
Woodworking machine operator	18	1.53	1.55	–0.40
Private household and building services	34	1.36	1.27	–1.02
Technicians and related support	40	0.97	0.99	–2.33
Precision metalworking	17	0.86	0.91	–1.19
Other precision production	12	0.80	0.85	–0.92
Managerial and professional specialty	162	0.54	0.56	–29.55
Textile machine operator	10	0.49	0.49	–1.52
Sales and administrative support	118	0.45	0.44	–25.76
Other services	8	0.29	0.31	–2.25
Health services	6	0.24	0.23	–2.08
Food preparation and service	<5	0.09	0.10	–3.86
Precision woodworking	0	0.00	0.00	–0.16
Overall	2645	2.42		

*Fatal injuries/100 000 person-years.
†Population attributable risk percentage.
NC, North Carolina; PAR, population attributable risk.

In this study, fatal injury rates in all age groups from 1992 to 2017 were lower than those reported in NC during the 1977–1991 period.[20] We found that older workers experienced substantially higher fatal injury rates than younger workers, and that the youngest workers had the lowest fatal injury rates.

Table 4 Occupational fatal injury rates by industry (NC, 1992–2017)

Industry	Fatal injuries	Crude rate*	Age adj-Rate*	PAR (%)†
Forestry and logging—manufacturing	140	65.52	64.31	5.11
Fishing, hunting and trapping	40	46.21	51.37	1.43
Agriculture	214	17.56	14.78	7.06
Agricultural services	162	15.51	18.08	5.22
Transport—bus, trolley, truck	282	12.79	12.54	8.83
Transport—taxi	9	11.91	12.05	0.27
Water supply and sanitation utilities	57	9.56	10.73	1.62
Mining and oil	11	7.88	10.04	0.29
Construction	719	7.74	8.05	20.44
Electric, gas pipelines and non-specialised utilities	49	5.80	6.23	1.09
Stone, clay, glass and concrete products—manufacturing	34	5.52	5.86	0.73
Warehouse storage and transport services	43	5.27	5.30	0.89
Transport—railroad, water, air	29	4.78	8.09	0.54
Sawmills, planing and miscellaneous wood products—manufacturing	29	4.53	4.42	0.51
Justice, public order and safety	84	4.34	4.72	1.43
Food and kindred products—manufacturing	49	3.67	3.86	0.64
Miscellaneous—manufacturing	37	3.60	3.76	0.46
Paper and allied products—manufacturing	19	3.28	3.21	0.19
Wholesale trade	95	2.64	2.60	0.32
Wood buildings and mobile homes—manufacturing	6	2.63	2.97	0.02
Primary metal—manufacturing	7	2.28	2.20	–0.02
Auto sales and services—retail and repair	50	2.21	2.27	–0.18
Fabricated metal products—manufacturing	20	1.90	2.28	–0.21
Detective and protective services	7	1.81	1.53	–0.09
Radio, television, phone and miscellaneous communications	26	1.81	1.73	–0.34
Entertainment and recreation services	18	1.53	1.80	–0.40
Rubber, leather and miscellaneous plastic products—manufacturing	15	1.39	1.32	–0.42
Business and repair services	56	1.39	1.45	–1.62
Chemicals and petroleum products—manufacturing	19	1.35	1.33	–0.58
Public administration	41	1.28	1.18	–1.41
Gasoline service stations—retail	3	1.26	1.60	–0.10
Textile mill products—manufacturing	26	1.07	1.07	–1.26
General retail trade	77	0.96	0.93	–4.76
Printing and publishing	10	0.94	0.91	–0.60
Tobacco manufactures	<5	0.90	1.31	–0.19
Machinery and transport equipment—manufacturing	20	0.69	0.75	–1.94
Lodging services	<5	0.42	0.29	–0.72
Personal services	8	0.38	0.36	–1.64
Furniture and fixtures—manufacturing	8	0.37	0.34	–1.73

continued

Table 4 continued

Industry	Fatal injuries	Crude rate*	Age adj-Rate*	PAR (%)†
Grocery, dairy and food stores—retail	7	0.32	0.31	−1.79
Eating and drinking places—retail	13	0.28	0.34	−4.00
Computer, medical, etc equipment—manufacturing	7	0.27	0.24	−2.15
Professional and related services	73	0.27	0.26	−29.28
Finance, insurance and real estate	17	0.27	0.26	−5.50
Personnel supply services	<5	0.13	0.09	−0.67
Apparel and finished textile product—manufacturing	<5	0.07	0.05	−1.38
Drug stores—retail	0	0.00	0.00	−0.49
Overall	2645	2.42		

*Fatal injuries/100 000 person-years.
†Population attributable risk percentage.
NC, North Carolina; PAR, population attributable risk.

This contrasts our prior finding that middle-age workers experienced the lowest fatal injury rates in NC during the 1977–1991 period.[20] These results are notable given prior findings that, from 2012 to 2018, US workers younger than 25 had the highest rates of non-fatal occupational injury.[38] These findings taken together may indicate that, while younger workers in general are still prone to non-fatal injuries due to a lack of workplace experience, they may be less likely to pursue work within highly hazardous industries and occupations relative to younger workers in prior decades and relative to workers in older age groups. While the overall decline in fatal injury rate within all age groups since the 1977–1991 period is encouraging, assessing the drivers of the substantially elevated fatal injury rates among older workers in NC is vital due to NC's rapidly ageing workforce.

We found that Hispanic workers had the highest fatal injury rates during the period of study. This is consistent with earlier findings, which showed that, in the Southern USA, the fatal occupational injury rate among Hispanic workers overtook that among non-Hispanic black workers in the mid-1990s.[17] Fatal injury rates among Hispanic workers are important to assess as the Hispanic workforce of NC has grown at a rapid pace, and these fatal injury trends demonstrate that this growing population is being placed at undue risk for occupational injury. After standardising rates to the age distribution of the total NC workforce, the fatal injury rate among Hispanic workers became greater relative to the crude rate, indicating that Hispanic workers were younger on average relative to the overall NC workforce and that, had the Hispanic workforce had the age distribution of the overall NC workforce, its average fatal injury rate would be even higher than observed. Additionally, occupation adjustment reduced the fatal injury rate among Hispanic workers, suggesting that occupational segregation contributes substantially to fatal injury disparities between Hispanic and non-Hispanic workers, with Hispanic workers on average working in more dangerous industries and occupations. Additional research examining employment segregation in NC relative to health outcomes among Hispanic workers is needed.

This study found that self-employed workers had higher fatal injury rates than private and civilian government workers. However, when adjusted for occupation, the difference between the fatal injury rates of self-employed and private workers fully disappeared. This suggests that the heightened fatal injury rate among self-employed workers is largely driven by these workers being employed in more dangerous occupations relative to private workers. These findings support those of a study examining NC workers from 1978 to 1994, which found that, while self-employed workers had higher overall fatal injury rates relative to private workers, self-employed workers had fatal injury rates that were lower than or comparable to those among private workers within many high-PAR industries, including the construction, agriculture and forestry and logging industries.[23] Additionally, after adjusting for age, the fatal injury rate among self-employed workers was attenuated. This indicates that self-employed workers tend to continue working into older age relative to private and government workers. Workers may also become self-employed after leaving private and government work due to retirement or employment loss. Fatal injury rates were consistently higher among self-employed and private workers relative to government workers, even after adjusting for age and occupation. This suggests that the occupational safety oversight and regulation of workplace conditions for self-employed and private workers may be inadequate relative to those in place for government workers.

The greatest fatal injury burdens were attributable to the construction industry, bus, trolley, and truck transport industry, agriculture and agricultural services industries, and forestry and logging industry. These industries and occupations have also been found to have high fatal injury rates both in the overall USA and globally.[13 14 16 32 39 40] These findings are consistent with those reported during the 1977–1991 period, during which these industries, with the exception of the agricultural services industry, were found to contribute most substantially to the overall fatal injury burden in NC.[20] The average fatal injury rate in each of these hazardous industries fell substantially between the 1977–1991 and 1992–2017 periods.[20] Based on these findings, it appears that progress has been made over these periods to improve safety within these hazardous industries, but that additional safety measures and policies are necessary to fully protect workers, who continue to be placed at heightened risk for fatal injury relative to the overall NC workforce.

This study has several limitations. Our analyses rely on rate denominator estimates that are derived from census data and reflect estimates of number of persons employed. This may imply that a person is constantly at-risk for fatal occupational injury, which is often not the case. Alternatives include the use of estimates of full-time equivalent units. However, we used census-based estimates when calculating persons at-risk because it allowed us to derive analyses cross-classified by age, sex, race/ethnicity, class of worker, occupation and industry. The use of census data facilitated the calculation of more highly stratified estimates than would be possible using Current Population Survey and American Community Survey data. However, the use of this census data hinders our ability to calculate fatal injury rates for workers who do not belong to the 'Hispanic', 'non-Hispanic white', and 'non-Hispanic black' categories of race/ethnicity, and, for 'self-employed' workers, the use of census data may result in an underestimation of time spent employed. Finally, this study is limited to the analyses of unintentional fatal occupational injuries. Additional research on occupational homicides and suicides is necessary to fully describe the state of occupational fatalities in NC.

In conclusion, we found that fatal occupational injury rates in NC declined throughout the first decade of the 21st century, but that these improvements have stagnated in recent years and are inequitably distributed. Further exploration of racial and sex-based differences in fatal occupational injuries by occupation

and industry is warranted to allow targeting of worker safety interventions.

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