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RESEARCH ARTICLE

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Forty years of struggle in North Carolina: Workplace segregation and fatal occupational injury rates

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Abstract

Objective: To assess workplace segregation in fatal occupational injury from 1992 to 2017 in North Carolina.

Methods: We calculated occupational fatal injury rates within categories of occupation, industry, race, age, and sex; and estimated expected numbers of fatalities among Black and Hispanic male workers had they experienced the rates of White male workers. We also estimated the contribution of workforce segregation to disparities by estimating the expected number of fatalities among Black and Hispanic male workers had they experienced the industry and occupation patterns of White male workers. We assessed person-years of life-lost, using North Carolina life expectancy estimates.

Results: Hispanic workers contributed 32% of their worker-years and experienced 58% of their fatalities in construction. Black workers were most overrepresented in the food manufacturing industry. Hispanic males experienced 2.11 (95% CI: 1.86–2.40) times the mortality rate of White males. The Black-White and Hispanic-White disparities were widest among workers aged 45 and older, and segregation into more dangerous industries and occupations played a substantial role in driving disparities. Hispanic workers who suffered occupational fatalities lost a median 47 life-years, compared to 37 among Black workers and 36 among White workers.

Conclusions: If Hispanic and Black workers experienced the workplace safety of their White counterparts, fatal injury rates would be substantially reduced. Workforce segregation reflects structural racism, which also contributes to mortality disparities. Root causes must be addressed to eliminate disparities.

KEYWORDS
health equity, injury, mortality, workplace

1 | INTRODUCTION

North Carolina's economy historically relied on textile production, furniture manufacturing, and agriculture but shifted toward industries with comparatively lower fatal injury rates, like service and technology, starting in the 1980s. However, across industries, North Carolina's workforce has a decades-long legacy of racial and ethnic workplace segregation (i.e., when one racial or ethnic group is over- or under-represented in a certain industry or occupation).[1–4] Before World War II, White workers shifted out of agricultural and

Abbreviations: CI, confidence interval; NC, North Carolina; SRR, standardized rate ratio.

blue-collar work faster than Black workers. Segregation then declined in the 1940s but worsened beyond its 1900s degree of severity by 1950, with Black workers being highly over represented in blue-collar jobs and underrepresented in professional services industries.[5] Sanctioned discrimination in access to education played a major role in southern Black/White workplace segregation, but economic analyses indicate that segregation persists even after controlling for educational attainment within industry.[5,6] Further changes in employment structure over the past 20 years accompanied the dramatic growth of the Hispanic population in North Carolina.[7] In the United States overall, Hispanic recent immigrants are likely to be assigned hazardous jobs or tasks within an occupationor industry.[8] In North Carolina, Hispanic workers are highly over-represented in the agricultural and construction industries largely because of informal networks and community ties, and their immigration status. These industries involve many hazardous conditions and tasks, often have reduced state and federal oversight, and can hold workers captive by maintaining secrecy around immigration documentation.[9,10] As a counterpoint to these challenges for occupational safety and health, North Carolina has a decades-long history of labor organizing advocating for safer and more equitable working conditions in the face of state and federal union-weakening policies.[6,11]

Workforce segregation in the United States frequently leads to health disparities, operating by sorting racially minoritized workers into more dangerous jobs with less power and decision latitude than their white counterparts.[12,13] North Carolina has seen persistent disparities by race and ethnicity in fatal occupational injury rates, historically with the highest rates of fatal occupational injury among Black men and, more recently, rising rates of fatal occupational injury among Hispanic men.[3,14] Epidemiological research focused on structural racism has highlighted occupational settings as important sites of health risk that need to be regulated.[13,15–17] The literature has called for greater intersection of research on health disparities and on occupational hazards.[18–20] However, traditional occupational epidemiology has provided insufficient documentation of the impacts of structural racism.[16,17,21,22] Many major epidemiological occupational cohort studies have been predominantly made up of White men.[22,23] Consequently, epidemiology studies often have not focused on the hazards that many racially minoritized communities experience due to structural racism.[18,24]

Throughout, we will be using the terms “Black,” “Hispanic,” and “White” to be succinct and consistent with administrative data sources. These are not intended to represent biological or genetic identities. We acknowledge that these terms oversimplify sociocultural diversity and are imperfect proxies for structural discrimination faced by racially minoritized people in North Carolina.[21] In these analyses, the terms “Black” and “White” refer to non-Hispanic Black and non-Hispanic White workers.

The purpose of this paper is to examine the role of workplace segregation in shaping racial and ethnic disparities in fatal occupational injury in North Carolina during the period from 1992 to 2017. In doing so, this study adds to a prior study from our team that focused on racial disparities in occupational mortality in North Carolina from 1977 to 1991.[3] We estimate fatal occupational injury rates among Hispanic, Black, and White workers and use standardization approaches to assess the extent of excess mortality among Hispanic and Black workers relative to White workers. These analyses can inform workplace policy and regulation to reduce disparities in fatal injury.

2 | METHODS

2.1 | Study setting

North Carolina is the ninth most populous state in the nation, located in the Southeastern United States (US). According to the 2020 US Census, 23% of the North Carolina population identifies as Black, and 11% identifies as Hispanic, the latter having increased from 5% in 2000.[25] In 2020, the service and technology industries employed the largest numbers of workers in North Carolina.[26]

2.2 | Fatal occupational injuries

The North Carolina Office of the Chief Medical Examiner (OCME) in the Division of Public Health in the North Carolina Department of Health and Human Services maintains a reporting, coding, and data retrieval system for the state. Medical examiners investigate fatal injuries in each of North Carolina's 100 counties, identify the cause of death, assess surrounding circumstances, and determine if a fatal injury occurred at work.[27] Medical examiners report their findings to the OCME. This study examines fatal occupational injuries in North Carolina between January 1, 1992 and December 31, 2017. Occupational fatal injury is defined as any injury (unintentional) leading to death within 30 days, in an individual engaged in legal work for pay in North Carolina, including individuals working for their own or family businesses. Cases of occupational fatal injury were identified for review and drawn from two data sources—the OCME data system and North Carolina State Center for Health Statistics death certificate data system. Deaths flagged as “at work” in the State Center for Health Statistics data system or “on the job” in the OCME data system, during the study period were considered eligible for inclusion in this study.

OCME records include the Medical Examiner's report, the official death certificate, and the autopsy and toxicology results. If available, the records also include family interviews and witness and police statements as well as supplemental files such as news articles, crime reports, and court transcripts. Trained investigators abstracted study data from these records, including means of death. They also reviewed the circumstances surrounding each death to determine “at work” status for inclusion. A team of experienced investigators (authors: JC, SM, MN, SIR, DBR) adjudicated complex cases. Occupation and industry at the time of fatal injury were abstracted from the medical examiner's report. Occupations and industries were coded to the U.S. Census year 2000 guidelines.

2.3 | Covariates

Investigators abstracted age, sex, race, and ethnicity of decedents from both the death certificate and the medical examiner's report. When Hispanic ethnicity was indicated on the death certificate the decedent's race often (80%, *n* = 207) was not recorded. In accordance with recommendations[28] and to avoid attempts to cross-classify Hispanic decedents by race, we classified decedents as either Hispanic, non-Hispanic Black, or non-Hispanic White for this analysis. Because of small numbers and heterogeneity in racial/ethnic identities, individuals coded as non-Hispanic and a race other than White or Black (including American Indian/Alaska Native, Asian, Native Hawaiian/Pacific Islander, and Other) were excluded from this analysis.

2.4 | Population at risk

We derived estimates of the North Carolina work force, aged 18 years and older and excluding military, from the 1990, 2000, and 2010 decennial US Census[25] tabulated in strata defined by categories of age, sex, race (classified as White, Black, or other), ethnicity (Hispanic or non-Hispanic), occupation (in 33 groups defined by census codes), and industry (in 51 groups defined by census codes). Annual estimates of the work force in intercensal years were estimated using a linear interpolation and the estimated numbers of workers in each stratum were summed to obtain estimates of person-years at risk. These estimates of the working population were used to approximate the number of person-years at risk in each stratum and calendar year.

2.5 | Statistical methods

Fatal occupational injury rates were calculated as the number of unintentional deaths due to injury at work divided by an estimate of the number of people employed in NC over the study period and were expressed as mortality rates per 100,000 worker-years. Mortality rates were sex and age-stratified, and strata with less than five fatalities were suppressed in reporting and excluded from stratified analyses.

We assessed person-years of life lost for each occupational fatality, using estimates from CDC life tables for North Carolina (when available) or the United States (when state life tables were not available) based on age at death and year of death.[29] Descriptive statistics were calculated to illustrate the distribution of person-years of life lost per death, fatalities, and person-years at risk by categories of occupation, industry, race and sex.

We assessed differences in fatal injury rate by race and ethnicity using marginal structural Poisson models, which report standardized rate ratios (SRRs) by comparing the observed mortality rates among minoritized groups to the expected mortality rates had those groups experienced the mortality rates of White workers, as well as 95% confidence intervals.[30] Black and Hispanic workers may have higher injury rates than White workers even when employed in the same industries and occupations. We estimated the expected occupational fatality rate among male Black and Hispanic workers if they had experienced the mortality rates of the male White worker population, within age strata. Additionally, we estimated the amount of disparity in fatal injury that is attributable to workforce segmentation, such that Black and Hispanic workers tend to be employed in different industries or different occupations. Marginal structural models allow us to estimate expected differences in injury rates by race or ethnicity that are not confounded by differences in employment patterns. We used weighting to estimate expected injury rates for comparison with the observed injury rates among Black and Hispanic workers, standardized to the occupational (or industry) structure of White workers employment. We want to compare Black workers' (*RE* = *1*) and Hispanic workers' (*RE* = *2*) to a comparison group of White workers (*RE* = 0) standardizing on covariate ***Z*** distribution. This is similar to other, frequently used standardized estimators, such as the standardized mortality ratio.[31] This standardized ratio is unconfounded by ***Z*** and is standardized to the target population *RE* = *0*. If there is effect measure modification by ***Z***, this standardized ratio offers a useful marginal estimate of the effect in a population that has the covariate distribution observed among the *RE* = *0* study subjects. We estimated the average injury rate among Black and Hispanic male workers if they had experienced the industry (or occupation) distribution of White male workers then summarized in ratios of expected to observed fatality rates. This ratio of fatality rates quantifies the disparities that would be observed if Black or Hispanic workers held the employment structure of White workers. A comparison of such a standardized rate ratio to the crude rate ratio indicates the amount of the racial/ethnic disparity attributable to industry (or occupational) segregation. These standardization approaches address different intervention-informing questions. Standardizing to the White fatal injury rates speaks to an intervention on the equity of workplace safety, while standardizing to the White pattern of employment by industry (or occupation) speaks to an intervention on segregation in employment.

3 | RESULTS

In North Carolina between 1992 and 2017, there were 2,586 deaths from unintentional injuries at work and a median of 38 person-years of life lost among fatally injured civilian Hispanic, non-Hispanic Black, and non-Hispanic White workers, aged 18 years and older (Table 1). Hispanic decedents tended to be younger than Black and White decedents (Table 1), and while overall 96% of fatalities occurred among male workers, among Hispanic decedents 99% were male (Table 1). Figure 1 shows population pyramids of the workforce by age group, comparing the White workforce to the Hispanic workforce (Figure 1A) and the White workforce to the Black workforce (Figure 1B). The Black workforce skewed younger than the White workforce, while the

TABLE 1 Descriptive characteristics of fatal injury at work decedents: North Carolina, 1992–2017.

Characteristic	Hispanic	Black	White	Total
Total number of deaths, *N*	280	466	1840	2586
Total number of worker-years, *N*	4,424,961	20,169,983	79,850,249	104,445,193
Age at death, median (25th, 75th)	34 (27, 42)	44 (35, 54)	45 (34, 57)	44 (33, 55)
Person-years of life lost per death, median (25th, 75th)	47 (38, 53)	37 (28, 46)	36 (25, 46)	38 (27, 47)
Male sex, *n* (%)	276 (99)	442 (95)	1,765 (96)	2,483 (96)
Industry groups, *n* (%)[a]				
Agriculture	36 (13)	24 (5)	150 (8)	210 (8)
Agricultural services	17 (6)	23 (5)	120 (7)	160 (6)
Business and repair services	5 (2)	12 (3)	37 (2)	54 (2)
Construction	160 (57)	91 (20)	456 (25)	707 (27)
Forestry and logging	6 (2)	38 (8)	91 (5)	135 (5)
General retail trade	5 (2)	11 (2)	60 (3)	76 (3)
Manufacturing–Sawmills, Planing Mills, and Wood Products	8 (3)	9 (2)	12 (1)	29 (1)
Transportation–Truck, Bus	5 (2)	86 (18)	185 (10)	276 (11)
Wholesale trade	6 (2)	16 (3)	71 (4)	93 (4)

[a]Industry groups with at least five deaths during the study period.

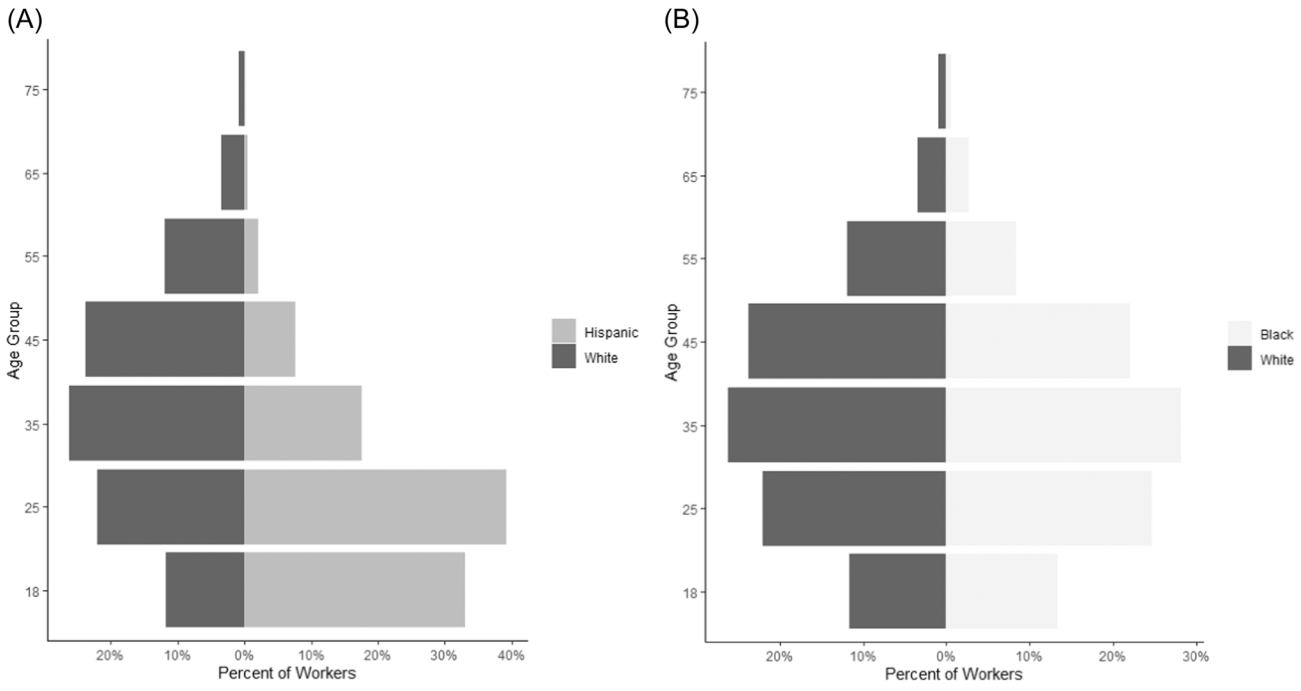

FIGURE 1 Population pyramids of Hispanic, Black, and White Workforces in North Carolina, 1992–2017.

Hispanic workforce was substantially more concentrated in the younger age groups compared to both the White and Black workforces. Hispanic workers experienced a median of 47 years of life lost due to occupational injury, compared to a median of 36 among White workers. The greatest number of Hispanic deaths occurred in the construction industry (57%), while construction worker deaths made up only 20% of deaths among Black workers and 25% of deaths among White workers (Table 1).

Hispanic workers were highly segregated into the food manufacturing, agriculture, wood manufacturing, and construction industries, representing 22%, 21%, 14%, and 13% of the respective sector workforces compared to 6% of the total workforce. Male Hispanic workers spent 32% of their worker-years in the construction industry. Black workers made up 17% of the total workforce. They were also overrepresented in the food manufacturing sector (making up 33% of the food manufacturing workforce), as well as in the water utilities and transportation sectors, representing 29% and 28% of the sector workforces, respectively. White workers made up 78% of the total workforce and were overrepresented in the finance, insurance, and real estate (making up 86% of the sector workforce) as well as the automotive sales and services sectors (representing 85% of the sector workforce) (Table 2).

The largest number of deaths occurred among White workers, but the unadjusted mortality rate was higher among Black than White workers (Table 3, row for all ages). Notably, the unadjusted mortality rate among Hispanic workers (8.64 per 100,000) was over 2 times the unadjusted rate among White workers (4.10 per 100,000). Workforce age distributions varied by race and ethnicity, but they were similar between males and females. Given the differences in age distribution by race and ethnicity, comparisons of unadjusted rates by race and ethnicity may be confounded by the older age distribution of White workers compared to Hispanic and Black workers. When examined within strata defined by age, the mortality rate among Hispanic workers was 1.6 times that of White workers among males aged 18–24 years. Among males aged 25–44 years and 45 and older, the mortality rate among Hispanic workers was over 2.5 times and 3.5 times that of White workers, respectively (Table 3). Among Black male workers aged 25–44 years and 45 years and older, the fatal injury rate was 1.2 and 1.3 times that of White male workers, respectively (Table 3). Very few fatal occupational injuries were observed among female workers (Table 1), and female fatal injury rates were uniformly less than 1 per 100,000 in all strata of age and race/ethnicity.

There was excess occupational mortality among Hispanic and Black males, relative to White males. Hispanic males overall experienced twice the number of deaths they would have expected, had they experienced the mortality rates of White males (SRR: 2.11, 95% CI: 1.86–2.40). Black males had 1.17 times the number of deaths

TABLE 2 Person-time at work by industry group among Hispanic, Black, and White male workers: North Carolina, 1992–2017.

Industry Sector	Hispanic number of worker-years *n* (%)	Black number of worker-years *n* (%)	White number of worker-years *n* (%)	Total number of worker-years *n*
All industries	*3,192,803 (6)*	*9,207,385 (17)*	*43,089,054 (78)*	*55,489,242*
Agriculture	193,789 (21)	100,152 (11)	645,968 (69)	939,909
Agricultural services	137,649 (18)	90,281 (12)	553,510 (71)	781,440
Automotive sales and services	37,686 (2)	241,960 (13)	1,601,490 (85)	1,881,136
Business and repair services	75,032 (3)	338,338 (15)	1,848,640 (82)	2,262,010
Construction	1,019,527 (13)	798,828 (10)	6,093,234 (77)	7,911,589
Eating and drinking places retail	210,535 (11)	427,327 (22)	1,275,324 (67)	1,913,186
Electric, gas, pipeline and nonspecific utilities	21,039 (3)	75,472 (13)	502,970 (84)	599,481
Finance, insurance, and real estate	20,822 (1)	325,527 (13)	2,071,326 (86)	2,417,675
Forestry and logging	15,102 (8)	32,610 (18)	134,593 (74)	182,305
General retail trade	88,846 (3)	536,341 (14)	3,252,656 (84)	3,877,843
Justice, public order, and safety	17,813 (1)	256,352 (21)	962,148 (78)	1,236,313
Machinery and transportation equipment manufacturing	61,065 (3)	348,849 (17)	1,654,387 (80)	2,064,301
Manufacturing–food and kindred products	168,539 (22)	246,382 (33)	334,177 (45)	759,098
Manufacturing–sawmills, planing mills, and wood products	71,964 (14)	97,192 (19)	332,716 (66)	501,872
Professional and related services	88,080 (1)	1,185,763 (16)	6,065,100 (83)	7,338,943
Transportation–truck, bus	13,183 (1)	497,961 (28)	1,278,006 (71)	1,789,150
Water supply and sanitation utilities	12,821 (3)	139,286 (29)	332,721 (69)	484,828
Wholesale trade	88,855 (4)	347,898 (14)	2,004,462 (82)	2,441,215

TABLE 3 Observed and expected occupational fatalities among male workers and standardized rate ratios comparing occupational fatalities among Hispanic and Black Male workers to White male worker reference rates: North Carolina, 1992–2017.

Age and race/ethnicity	Observed number of deaths	Number of worker-years	Crude rate[b]	Expected number of deaths[a]	Standardized rate ratio (95% CI)
Age 18–24					
Hispanic	48	1,005,496	4.77	30	1.61 (1.16–2.24)
Black	25	1,150,581	2.17	34	0.73 (0.48–1.12)
White	135	4,560,485	2.96	135	1.00
Age 25–44					
Hispanic	166	1,852,611	8.96	64	2.60 (2.20–3.08)
Black	200	4,856,762	4.12	167	1.20 (1.02–1.40)
White	719	20,889,275	3.44	719	1.00
Age 45+					
Hispanic	62	334,696	18.52	17	3.59 (2.77–4.63)
Black	217	3,200,042	6.78	165	1.31 (1.13–1.52)
White	911	17,639,294	5.16	911	1.00
All ages					
Hispanic	276	3,192,803	8.64	131	2.11 (1.85–2.40)
Black	442	9,207,385	4.80	377	1.17 (1.06–1.30)
White	1,765	43,089,054	4.10	165	1.00

[a]Number of deaths expected had the workers experienced the mortality rate of the White worker population.
[b]Deaths per 100,000 worker-years.

they would have had under the White male rate (SRR: 1.17, 95% CI: 1.06–1.30). The Hispanic-White and Black-White disparities were greatest in the 45 and older age group, with Hispanic males having 3.59 times the mortality rate expected under White mortality reference rates (SRR: 3.59, 95% CI: 2.77–4.63) and Black males experiencing 1.31 times the expected rate (SRR: 1.31, 95% CI: 1.13–1.52). Hispanic males also had excess mortality in both younger age groups, and Black males had excess mortality in the middle age group (25–44) (Table 3).

Table 4 shows the contributions of industry and occupational segregation on the occupational fatality rate disparity by race and ethnicity among male workers. The rate ratio comparing occupational fatality rates among Hispanic workers to that among White workers was 1.33 (95% CI: 1.17–1.52) when the Hispanic workers' person-time was standardized to the industry patterns of the White workers. Standardizing the Black workers' person-time to the industry patterns of the White workers did not impact the rate ratio. In terms of occupational standardization, adjusting for occupational segregation decreased the Hispanic/White rate ratio to 1.35 (95% CI: 1.18–1.54), and it decreased the Black/White rate ratio from 1.17 (95% CI: 1.06–1.30) to 1.03 (95% CI: 0.93–1.15).

The greatest numbers of occupational fatalities occurred in the construction industry. Among Hispanic male workers, 58% of the observed fatal injuries occurred in the construction industry. The rate of fatal injury among Hispanic male workers in the construction industry (15.50 per 100,000) was over twice that observed among White males in that industry. Black male workers also experienced higher rates of fatal injury in construction (11.14 per 100,000) than White construction workers (7.42 per 100,000). Fatalities among Hispanic workers in the construction industry resulted in a median person-years of life lost nearly 9 years greater than that experienced by White workers in the construction industry (Table 5).

Another 19% of the observed fatal injuries among Hispanic males occurred in agriculture or agricultural services industries. The unadjusted rate of fatal injury among Hispanic male workers in the agricultural and agricultural services industries (15.69 per 100,000) was 0.7 times that observed among White males in these industries (21.93 per 100,000). Black male workers experienced substantially higher rates of fatal injury in the agricultural and agricultural services industries (24.16 per 100,000) than Hispanic and White agriculture workers (Table 5). These industry-specific rates did not have the numbers to support stable, age stratified estimates and are therefore confounded by age. For example, the rates are higher among Hispanic workers, and they were younger when they died. The other leading industries in which fatalities among Hispanic workers were observed included sawmill and wood manufacturing (8 deaths), forestry and logging (6 deaths), wholesale trade (6 deaths), general retail trade (5 deaths), and truck/bus transportation (5 deaths) (Table 1).

TABLE 4 Effect of adjusting for employment patterns on the rate ratio comparing occupational fatalities among Hispanic and Black male workers to White male worker reference rates.

Race/ethnicity	Crude rate	Crude rate ratio (95% CI)	Industry-adjusted rate[a]	Industry-adjusted rate ratio (95% CI)	Occupation-adjusted rate[b]	Occupation-adjusted rate ratio (95% CI)
Hispanic	8.64	2.11 (1.85–2.40)	5.31	1.33 (1.17–1.52)	5.39	1.35 (1.18–1.54)
Black	4.80	1.17 (1.06–1.30)	4.67	1.17 (1.05–1.30)	4.11	1.03 (0.93–1.15)
White	4.10	1.00	4.10	1.00	3.99	1.00

[a]Fatal injury rate expected among workers if their industry patterns were the same as those of White workers.
[b]Fatal injury rate expected among workers if their occupation patterns were the same as those of White workers.

TABLE 5 Worker-years and rates of fatal unintentional injury at work and person-years of life lost by industry group among Hispanic, Black, and White male workers: North Carolina, 1992–2017.

Race/ethnicity and industry group[a]	Number of deaths	Number of worker-years	Crude rate[b]	Person-years of life lost per death, median (25th, 75th)
Hispanic				
Agriculture	35	193,789	18.06	44.44 (33.35, 51.60)
Agricultural services	17	137,649	12.35	43.44 (39.50, 51.04)
Agricultural industries combined	52	331,438	15.69	43.92 (39.88, 47.96)
Construction	159	1,019,527	15.60	46.90 (37.94, 52.67)
Forestry and logging	6	15,102	39.73	49.25 (43.47, 56.50)
Transportation - Truck, Bus	5	13,183	67.61	40.40 (39.65, 46.90)
Black				
Agriculture	23	100,152	22.97	28.80 (20.80, 35.15)
Agricultural services	23	90,281	25.48	31.67 (26.56, 42.75)
Agricultural industries combined	46	190,433	24.16	30.01 (22.05, 37.97)
Construction	89	798,828	11.14	38.00 (29.00, 43.60)
Forestry and logging	38	32,610	116.53	28.93 (23.10, 39.50)
Transportation - truck, bus	85	497,961	17.07	38.60 (30.58, 46.90)
White				
Agriculture	145	645,968	22.45	24.80 (13.80, 37.94)
Agricultural services	118	553,510	21.32	38.00 (28.70, 49.80)
Agricultural industries combined	263	1,199,478	21.93	32.46 (24.50, 40.42)
Construction	452	6,093,234	7.42	38.00 (28.55, 47.30)
Forestry and logging	91	134,593	67.61	37.70 (27.13, 46.33)
Transportation - truck, Bus	177	1,278,006	13.85	33.20 (23.40, 42,30)

[a]Top five industry groups with regard to number of deaths during the study period.
[b]Deaths per 100,000 worker-years.

Figure 2 shows median years of life lost by race/ethnicity and industry group. Hispanic male workers experienced substantially greater person-years of life lost than White workers in all industry groups. The greatest disparities were in the Agriculture and Forestry and Logging industries, with Hispanic workers having median person-years of life lost nearly 20 and 12 years greater than White workers, respectively (Table 5).

The greatest number of construction deaths were related to falls (34%). Nearly half of deaths in the agriculture industry were due to

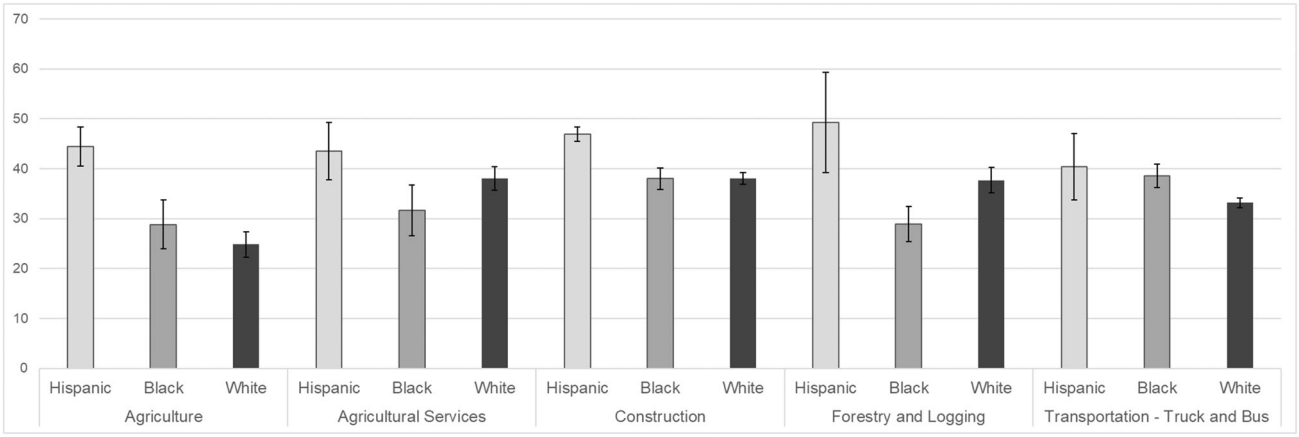

FIGURE 2 Person-years of life lost per death by industry group among Hispanic, Black, and White Male Workers: North Carolina, 1992–2017.

TABLE 6 Means of fatal unintentional injury at work among workers in construction, agriculture, and agricultural services industries: North Carolina, 1992–2017.

Means of death	Construction number of deaths = 718 *n* (%)	Agriculture number of deaths = 241 *n* (%)	Agricultural services number of deaths = 169 *n* (%)
Fall/Jump	241 (34)	14 (6)	47 (28)
Motor vehicle	126 (18)	40 (17)	23 (14)
Machinery	98 (14)	118 (49)	24 (14)
Blunt	86 (12)	12 (5)	52 (31)
Electrocution	68 (9)	6 (2)	6 (4)
Transportation	<5	12 (5)	<5

machinery (49%), while 31% of agricultural services deaths were each related to falls and blunt trauma (Table 6).

4 | DISCUSSION

4.1 | Major findings

In North Carolina from 1992 through 2017, Hispanic workers experienced over double the rate of fatal injury as would be expected had they experienced the rates (i.e. workplace safety) of White workers. Hispanic workers were highly segregated into food manufacturing, agriculture, wood manufacturing, and construction industries. Black workers also experienced excess mortality relative to White workers, and fatalities overwhelmingly occurred among male workers. The mortality disparities were widest among workers aged 45 and older, with Hispanic workers experiencing more than 3.5 times the mortality rate of White workers and Black workers experiencing 1.3 times the White mortality rate. Hispanic and Black workers contributed greater proportions of their worker years at younger ages. The median person-years of life lost among North Carolina occupational fatalities was 38. Fatally injured Hispanic workers lost a median of 11 more person-years of life than fatally injured White workers.

4.2 | Comparison to 1998 analysis

Since the 1998 analyses of racial disparities in fatal injury,[3] the Hispanic workforce has grown substantially in NC,[1] and Hispanic workers have displaced Black workers in many of the most dangerous industries. The disparities remain as wide as those reported in the 1998 analysis,[3] but they largely exist between Hispanic and White workers, while the Black/White disparity is reduced. Among Hispanic workers, we found that segregation into dangerous industries and occupations contributes substantially to the increased rate, while occupational segregation largely drives the Black/White disparity. Differences in access to labor activism and government-run workplace safety initiatives (which are associated with reduced disparities in other states[32–34]) are unlikely drivers of the changes in mortality disparities, as NC's occupational safety initiatives remain insufficient,[35] and union density continues to decline as a result of union-weakening policies like NC's right-to-work state status.[36,37]

4.3 | Mechanisms for occupational fatality disparities

Mortality disparities can be explained by multiple interacting pathways. The literature suggests that racial/ethnic and gender differences in workplace safety have little to do with individual characteristics and choices but, rather, structural factors influencing differences in work environments and conditions.[38,39] Structural discrimination also manifests at the workplace through differences in pay. Access to education and other social factors, like generational privilege and institutional discrimination, contribute to employment segregation.[39,40] The estimated disparity in fatal injury in NC is, in part, attributable to workforce segregation, such that Black and Hispanic workers have different industry and occupation employment patterns than White workers. Hispanic workers have higher injury rates than White workers in part because they are employed in more dangerous industries or in jobs that tend to have relatively higher injury rates.[3,22,41] This results in disparities in rates by race or ethnicity despite similar risks for workers in any specific industry or job regardless of race or ethnicity. Additionally, nonwhite workers may tend to have higher injury rates than White workers even when employed in the same industries and occupations. This could result from historical racial differences in job opportunity operating through factors like education and/or disparities in task assignments among nonwhite and White workers despite nominally working in the same industry or occupation.[4,39,40] Regional and employer characteristic (i.e. size of staff, size of overall company or organization) variation could occur through differences in safety and health oversight, potentially modifying facility-specific occupational segregation and/or its impact on mortality disparities. Immigration and documentation status of workers also impacts access to jobs.[42] For example, in NC, Hispanic and undocumented immigrant construction workers are more likely to be employed by smaller companies with less oversight and union representation than White workers.[43] Construction, agriculture, and forestry industries are known to be among the most hazardous occupational settings with highest occupational fatality rates —industries into which Hispanic workers are highly segregated.

4.4 | The role of attained age and selection effects

The differences in age distributions among Hispanic and Black workers compared to White workers may reflect a health-related selection effect[44] such that, older Hispanic and Black workers who survived the hazardous conditions in younger years either no longer remain employed in NC or are not fit to be employed in the same hazardous conditions at an older age. We observed greater numbers person-years of employment in hazardous industries, such as agriculture, among older White workers than older non-Whites. Estimates of years of life lost provide additional information on the public health burden of occupational fatalities among Black and Hispanic workers. In the construction industry, for example, not only are the rates of occupational fatality higher among Hispanic workers, but workers are also dying at a younger age, which leads to a greater societal potential loss for the community, thereby highlighting additional hidden costs of systemic oppression. Further, not only do the construction and agricultural industries have high fatal injury rates, but they also have some of the largest workforces in NC,[41] meaning they have a large impact on the overall fatal injury rate of Hispanic workers, relative to industries with smaller workforces.

4.5 | Limitations

While these analyses leverage excellent quality surveillance data and support theory-informed findings, the interpretations are subject to some limitations and caveats. First, the analyses are limited to information collected in administrative data and therefore cannot be used to make inferences about many factors influencing an individual worker's fatal injury risk. Second, there are documented biases in medical examiners' documentation of race and ethnicity[45] as well as inconsistencies in their designation of fatal occupational injuries.[46,47] It is unclear the degree to which these inconsistencies impacted our findings, as this may have prevented deaths from inclusion in the analytical data set. Third, documentation status likely affects both the fatality and workforce estimates, particularly in the Hispanic population and industries with large migrant workforces, which may explain the lower than expected mortality rates we estimated for the agricultural industries. Undocumented workers' ethnic identities are more likely to be misclassified on death certificates.[14,45] Additionally, industries with the largest migrant workforce (e.g. agriculture) may be disincentivized to attribute injuries to workplace causes, and disproportionately underreport workplace fatalities among undocumented workers.[48,49] Given that these limitations are likely to mask the true magnitude of disparities, we call for improved training and community collaboration within the public health workforce to improve collection methods for race and ethnicity data on death certificates. Fourth, as demonstrated in Figure 1, the age distributions of the Hispanic and Black workforces differ substantially from those in the entire population, and this can make age-standardized measures of inequity inaccurate or irrelevant to the populations of interest.[50] While we estimated age-standardized overall measures of inequity, we also estimated age-stratified measures to highlight the true magnitude of disparities. Finally, some stratum-specific estimates are based on a small number of deaths, so the confidence intervals are wide, and this precluded robust analyses of segregation of jobs within industry sectors. Confidence intervals in this study are estimated using standard practice for observational studies, but the methods are based in experimental designs in samples. This may not be appropriate for our analytical data set, which represents a full census of workers. The statistical imprecision in effect estimates does not reflect uncertainty in the number of deaths or disparities we documented in the study.

5 | PUBLIC HEALTH IMPLICATIONS

These analyses suggest that if Hispanic and Black workers were not segregated into high-risk industries and occupations, and instead experienced the workplace fatality patterns of their White

counterparts, their rates of fatal injury would be substantially reduced. Hispanic workers experienced the highest fatality rates, and these fatalities occurred most frequently in the construction and agriculture industries. Most fatalities in these industries were due to falls and machinery failures. While engineering controls and shifting industry landscape have improved overall workplace safety in North Carolina, our findings show that segregation of racially minoritized people to more dangerous industries and occupations persists.

This represents pervasive structural discrimination in a society that limits educational and employment growth opportunities from racially minoritized people. Racially minoritized workers have struggled to survive dangerous working conditions and, as a result, suffer disproportionate mortality compared to their White counterparts. Such inequities must be addressed via a repertoire of interventions targeting multiple levels of influence. We use the social-ecological model to inform policy recommendations, recognizing that fully addressing root causes may not be feasible.[51–54] The social-ecological model outlines four nesting levels of influence in health promotion—individual, relationship, community, and societal. Solutions to address structural inequality should focus on changes at the societal level—we recommend policies to increase national and state-level capacity to administer and enforce workplace safety regulations. Specifically, we recommend legislation to strengthen unions and protect individual workers from retaliation, particularly in states like North Carolina with a history of union-weakening, "Right-to-Work" legislation, and increased funding for workplace regulation by OSHA and state regulatory bodies. This will require a major political shift in philosophy and resource distribution.[55]

Given the time, resource, and political barriers to structural change, we also recommend interventions at lower levels of the social-ecological model. Trainings on safety and equity for workers and managers can help mitigate health disparities related to workforce segregation.[4,56] There are documented inequities in existing safety trainings, and this literature calls for improved participation and elevating worker voices in these processes through labor committees and third-party certification.[57–60] Trainings for managers should draw on the NIOSH hierarchy of controls[61] and encourage addressing occupational risks at the top of the hierarchy of controls, rather than placing the responsibility on individual workers to mitigate their own risk. Trainings for workers must be culturally appropriate and accessible. This will require community engaged approaches, multilingual translation, and leveraging informal networks like faith-based centers, Hispanic and Black chambers of commerce and employers, and community centers. Public health practitioners can draw on examples from historic organizing successes, like the Black Workers for Justice's health screening van for workers at the Schlage Lock manufacturing facility in Rocky Mount, NC, which mobilized dozens of workers to get screened in their home communities.[62] A similarly organized van could offer workplace safety trainings for workers in dangerous jobs and industries to mitigate risk at the individual, relationship, and community levels.

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. Amelia T. Martin assisted in analytic strategy and approach, provided commentary on the analysis, contributed to editing of the manuscript, 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. John Cantrell assisted in analytic approach, provided content to the analysis, provided commentary on the analysis, contributed to editing of the manuscript, and approved the final manuscript as submitted. Stephen Marshall 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. 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 no conflicts of interest.

DISCLOSURE BY AJIM EDITOR 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 STATEMENT

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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