Journal of Safety Research 95 (2025) 455–467

Contents lists available at ScienceDirect

Journal of Safety Research

journal homepage: www.elsevier.com/locate/jsr

Mortality of American Indian and Alaska Native workers by occupation and industry, 2020–2022☆

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ARTICLE INFO

Keywords:
AI/AN
Cause of death
Death certificates
Occupational health
Proportionate mortality ratio

ABSTRACT

Introduction: Little occupational health and safety information exists on American Indian or Alaska Native (AI/AN) workers. The objective of this study is to describe the leading underlying causes of death among AI/AN workers by occupation and industry. *Methods:* Mortality data indicating decedents' race as: (1) 'American Indian/Alaska Native' (AI/AN) single-race or (2) AI/AN single-race and AI/AN in combination with any other race(s) were abstracted from 2020 to 2022 public use multiple cause of death files maintained in the National Vital Statistics System. Records with decedents: (a) 15 years of age and older, (b) residing in the United States, and (c) having both usual industry and usual occupation were included in this analysis. Mortality data were analyzed by occupation and industry for the 15 leading causes of death and COVID-19. Age-adjusted proportionate mortality ratios (PMRs) and 95% confidence intervals were calculated for usual occupation groups and usual industry groups for these causes of death. *Results:* Occupation groups with the highest number and proportion of deaths were construction and extraction (AI/AN single-race 15.9%; AI/AN combined 14.9%) and production (AI/AN single-race and combined 8.8%). The industry groups with the highest number and proportion of deaths include construction (AI/AN single-race 15.7%; AI/AN combined 14.9%) and healthcare and social assistance (AI/AN single-race 12.3%; AI/AN combined 12.2%). The three highest PMRs by occupation were suicide in the military and computer and mathematical occupations and homicide in construction and extraction occupations. The three highest PMRs by industry were suicide in the military and utilities industries and hypertension in the information industries. The top three causes of death for AI/AN combined race decedents were heart disease, cancer, and COVID-19. *Conclusion:* These results indicate that causes of death among AI/AN workers vary by specific occupations and industries. Focusing intervention and prevention in these highest risk occupations and industries may reduce morbidity and mortality among workers. *Practical Applications:* The results of this study can be used by tribes, tribal organizations, tribal leaders, and researchers to assist in prevention, control methods, and tailored communication efforts.

1. Introduction

Occupational safety and health information is limited for American Indian Alaska Native (AI/AN) workers. Few public health surveillance systems in the United States require collection of industry and occupation. Furthermore, there are no tribal surveillance systems or data sources known to the authors that collect this information. Also, race and ethnicity are often not required in existing occupational safety and health data sources. Although misclassification of AI/AN in death certificate data has been acknowledged for some time (Arias et al., 2008), the COVID-19 pandemic highlighted serious issues with AI/AN data including misclassification of AI/AN race/ethnicity data and missing data (Moy et al., 2006; Yellow Horse & Huyser, 2022). Occupational fatalities occurring on tribal lands and reservations are often not reported to the Occupational Safety and Health Administration (Hill et al., 2013); therefore, work-related fatalities among AI/AN workers are

☆ This article is part of a special issue entitled: 'Diversity, Equity, and Inclusion' published in Journal of Safety Research.

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https://doi.org/10.1016/j.jsr.2025.10.025
Received 19 May 2025; Received in revised form 27 August 2025; Accepted 30 October 2025
Available online 7 November 2025
0022-4375/

likely underestimated.

In 2022, American Indian and Alaska Native (AI/AN) people accounted for approximately 2.6% of the total U.S. population (U.S. Census Bureau, 2022). On average from 2019 to 2021, of AI/AN individuals 16 years of age and older in the United States who consider AI/AN to be their only race, 60.2% were active in the workforce (Brundage, 2023 chart 2 average 2019, 2020, 2021). The percentage of AI/AN individuals working or looking for work was slightly lower (52.4%) for those residing on tribal lands, such as federal or state reservations or trust lands, and slightly higher (63.1%) for AI/AN people living elsewhere (Brundage, 2023 Table 3). Compared to the total U.S. population, AI/AN workers were less likely to work in management, professional, and related occupations and more likely to work in service occupations (Brundage, 2023, Table 4).

Research related to AI/AN people in workforce sectors with the smallest number of AI/AN workers (i.e., agriculture, forestry, and fishing; mining) has been more prevalent compared to sectors with greater numbers of AI/AN workers (i.e., services; healthcare and social assistance) (Wingate et al., 2023). AI/AN workers are more likely to work in high-risk occupations (occupations defined as having a "days away from work" nonfatal injury and illness rate that is two or more times the national rate per 10,000 full time equivalent workers) compared to non-Hispanic White workers (Steege et al., 2014). Furthermore, AI/AN workers are more often employed in job fields requiring lower levels of education (e.g., healthcare support, food preparation) compared to White workers (Liebler, 2018). Though age-specific and age-adjusted death rates among AI/AN persons have been evaluated (Arias et al., 2021), to our knowledge no studies have evaluated percent of deaths by occupational group or evaluated the leading cause of death by occupation or industry for AI/AN workers. It is important to consider a person's occupation and industry when examining mortality, because work is a social determinant of health and can influence physical and mental health, workplace injury, healthcare access, and additional factors that impact the risk of mortality. Working conditions including long working hours, shift work, and occupational sitting, among others, have been shown to increase mortality risk (Gao et al., 2024; Jørgensen et al., 2017; Pega et al., 2021). Workplace hazards and working conditions vary across occupations and industries, and occupational health and safety disparities often overlap with other social disparities (Steege et al., 2023). The purpose of this analysis is to describe the leading causes of death among AI/AN workers by occupation and industry and identify occupations and industries with a disproportionate number of deaths among AI/AN workers to guide potential areas for intervention and education.

Table 1
Causes of death categories and corresponding ICD–10 Codes.

	ICD–10 Codes[*]
All causes	
Heart Disease	I00–I09, I11, I13, I20–I51
Cancer	C00–C97
COVID-19	U07.1
Unintentional injuries	V01–V99, W00–W99, X00–X59, Y85–Y86
Motor vehicle[**]	V02-V04, V09.0, V12-V14, V19.0-V19.2, V19.4-V19.6, V20-V79, V80.3-V80.5, V81.0-V81.1, V82.0-V82.1, V83-V86, V87.0-V87.8, V88.0-V88.8, V89.0, V89.2
Chronic liver disease and cirrhosis	K70, K73–K74
Diabetes mellitus	E10–E14
Chronic lower respiratory disease	J40–J47
Stroke	I60–I69
Suicide	U03, X60–X84, Y87.0
Alzheimer's disease	G30
Kidney disease	N00–N07, N17–N19, N25–N27
Influenza and pneumonia	J09–J18
Homicide	U01–U02, X85–Y09, Y87.1
Septicemia	A40–A41
Hypertension	I10, I12, I15
Pneumonitis due to solids and liquids	J69
All other causes	

[*] International Classification of Diseases, 10th Revision
[**] Subset of "Unintentional injuries".

Table 2
Mortality among the American Indian or Alaska Native workers aged 15 years and older by demographic characteristics: United States, 2020–2022.

	AI/AN Single-race (n = 56,413)		AI/AN Combined Race[a] (n = 76,352)	
	Number	Percent of total deaths	Number	Percent of total deaths
Ethnicity				
Hispanic	3,537	6.3	6,125	8.0
Non-Hispanic	52,816	93.7	70,139	92.0
Sex				
Male	34,854	61.8	46,615	61.1
Female	21,559	38.2	29,737	38.9
Mean age, years (±SD)	63.1 (17.9)		64.2 (17.9)	
15–24 years	1,061	1.9	1,395	1.8
25–34 years	3,715	6.6	4,637	6.1
35–44 years	5,088	9.0	6,260	8.2
45–55 years	6,687	11.9	8,433	11.0
55–64 years	10,989	19.5	14,478	19.0
65–74 years	12,340	21.9	17,028	22.3
75–84 years	10,243	18.2	14,531	19.0
85 years and older	6,290	11.2	9,590	12.6

[a] AI/AN single-race and in combination with any other race(s) (i.e., White, Black, Asian, Native Hawaiian and Other Pacific Islander, or Other, regardless of Hispanic ethnicity).

2. Methods

Mortality data records indicating decedents' race as: (1) 'American Indian/Alaska Native' (AI/AN) single-race or (2) AI/AN single-race and in combination with any other race(s) (i.e., White, Black, Asian, Native Hawaiian and Other Pacific Islander, or Other, regardless of Hispanic ethnicity) were abstracted from 2020, 2021, and 2022 public use multiple cause of death files maintained in the National Vital Statistics System (NVSS, 2024). These groups will be referred to as (1) AI/AN single-race, and (2) AI/AN combined race in this manuscript. AI/AN racial misclassification in death certificate data has been noted in other analyses (Arias et al, 2016). Our analysis includes decedents whose ethnicity was recorded as both Hispanic and non-Hispanic. Since 2020, occupation and industry information from death certificates has been available in the NVSS through a collaboration between the National Institute for Occupational Safety and Health (NIOSH) National Occupational Mortality Surveillance (NOMS) program, the National Center for Health Statistics (NCHS), and Vital Statistics jurisdictions (Steege et al., 2021). Occupation and industry data were available from 47 jurisdictions in 2020 (all included except: North Carolina, Arizona, Iowa, Rhode Island, and Washington, D.C.), from 50 jurisdictions in 2021 (all included except: Rhode Island and Washington, D.C.), and 52 jurisdictions in 2022 (all included) (NIOSH, 2024). For vital statistics purposes, New York City is a separate jurisdiction from New York state.

Records with decedents: (a) 15 years of age and older; (b) residing in the United States; and (c) having both usual industry and usual occupation (coded to 2012 U.S. Census Bureau 4-digit industry and occupation codes) were included in this analysis. Usual occupation is the kind of work a person did during most of his or her working life, such as claim adjuster, teacher, bricklayer. Usual industry is the type of business where the usual occupation was performed, such as an insurance company, elementary school, residential construction. Usual occupation or industry may differ from current occupation or industry at time of death.

Table 3
Mortality among the American Indian or Alaska Native workers aged 15 years and older by usual occupation group: United States, 2020–2022.

Usual occupation group	AI/AN Single-race (n = 56,413)		AI/AN Combined Race[a] (n = 76,352)	
	Number	Percent of total deaths	Number	Percent of total deaths
Construction and extraction	8,967	15.9	11,342	14.9
Production	4,956	8.8	6,731	8.8
Transportation and material moving	4,554	8.1	6,232	8.2
Office and administrative support	3,981	7.1	5,676	7.4
Management	3,890	6.9	5,451	7.1
Building and grounds cleaning and maintenance	3,589	6.4	4,450	5.8
Sales and related	2,796	5.0	4,244	5.6
Food preparation and serving related	3,209	5.7	4,160	5.4
Installation, maintenance, and repair	2,644	4.7	3,703	4.8
Personal care and service	2,614	4.6	3,450	4.5
Education, training, and library	2,008	3.6	2,764	3.6
Healthcare practitioners and technical	1,910	3.4	2,764	3.6
Protective service	1,934	3.4	2,455	3.2
Healthcare support	1,712	3.0	2,306	3.0
Farming, fishing, and forestry	1,818	3.2	2,082	2.7
Arts, design, entertainment, sports, and media	1,297	2.3	1,895	2.5
Community and social services	1,396	2.5	1,824	2.4
Business and financial operations	1,045	1.9	1,563	2.0
Architecture and engineering	633	1.1	1,032	1.4
Military	508	0.9	844	1.1
Life, physical, and social science	394	0.7	543	0.7
Computer and mathematical	283	0.5	469	0.6
Legal	275	0.5	372	0.5

[a] AI/AN single-race and in combination with any other race(s) (i.e., White, Black, Asian, Native Hawaiian and Other Pacific Islander, or Other, regardless of Hispanic ethnicity).

Records without census codes (e.g., industry or occupation coded: missing, homemaker, volunteer, retired) are not included in this analysis (n = 21,826, 22%) as these may reflect decedents outside of the labor force. Among those excluded, 11,334 (52%) had housewife or homemaker coded; 6,529 (30%) had unknown industry or occupation coded; 2,949 (14%) had did not work, child or infant, patient, or inmate coded; 878 (4%) had student coded; 98 (<1%) had retired coded; and 38 (<1%) had student coded. Additionally, 6,211 records were excluded that came from jurisdictions where text for industry or occupation was not submitted and therefore no census code was assigned (Steege et al., 2021). This results in a larger number and proportion of deaths in males due to more females being identified as homemakers. In addition, higher numbers of AI/AN people work in some industries and occupations resulting in more deaths occurring in those industries and occupations. Although a military census code is not used, generic supplementary codes are assigned, so military was included in our analyses as both an industry and occupation. Military occupations and industries include any decedent whose longest held occupation and industry was recorded as military on their death certificate in the industry and occupation fields.

The underlying cause of death—which is the disease or condition

Table 4
Mortality among the American Indian or Alaska Native workers aged 15 years and older by usual industry group: United States, 2020–2022.

Industry group	AI/AN Single-race (n = 56,413)		AI/AN Combined Race[a] (n = 76,352)	
	Number	Percent of total deaths	Number	Percent of total deaths
Construction	8,861	15.7	11,400	14.9
Healthcare and social assistance	6,944	12.3	9,351	12.2
Manufacturing	5,493	9.7	7,844	10.3
Public administration	4,894	8.7	6,083	8.0
Other services (except public administration)	3,525	6.2	4,966	6.5
Retail trade	3,375	6.0	4,954	6.5
Education services	3,631	6.4	4,809	6.3
Accommodation and food services	3,648	6.5	4,807	6.3
Transportation and warehousing	2,983	5.3	4,397	5.8
Agriculture, forestry, fishing, and hunting	3,023	5.4	3,513	4.6
Arts, entertainment, and recreation	2,805	5.0	3,462	4.5
Administrative and support and waste management and remediation services	1,988	3.5	2,736	3.6
Professional, scientific, and technical services	1,131	2.0	1,851	2.4
Mining	988	1.8	1,235	1.6
Finance and insurance	559	1.0	961	1.3
Information	551	1.0	917	1.2
Military	509	0.9	843	1.1
Utilities	592	1.0	804	1.1
Real estate, rental, and leasing	483	0.9	752	1.0
Wholesale trade	358	0.6	555	0.7
Management of companies and enterprises	72	0.1	112	0.1

[a] AI/AN single-race and in combination with any other race(s) (i.e., White, Black, Asian, Native Hawaiian and Other Pacific Islander, or Other, regardless of Hispanic ethnicity).

responsible for initiating events leading to death—was used for all analyses. Underlying cause of death in the mortality file is coded to the International Classification of Disease, 10th Revision (ICD–10) (CDC, 2024). These codes were grouped into the 15 leading causes of death categories for AI/AN people as of 2019 (Arias et al., 2021) as defined by NCHS (Table 1). Due to the large number of deaths attributed to COVID-19 during the time period, we also included a category for death from COVID-19—defined as having an underlying cause of death with ICD–10 code U07.1 (CDC, 2020). In addition, Motor Vehicle-injury deaths—a subset of unintentional injuries—were also included due to the importance of transportation for those working in rural locations.

Among those whose death certificate data indicated AI/AN race, the total number of deaths and corresponding percentages were calculated by demographic characteristics, 15 leading causes of death and deaths from COVID-19, usual occupation group, and usual industry group. Calculations were done for AI/AN single-race and combined race categories as defined above. Differences in percentages of those decedents in each AI/AN category were tested across occupations and industries using a *t*-test for paired samples. No statistically significant differences were found between the two AI/AN groupings.

Age-adjusted proportionate mortality ratios (PMR) and 95% confidence intervals were calculated for usual occupation group and usual industry group for the 15 leading causes of death and deaths from COVID-19 for the AI/AN combined race. The same methods for calculating PMRs were used for all outcomes, including cancer. PMRs evaluate relative mortality using a ratio of two proportions: (1) the proportion of deaths with the underlying cause of death among individuals in a specified industry or occupation group (numerator), and (2) the proportion of deaths from that same condition among all individuals (denominator, in this case, all AI/AN decedents). This ratio is multiplied by 100 (Billock et al., 2023; NIOSH National Occupational Mortality Surveillance (NOMS), 2024a). PMRs were calculated because the number of AI/AN workers in these occupations and industries is not available to allow us to calculate rates. PMRs may be used to identify populations with the highest proportions of deaths from the specified cause of death. In this analysis, direct standardization of the PMR to the total population of AI/AN decedents by 5-year age increments was performed. A separate analysis calculating PMRs among decedents aged 15 through 64 was performed to see if limiting the population to working age decedents would dramatically affect results. The strength of some PMRs changed and some relationships disappeared among causes of death that are more prevalent in older populations; however, the results discussed in this paper were not greatly affected. Authors chose to report PMRs among all decedents, as labor force participation rates have increased among workers aged 65 and older (NIOSH, 2024b).

PMRs range in value from zero to infinity. A value less than 100 indicates an inverse association, equal to 100 indicates no association, and greater than 100 indicates a positive association between the exposure (i.e., occupation or industry) and the cause(s) of death of interest. A PMR is statistically significant when the 95% confidence interval does not include 100 (Robinson et al., 2015). All calculations were done using SAS V. 9.4 (SAS Institute, Inc., Cary, NC).

This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy.[§1].

3. Results

During the time period of this study (2020–2022), 56,413 death records having AI/AN single-race category and 76,352 records having AI/AN combined race category were identified. A similar pattern in demographic characteristics was seen in decedents with AI/AN single-race and AI/AN combined (Table 2). The highest percent of total deaths was observed for those who were of non-Hispanic ethnicity. Of total deaths, 61.8% were male (38.2% female) in the AI/AN single-race category and 61.1% were male (38.9% female) in the AI/AN combined race category. The mean age at death was 63.1 (SD ± 17.9) for AI/AN single-race and 64.2 (SD ± 17.9) for AI/AN combined.

For 2020 to 2022, the usual occupation groups with the highest number and percent of deaths were construction and extraction (AI/AN single 15.9%; AI/AN combined 14.9%), production (AI/AN single and combined 8.8%), and transportation and material moving (AI/AN single 8.1%; AI/AN combined 8.2%) (Table 3).

For 2020 to 2022, the top three industry groups with the highest number and percent of total deaths include construction (AI/AN single 15.7%; AI/AN combined 14.9%), healthcare and social assistance (AI/AN single 12.3%; AI/AN combined 12.2%), and manufacturing (AI/AN single 9.7%; AI/AN combined 10.3%) (Table 4).

The top three causes of death for AI/AN combined race category for 2020 and 2021 by number of deaths were heart disease, COVID-19, and cancer (Table 5). Though the percent of total deaths attributed to COVID-19 in 2020 (13.9%) was less than that of cancer (15.3%), by 2021, COVID-19 was the leading cause of death in AI/AN people (16.9%), followed closely by heart disease (15.4%), then cancer (13.5%). In 2022, heart disease (17.4%) and cancer (15.4%) remained the leading causes of death, with COVID-19 (7.0%) dropping below unintentional injuries (12.2%). For 2020 and 2021, unintentional injuries and chronic liver disease/cirrhosis were the fourth and fifth leading cause of death among AI/AN workers.

[§] See e.g., 45C.F.R. part 46.102(l)(2), 21C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.

3.1. Proportionate mortality ratios (PMRs)

For decedents in the AI/AN combined group, age-adjusted PMRs for the 15 leading causes of death plus COVID-19 by occupation and industry were calculated combining data for the years 2020–2022. PMRs are reported here for the five leading causes of death by occupation (Table 6) and industry (Table 7) with the full 15 leading causes of death available in Appendices 1 and 2.

1. Heart disease

Heart disease was the most common underlying cause of death in this study and included 12,606 deaths, or 16.5% of all deaths over the three years of data among AI/AN combined workers. Age-adjusted PMRs for heart disease varied across occupation and industry groups. There were elevated PMRs (higher proportion of deaths in these occupations than in the total population of all AI/AN decedents) for heart disease deaths among decedents whose occupation was protective service (PMR: 111; 95% C.I. 101, 122), transportation and material moving (PMR: 107; 95% C.I. 101, 112), construction and extraction (PMR: 106; 95% C.I. 102, 110), and production (PMR: 105; 95% C.I. 101, 110). Elevated PMRs were also seen for decedents employed in manufacturing (PMR: 109; 95% C.I. 104, 113) and construction industries (PMR: 105; 95% C.I. 101, 109).

2. Cancer

Cancer was the second most common cause of death and included 11,190 deaths, or 14.7%, over the three years of data among AI/AN combined workers. Elevated cancer PMRs were observed among AI/AN decedents working in computer and mathematical (PMR: 130; 95% C.I. 105, 160), life, physical, and social science (PMR: 128; 95% C.I. 104, 155), business and financial operations (PMR: 122; 95% C.I. 108, 136), management (PMR: 114; 95% C.I. 107, 121), education, training, and library (PMR: 112; 95% C.I. 102, 122), and office and administrative support occupations (PMR: 108; 95% C.I. 101, 115). Cancer PMRs were also elevated for AI/AN workers in finance and insurance (PMR: 124; 95% C.I. 107, 144), real estate and rental and leasing (PMR: 120; 95% C.I. 101, 141), professional, scientific, and technical service (PMR: 114; 95% C.I. 102, 127), and education services industries (PMR: 109; 95% C.I. 102, 117).

3. COVID-19

COVID-19 was the third most common cause of death and included 9,704 deaths, or 12.7%, over the three years of data among AI/AN combined workers. COVID-19 PMRs were elevated among AI/AN workers in community and social services (PMR: 130; 95% C.I. 116, 145) and transportation and material moving occupations (PMR: 111; 95% C.I. 104, 118). COVID-19 PMRs were also elevated for workers in mining (PMR: 130, 95% C.I. 113, 150), utilities (PMR: 125; 95% C.I. 105, 148), transportation and warehousing (PMR: 111; 95% C.I. 103, 120), public administration (PMR: 110; 95% C.I. 102, 117), retail trade (PMR: 109; 95% C.I. 101, 117), and healthcare and social assistance industries (PMR: 108; 95% C.I. 104, 113).

4. Unintentional injuries and motor-vehicle injuries

Unintentional injuries including motor-vehicle events included 8,001 deaths, or 10.5%, over the three years of data among AI/AN combined workers. Unintentional injury PMRs and motor-vehicle injury PMRs, a subset of unintentional injuries, were elevated in both occupation and industry groups. Unintentional injury PMRs were elevated among AI/AN workers in construction and extraction (PMR: 126; 95% C.I. 122, 130) and farming, fishing, and forestry occupations (PMR: 121; 95% C.I. 107, 136) as well as construction and agriculture, forestry,

Table 5
Number of deaths and percent of total deaths by the 15 leading causes of death and COVID-19 for American Indian or Alaska Native workers[a]: United States, 2020–2022.

Cause of death	2020[b] (n = 21,466) Number	Percent of total deaths	2021[c] (n = 28,918) Number	Percent of total deaths	2022[d] (n = 25,968) Number	Percent of total deaths	Total (n = 76,352) Number	Percent of total deaths
Heart disease	3,643	17.0	4,454	15.4	4,509	17.4	12,606	16.5
Cancer	3,277	15.3	3,909	13.5	4,004	15.4	11,190	14.7
COVID-19	2,991	13.9	4,895	16.9	1,818	7.0	9,704	12.7
Unintentional injuries	1,911	8.9	2,932	10.1	3,158	12.2	8,001	10.5
Motor vehicle	675	2.0	434	2.3	705	2.7	1,814	2.4
Chronic liver disease and cirrhosis	1,076	5.0	1,722	6.0	1,503	5.8	4,301	5.6
Diabetes mellitus	1,038	4.8	1,335	4.6	1,229	4.7	3,602	4.7
Chronic lower respiratory disease	829	3.9	978	3.4	1,015	3.9	2,822	3.7
Stroke	761	3.5	923	3.2	917	3.5	2,601	3.4
Suicide	538	2.5	697	2.4	698	2.7	1,933	3.4
Alzheimer's disease	426	2.0	450	1.6	458	1.8	1,334	1.8
Kidney disease	318	1.5	412	1.4	441	1.7	1,171	1.5
Influenza and Pneumonia	331	1.5	324	1.1	395	1.5	1,050	1.4
Homicide	251	1.2	331	1.1	385	1.5	967	1.3
Septicemia	215	1.0	288	1.0	297	1.1	800	1.1
Hypertension	222	1.0	298	1.0	271	1.0	791	1.0
Pneumonitis due to solids and liquids	84	0.4	115	0.4	105	0.4	304	0.4
All other	3,555	16.6	4,855	16.8	4,765	18.4	13,175	17.3

[a] AI/AN single-race and in combination with any other race(s) (i.e., White, Black, Asian, Native Hawaiian and Other Pacific Islander, or Other, regardless of Hispanic ethnicity).
[b] 2020 includes 46 jurisdictions (missing data from Arizona, Iowa, North Carolina, Rhode Island, and Washington, D.C.
[c] 2021 includes 50 jurisdictions (missing data from Rhode Island and Washington, D.C.).
[d] 2022 includes data from all jurisdictions 50 states, New York City and Washington, D.C.

fishing and hunting industries (PMR: 127; 95% C.I. 123, 131, and PMR: 115; 95% C.I. 104, 127, respectively). Motor-vehicle injury PMRs were elevated among AI/AN workers in installation, maintenance, and repair (PMR: 139; 95% C.I. 115, 167); management (PMR: 130 95% C.I. 106, 157); and construction and extraction occupations (PMR: 120; 95% C.I. 108, 132). Motor-vehicle injury PMRs were elevated among AI/AN workers in real estate and rental and leasing (PMR: 169; 95% C.I. 105, 259), transportation and warehousing (PMR: 124; 95% C.I. 101, 150), and construction industries (PMR: 122, 95% C.I. 110, 134).

5. Chronic liver disease and cirrhosis

Chronic liver disease or cirrhosis deaths including alcoholic liver disease, chronic hepatitis, and fibrosis and cirrhosis of liver included 4,301 deaths, or 5.6%, over the three years of data among AI/AN combined workers. Chronic liver disease and cirrhosis PMRs were elevated among AI/AN workers who worked in food preparation and serving related occupations (PMR: 128; 95% C.I. 116, 142) and office and administrative support occupations (PMR: 118; 95% C.I. 106, 131) as well as accommodation and food services (PMR: 128; 95% C.I. 116, 140), public administration (PMR: 126; 95% C.I. 114, 140), and arts, entertainment, and recreation industries (PMR: 116; 95% C.I. 103, 130).

3.2. *Highest PMRs overall*

Causes of death and occupations with the highest PMRs were suicide among military occupations (PMR: 224, 95% C.I. 155, 313), suicide among computer and mathematical occupations (PMR: 179; 95% C.I. 108, 280), homicide among construction and extraction occupations (PMR: 171, 95% C.I. 153, 191), hypertension among arts, design, entertainment, sports, and media occupations (PMR: 169, 95% C.I. 115, 240), and Alzheimer's disease (AD) among office and administrative support occupations (PMR: 141, 95% C.I. 120, 165) (Appendix 1). The highest industry-specific PMRs were suicide among military industries (PMR: 229, 95% C.I. 165, 310), suicide within the utilities industry (PMR: 180, 95% C.I. 119, 262), hypertension within the information industry (PMR: 170, 95% C.I. 101, 268), homicide within the construction industry (PMR: 169, 95% C.I. 151, 189), and lastly, motor-vehicle injuries within the real estate and rental and leasing industry (PMR: 169, 95% C.I. 105, 259) (Appendix 2).

4. Discussion

There are few published studies on AI/AN workers in general, and particularly on mortality by the decedents' usual occupation and industry. Our results show that the highest percentage of deaths for AI/AN workers occurred in the construction and extraction occupation group, followed by production occupations, and transportation and material moving occupations. Industries with the highest percentage of deaths for AI/AN also occurred in the construction industry, followed by the healthcare and social assistance industry, and the manufacturing industry.

In addition, our results show that the top three leading causes of death among AI/AN from 2020 to 2022 overall were cancer, heart disease, and COVID-19. Earlier studies among AI/AN populations reported similar leading causes of death, with the exception of COVID-19 (Arias et al., 2021; Jacobs-Wingo et al., 2016. These results are interesting in light of our results, which also show high PMRs for these diseases in relation to work in specific occupations and industries.

Certain factors integral to a job may contribute to disease outcomes, which will be considered here. To our knowledge, this is the first report on AI/AN workers' leading causes of death by occupation and industry.

1. Heart disease and hypertension

Heart disease PMRs were elevated in individuals who worked in construction and extraction, production, and transportation and material moving occupation groups. Individuals who work in these occupations frequently experience workplace factors that have been shown to be associated with heart disease (Makar et al., 2024; Ollay et al., 2024).

Table 6
Age-adjusted proportionate mortality ratios by the 5 leading causes of death by usual occupation for American Indian or Alaska Native workers[a]: United States, 2020–2022.

Occupation group	Heart disease PMR (95% CI)	Cancer PMR (95% CI)	COVID-19 PMR (95% CI)	Unintentional injury PMR (95%CI)	Motor vehicle (subset of unintentional injuries) PMR (95%CI)	Chronic liver disease and cirrhosis PMR (95%CI)
Architecture and engineering	108 (94, 123)	106 (91, 123)	94 (79, 112)	91 (69, 117)	128 (75, 205)	97 (68, 133)
Arts, design, entertainment, sports, and media	87 (76, 98)	105 (93, 118)	88 (77, 101)	113 (99, 128)	79 (56, 107)	105 (87, 125)
Building and grounds cleaning and maintenance	97 (89, 104)	87 (80, 95)	101 (93, 109)	99 (91, 108)	89 (73, 108)	109 (97, 122)
Business and financial operations	106 (94, 119)	**122 (108, 136)**	96 (83, 110)	72 (57, 88)	69 (40, 110)	88 (68, 111)
Community and social services	95 (85, 106)	104 (93, 116)	**130 (116, 145)**	87 (71, 106)	117 (77, 170)	61 (45, 82)
Computer and mathematical	118 (95, 145)	**130 (105, 160)**	97 (74, 125)	54 (36, 79)	–	100 (68, 142)
Construction and extraction	**106 (102, 110)**	93 (89, 97)	84 (80, 89)	**126 (122, 130)**	**120 (108, 132)**	100 (94, 108)
Education, training, and library	90 (83, 99)	**112 (102, 122)**	104 (94, 115)	71 (59, 85)	83 (55, 121)	115 (95, 138)
Farming, fishing, and forestry	107 (96, 118)	86 (76, 97)	91 (80, 103)	**121 (107, 136)**	104 (78, 136)	90 (74, 109)
Food preparation and serving related	89 (82, 97)	91 (83, 100)	91 (83, 100)	96 (89, 104)	73 (61, 87)	**128 (116, 142)**
Healthcare practitioners and technical	93 (85, 102)	99 (90, 109)	107 (96, 118)	89 (77, 103)	100 (71, 136)	87 (71, 106)
Healthcare support	90 (81, 100)	100 (90, 111)	95 (84, 107)	92 (81, 106)	83 (60, 111)	102 (86, 121)
Installation, maintenance, and repair	108 (100, 117)	99 (91, 108)	95 (87, 104)	110 (99, 121)	**139 (115, 167)**	91 (79, 105)
Legal	79 (59, 103)	107 (83, 136)	104 (78, 136)	113 (76, 163)	–	115 (70, 178)
Life, physical, and social science	97 (78, 119)	**128 (104, 155)**	98 (76, 125)	116 (89, 149)	136 (78, 221)	105 (71, 150)
Management	97 (91, 104)	**114 (107, 121)**	106 (98, 114)	87 (78, 97)	**130 (106, 157)**	90 (78, 103)
Office and administrative support	93 (87, 99)	**108 (101, 115)**	103 (95, 110)	74 (67, 81)	71 (57, 88)	**118 (106, 131)**
Personal care and service	95 (87, 104)	96 (88, 105)	105 (96, 115)	93 (85, 103)	87 (70, 108)	99 (86, 113)
Production	**105 (101, 110)**	94 (89, 101)	107 (100, 114)	102 (94, 111)	101 (84, 121)	92 (82, 104)
Protective service	**111 (101, 122)**	93 (83, 103)	112 (100, 124)	79 (69, 89)	98 (76, 124)	107 (92, 124)
Sales and related	101 (93, 109)	107 (99, 116)	103 (94, 112)	92 (84, 100)	82 (68, 99)	109 (96, 122)
Transportation and material moving	**107 (101, 112)**	94 (88, 101)	**111 (104, 118)**	103 (95, 111)	116 (99, 134)	75 (66, 84)
Military	108 (93, 126)	115 (97, 135)	78 (62, 97)	77 (56, 102)	135 (82, 208)	102 (69, 145)

– Indicates fewer than 10 decedents in occupation group who died of this condition.
PMR=Proportionate mortality ratio.
CI=Confidence interval.
Bold text indicates statistical significance at the $p < 0.05$ level.
[a] AI/AN single-race and in combination with any other race(s) (i.e., White, Black, Asian, Native Hawaiian and Other Pacific Islander, or Other, regardless of Hispanic ethnicity).

For example, low physical activity level and sedentary behavior is associated with heart disease (Carter et al., 2017; Park et al., 2020). White collar jobs tend to be more sedentary compared to blue-collar jobs. However, while blue-collar workers often spend work time standing, they are less likely to participate in physical activity outside of work compared to white collar workers (Moreno-Llamas et al., 2023; Pulakka et al., 2018). Prolonged exposure to physical hazards such as heat, vibration, and noise is also linked to heart disease and potential exposures that workers in construction, transportation and material moving, and production occupations might experience (Freitas et al., 2021; Gibb et al., 2024; Krajnak, 2018; Sokolski & Sokolska, 2022). Lastly, individuals who work in transportation and material moving or production occupations frequently work in shifts, which is associated with heart disease (Ha & Park, 2005; Makar et al., 2024; Rudin-Brown et al., 2019). Further research may help clarify if these risk factors are relevant for AI/AN workers, or if there are additional factors unique to this worker population for focused intervention and prevention.

In addition to workplace factors, hypertension is also a major risk factor for heart disease (Kokubo & Matsumoto, 2017). Hypertension PMRs were among the highest PMRs in this population for AI/AN who worked in arts, design, entertainment, sports, and media occupations and the information industry. The prevalence of hypertension among AI/AN people has increased over time and is higher than for other race/ethnicities (Hutchinson & Shin, 2014; Rhoades et al., 2007). Risk factors for hypertension include the presence of comorbid conditions including obesity, diabetes, and microalbuminuria (Wang et al., 2006). Shockey et al. (2017) reported that individuals who worked in arts, design, entertainment, sports, and media had the highest adjusted prevalence

Table 7
Age-adjusted proportionate mortality ratios by the 5 leading causes of death by usual industry for American Indian or Alaska Native workers[a]: United States, 2020–2022.

Industry group	Heart disease PMR (95% CI)	Cancer PMR (95% CI)	COVID-19 PMR (95% CI)	Unintentional injuries PMR (95%CI)	Motor vehicle (subset of unintentional injuries) PMR (95%CI)	Chronic liver disease and cirrhosis PMR (95%CI)
Accommodation and food services	90 (83, 98)	92 (84, 100)	91 (84, 100)	97 (90, 104)	77 (66, 90)	**128 (116, 140)**
Administrative and support and waste management and remediation services	102 (92, 112)	91 (82, 101)	94 (84, 104)	100 (90, 111)	93 (74, 116)	92 (79, 106)
Agriculture, forestry, fishing and hunting	101 (93, 109)	87 (80, 96)	100 (91, 109)	**115 (104, 127)**	112 (90, 138)	87 (74, 102)
Arts, entertainment, and recreation	100 (91, 109)	94 (85, 103)	100 (91, 110)	96 (87, 105)	81 (65, 100)	**116 (103, 130)**
Construction	**105 (101, 109)**	96 (91, 100)	81 (77, 86)	**127 (123, 131)**	**122 (110, 134)**	102 (95, 109)
Education services	89 (83, 95)	**109 (102, 117)**	108 (100, 116)	78 (68, 89)	102 (77, 132)	94 (81, 110)
Finance and insurance	98 (84, 114)	**124 (107, 144)**	85 (70, 103)	76 (58, 98)	88 (48, 148)	84 (60, 115)
Healthcare and social assistance	90 (86, 94)	103 (99, 107)	**108 (104, 113)**	87 (81, 94)	97 (83, 112)	97 (88, 106)
Information	95 (81, 112)	98 (83, 116)	96 (80, 116)	88 (68, 111)	–	93 (66, 127)
Management of companies and enterprises	116 (75, 171)	101 (60, 159)	96 (53, 162)	–	–	–
Manufacturing	**109 (104, 113)**	99 (94, 104)	100 (95, 106)	102 (94, 110)	108 (92, 128)	89 (79, 99)
Mining	99 (86, 114)	100 (86, 115)	**130 (113, 150)**	92 (77, 110)	122 (86, 168)	82 (62, 106)
Other services (except public administration)	106 (99, 113)	95 (88, 102)	100 (92, 108)	108 (99, 118)	115 (95, 136)	89 (78, 100)
Professional, scientific, and technical services	104 (93, 116)	**114 (102, 127)**	90 (78, 103)	88 (74, 103)	99 (70, 137)	99 (80, 120)
Public administration	98 (93, 103)	99 (93, 106)	**110 (102, 117)**	76 (68, 84)	88 (70, 108)	**126 (114, 140)**
Real estate and rental and leasing	104 (88, 123)	**120 (101, 141)**	88 (70, 108)	112 (87, 142)	**169 (105, 259)**	94 (65, 133)
Retail trade	101 (94, 109)	105 (97, 113)	**109 (101, 117)**	85 (79, 93)	72 (60, 86)	100 (90, 112)
Transportation and warehousing	106 (99, 113)	102 (94, 110)	**111 (103, 120)**	99 (90, 110)	**124 (101, 150)**	71 (61, 83)
Utilities	97 (82, 115)	110 (93, 130)	**125 (105, 148)**	90 (69, 115)	89 (48, 153)	73 (48, 105)
Wholesale trade	106 (86, 130)	113 (91, 139)	94 (73, 120)	93 (71, 120)	107 (61, 173)	103 (71, 144)
Military	106 (92, 122)	114 (98, 131)	76 (62, 92)	79 (61, 102)	140 (91, 207)	106 (75, 145)

– Indicates fewer than 10 decedents in occupation group who died of this condition.
PMR=Proportionate mortality ratio.
CI=Confidence interval.
Bold text indicates statistical significance at the $p < 0.05$ level.
[a] AI/AN single-race and in combination with any other race(s) (i.e., White, Black, Asian, Native Hawaiian and Other Pacific Islander, or Other, regardless of Hispanic ethnicity).

for overall unhealthy days, frequent mental distress, and low levels of physical activity. Similarly, this occupation has one of the highest prevalences of non-standard work arrangements including temporary positions and alternative shifts (Alterman et al., 2013). Work in this occupation has also been found to be associated with higher work demands that make work-life balance difficult resulting in high levels of stress (Schieman & Young, 2010). Although the studies mentioned above do not specifically evaluate hypertension, shift work, job stress, and noise, they have independently been found to be associated with hypertension at work (Kang, 2022) and may account for the high rates of hypertension observed in this population working in these occupations and industries.

2. Cancer

Cancer was also a leading cause of death. In this population, high cancer PMRs were associated with education, training, and library occupations and the education services industry. These results are similar to previous research that found higher rates of cancer in the teaching profession, particularly for breast cancer (Rafeemanesh et al., 2018). Overall evidence suggests that occupational exposure to carcinogens is related to socio-professional categories (Kroenke & Kawachi, 2017). In general, manual or blue-collar workers are more likely to be exposed to carcinogens, which can reflect the social inequalities observed in cancer incidence (Kawachi & Kroenke, 2009). In contrast, elevated cancer PMRs in our study were mostly associated with white collar work including business and financial operations occupations, computer and mathematical, management, and office and administrative support occupations. This may reflect other social determinants of health seen in this population (Melkonian et al., 2024). For example, AI/AN people are more likely to use commercial tobacco and less likely to adhere to cancer screening recommendations in comparison to other race or ethnicity groups (Welch et al., 2024) due to limited resources and barriers to screening and treatment (Haozous, 2020; Roubidoux et al., 2022). These factors may contribute to the results we see here.

3. COVID-19

AI/AN people were disproportionately affected by COVID-19 compared to other races and ethnicities, experiencing higher rates of infection, hospitalization, and death (Hill et al., 2022; Yellow Horse & Huyser, 2022). In this study, COVID-19 was the third leading cause of death in 2020 and 2021, and the fourth in 2022, falling just below unintentional injuries. COVID-19 PMRs were highest among AI/AN workers in community and social services and transportation and material moving occupations and mining, utilities, and transportation and warehousing industries. Billock (2022), also using 2020 NVSS data, found elevated COVID-19 PMRs in non-Hispanic AI/AN workers and non-Hispanic Whites who worked in community and social service occupations. COVID-19 PMRs were also elevated for the healthcare and social assistance industry, which accounted for the second highest percentage of deaths by industry group in this population. Similarly, a study that evaluated COVID-19 mortality in Massachusetts found that workers in healthcare support occupations had high COVID-19 mortality rates (Hawkins et al., 2021). This was further supported by research analyzing National Health Interview Survey (NHIS) data (Gaffney et al., 2023), which found that the health care and social assistance industry had one of the highest proportions of workers who experienced COVID-19. In general, risk factors associated with higher rates of COVID-19 with work in the healthcare and social assistance industry included ongoing and prolonged exposure to infected patients, performing procedures such as intubation that increased the chances of exposure to infected aerosols, lack of personal protective equipment, or lack of adherence to or training on infection control practices (Mhango et al., 2020; Sharma et al., 2023). Individual level factors associated with a higher risk of infection and severity in this worker group included being male, being either AI/AN or Black, and the presence of underlying health conditions such as diabetes, obesity, and cardiovascular disease (Carethers, 2021). Additional risk factors associated with an increased risk of COVID-19 infection were foreign native language and lower socioeconomic background (Chadeau-Hyam et al., 2020; Kääriäinen et al., 2023). These results, including ours, indicate that occupation and race/ethnicity differences were important factors in COVID-19 and death rates. Targeted public health messaging, vaccination, access to personal protective equipment, and training on infection control can reduce the risk of COVID-19 infection and death.

Similar to our results that showed that COVID-19 PMRs were highest among AI/AN workers in transportation and material moving occupations and mining, utilities, and transportation and warehousing industries, Billock et al. (2022) using 2020 data also found elevated COVID-19 PMRs in the transportation and warehousing industry. Though not in industries, these results are supported by two other studies conducted in Massachusetts and California that reported increased COVID-19 mortality rates for workers in material moving and transportation occupations (Cummings et al., 2022; Hawkins et al., 2021). Although race was considered in these two studies, AI/AN workers were not evaluated (Cummings et al., 2022; Hawkins et al., 2021). Furthermore, although neither of these studies found elevated mortality rates of COVID-19 in workers in the mining and utilities industry, both found elevated rates of COVID-19 mortality in construction and extraction occupations. Extraction includes some mining processes. In contrast, the NHIS study in all workers regardless of race found that workers in the mining and utilities industries had a high prevalence of COVID-19 (Gaffney et al., 2023). In fact, utilities was one of the industries with the highest proportion of workers with COVID-19. Risk factors in material moving and transportation occupations and transportation and warehousing and mining and utilities industry groups include the presence of preexisting conditions, shiftwork, temporary work, close physical proximity, public interaction, insufficient use of protective equipment, and lower rates of vaccination (Gaffney et al., 2023; Menezes-Júnior et al., 2023; Nascimento et al., 2022; Öngel et al., 2022; Sokale et al., 2022). These risk factors may indicate areas in which intervention could reduce illness and death among AI/AN workers in the mining and utilities industry.

4. Unintentional injuries and motor vehicle injuries

Unintentional injury and motor-vehicle injury PMRs were elevated among AI/AN workers in construction and extraction occupations and the construction industry. Construction is considered one of the most hazardous work environments with both high rates of injuries and death (Tripathi & Mittal, 2024). Deaths as a result of unintentional injury and motor-vehicle injury in this population are consistent with a Bureau of Labor Statistics study that found that factors such as falls, transportation events, being hit by an object, electrocution, and exposure to harmful substances were leading causes of death for individuals working in construction (Gray, 2007). A number of factors contribute to construction being a high-risk occupation including unsafe worksites and practices and inadequate communication (Pandit et al., 2019; Tripathi & Mittal, 2024). Individual level factors such as stress, burnout, and social insensitivity within the work environment can affect workers. These factors affect workplace safety and cohesion, decreasing safety on the worksite (Pandit et al., 2019; Ramadan et al., 2022). Injury prevention should be based on the hierarchy of controls including elimination, substitution and engineering controls to control hazardous exposures because they remove possible human error (CDC, 2024). Secondarily, a positive safety climate, effective risk and safety communication, and management and education on cultural differences can help reduce injury and death at construction sites (Tripathi & Mittal, 2024).

5. Chronic liver disease and cirrhosis

Chronic liver disease or cirrhosis deaths was the fifth highest cause of death for AI/AN combined workers. PMRs were elevated in two occupation groups (food preparation and serving related occupations, and office and administrative support occupations) and three industry groups (accommodation and food services, public administration, and arts entertainment and recreation industries). A study using older vital statistics data for workers of all races (1999–2014) found elevated alcoholic liver disease (a subset of Chronic liver disease and cirrhosis) PMRs for food preparation and service occupations (PMR = 132), and arts, design, entertainment, sports and media occupations (PMR = 115) but not office and administrative support occupations (PMR = 84) (Rayhall, 2022). Unlike our results they also found elevated PMRs for construction workers (PMR = 141) and grounds maintenance workers and supervisors (PMR = 126) and farming, forestry and fishing occupations (PMR = 119) (Rayhall, 2022). Lifestyle factors may play a part in these differences.

Infectious agents can also be risk factors for occupational liver disorders. Hepatitis B and C viruses have been risk factors for liver disorders among workers in healthcare and solid-waste management workers, and Hepatitis E virus in workers with exposure to swine (Levy, 2017). The current study did not see elevated chronic liver disease and cirrhosis PMRs in healthcare workers or in agriculture, forestry, fishing and hunting industries or farming, fishing, and forestry occupations, either. A study of chronic liver disease among AI/AN patient populations in the southwestern United States implicated alcohol and hepatitis C, and a combination of the two. In approximately one third of cases no cause was found, although many had not been tested for Hepatitis C (Bialek et al., 2008).

The literature includes associations between numerous chemicals found in the workplace and liver injury with different balances of toxin and host factors determining the extent of injury. These toxic liver conditions are not included in the category ‘Chronic liver disease and cirrhosis’ that we utilize for this study. Granulomatous hepatitis can result from infectious disease potentially related to occupation, but this is also excluded in the chronic liver disease and cirrhosis leading cause of death category. Exclusion of toxic liver disease from the chronic liver disease and cirrhosis cause of death category precludes us from evaluating their relationship to industry and occupation in this analysis. Future research may help clarify this among AI/AN workers.

4.1. Other causes of death with high PMRs for specific occupations and industries

Homicide PMRs were also elevated among AI/AN people who worked in construction and extraction occupations and the construction industry. A study that evaluated the resident population aged 16 years old or older employed from 2006 to 2009 in Georgia reported that homicide PMRs were significantly elevated for construction and extraction occupations (Lavender et al., 2016). Lavender et al. (2016) also found that the most common circumstances leading to homicide in workers overall included conflict over property, drugs or something other than money, abuse, an argument, intimate partner violence, or while committing another crime. Lavender (2016) did not evaluate differences in deaths by race. Although homicide is not a common cause of death on construction sites, the lack of safety training and personal protective equipment, the presence of skilled and unskilled workers, and frequent crew rotation are associated with homicide (Ichniowski, 2013; Kanchana et al., 2015; Namian et al., 2022; Pandit et al., 2019). Furthermore, safety issues, unintentional injuries, and fatalities on the worksite may exacerbate feelings of burnout and stress resulting in acts of violence (van Heerden et al., 2021; Zhou et al., 2022). Research evaluating unintentional injuries in Hispanic and migrant construction workers that may also be relevant among AI/AN workers have found that factors such as language barriers, discrimination while on the job, and cultural differences may also contribute to higher homicide PMRs in construction workers (Canales et al., 2009; Jaselskis et al., 2008; Ling et al., 2013). Trust, appropriate and respectful communication and policies may reduce homicide deaths among AI/AN workers in construction (Canales et al., 2009; Kang et al., 2016; Sang & Powell, 2013). However, further research is important to clarify the specific risk factors associated with high homicide rates and potential protective factors among AI/AN construction workers.

In this study, the highest PMRs were observed for suicide among AI/AN people who worked in the military, computer and mathematical occupations, and utilities industry groupings. Suicide rates among AI/AN military personnel have been found to be high; having doubled over the last 15-year period from 19.1/100,00 in 2004–2008 to 47.0/100,000 in 2014–2018 and are 1.5 times that of their White non-Hispanic military counterparts (Brenner et al., 2023; Mohatt et al., 2022). Suicide risk is multifactorial including presence of psychological conditions such as posttraumatic stress and depression, previous trauma, socioeconomic factors, interpersonal loss or stress, and substance use (Bachmann, 2018; Prieto & Tavares, 2005) which could be related to their military experience. Being aware of the high rates of suicide among AI/AN persons with careers in the military allows tribes, tribal organizations, and veteran support groups to focus resources on identifying risk factors and protective factors specific to them to help treat and prevent suicide.

The high suicide PMRs for AI/AN workers in computer and mathematical occupations conflicts with previous research, which in general found that suicide rates in computer and mathematical occupations are lower compared to occupations such as farming, fishing, and forestry; construction and extraction; and arts, design, entertainment, sports, and media (Stallones et al., 2013; Sussell et al., 2023). One of these studies was conducted using the Colorado National Violent Death Reporting System (CONVDRS) and another using 2021 National Vital Statistics System (Stallones et al., 2013; Sussell et al., 2023). The CONVDRS data consisted of White males and females, while the NVSS data consisted of individuals aged 16–64 from 49 states, excluding Rhode Island and the District of Columbia. Neither of these studies evaluated suicide rates among AI/ANs by occupation. It is not clear why suicide PMRs may be high among AI/AN people who work in computer and mathematical occupations and it would be beneficial to further examine this finding to better understand the causes and potential interventions. Higher suicide PMRs observed for different occupations and industries are likely the result of a complex interplay of factors such as work stress, access to means, and the presence of mental health challenges (Boxer et al., 1995). Among AI/AN people, these issues may be further exacerbated by factors such as historical trauma, impact of colonization, hopelessness, and family conflict (Colon, 2024; Strickland et al., 2006). With this in mind, engagement in tribal cultural practices, emphasizing family and community, and building resilience may help reduce suicide rates (Bogic et al., 2024; Strickland et al., 2006; Wiglesworth et al., 2022; Yoder et al., 2006).

Alzheimer's disease PMRs stood out in this population. Alzheimer's disease PMRs were high among AI/AN workers in office and administrative support occupations and finance and insurance industries. There is no direct evidence linking Alzheimer's disease to administrative and office occupations or finance industries. However, there are both physical and mental risk factors associated with work in these fields that are also associated with Alzheimer's disease (Evstatieva et al., 2012; Fida et al., 2011; Forstmeier & Maercker, 2009; Govindugari et al., 2023; Mahamed et al., 2024; Oliosi et al., 2023). For example, work in office and administrative support and the finance industry is associated with risk factors such as prolonged sitting, lack of physical activity, and high levels of stress (Evstatieva et al., 2012; Fida et al., 2011; Mahamed et al., 2024; Oliosi et al., 2023). Extended periods of sitting and lack of physical activity are associated with cardiovascular disease, diabetes, and obesity and have been found to negatively affect cognitive functions including memory, executive function, and attention (Baker et al., 2018; Chandrasekaran et al., 2021; Dunstan et al., 2011). High work demands and workload combined with low levels of control are associated with high levels of stress in these occupations, which is associated with Alzheimer's disease (Anant et al., 2021; Jiang et al., 2013; Wang et al., 2012). In addition to chronic stress, obesity, lack of physical activity, hypertension and diabetes are also associated with Alzheimer's disease (Forstmeier & Maercker, 2009; Govindugari et al., 2023). In general, regardless of the type of occupation or industry, research indicates that AI/AN people have higher rates of obesity, diabetes, and lower levels of physical activity than other races and ethnicities (Bersamin et al., 2014; Zamora-Kapoor et al., 2019). Therefore, chronic stress in combination with the higher rates of diabetes, obesity, and low physical activity in individuals who work in finance or office and administration may explain the results observed here.

4.2. Limitations and Strengths

Limitations of this research include the likelihood of missing race data and therefore an underestimate of the number of deaths for each occupation and industry evaluated here. Arias et al (2021) found that 34% of non-Hispanic AI/AN decedents' race is misclassified on death certificates, so they adjusted for misclassification of Hispanic origin and race in the data (Arias et al., 2008; Arias et al., 2016; Arias et al., 2019). Since we are including both Hispanic and non-Hispanic AI/AN, as well as AI/AN combined with other races, it is not appropriate to use the classification ratios available in Arias et al. There is a need for more data sources as well as more complete race classification particularly for AI/AN workers. In addition, results from four states (North Carolina, Arizona, Iowa, Rhode Island) plus Washington, DC in 2020 and Rhode Island and Washington, DC in 2021 are not included due to unavailable industry and occupation data. Another potential limitation is that the death certificate specifies usual or longest held industry and occupation, which may not be the decedent's industry and occupation at time of death. This would be important to consider for acute causes of death such as COVID-19, and unintentional injuries including motor-vehicle-related deaths where a person's previous industry and occupation would not be relevant.

A strength of this study is that PMRs are useful for describing the distribution of industry and occupation deaths by disease when population data are not available to calculate rates. While data describing labor force characteristics among U.S. workers does exist, AI/AN is often excluded from detailed analyses examining race and ethnicity, making the calculation of rates inaccurate if not impossible (Brundage, 2023). Caution needs to be exercised in interpretation of PMRs; PMRs can only be compared within a cause of death category, not across causes of death since one is comparing the proportion of deaths from "cause X" for workers in a specific industry (or occupation) to the proportion of deaths from "cause X" in all workers. This is the first study to evaluate the 15 leading causes of death and COVID-19 by occupation and industry among AI/AN workers. Census industry and occupation codes were only included in U.S. mortality data starting with 2020 (Steege et al., 2021). For 2022, industry and occupation are included for all U.S. jurisdictions. This makes it possible to describe the distribution of industry and occupation by cause of death in specific populations, such as AI/AN workers.

5. Conclusion and Practical Applications

Work is an important social determinant of health. It is important for one's sense of purpose and well-being (Ward & King, 2017). However, as demonstrated in our study, work factors can also be associated with disproportionate mortality. Little data exist on mortality among AI/AN workers in general but particularly associated with occupation and industry (Wingate et al., 2023). Lack of data is a result of missing data, racial misclassification, and AI/AN often being collapsed into the "other" race category (Arias et al., 2021; Duke et al., 2019). This lack of data interferes with tribes, tribal organizations, and tribal leaders' ability to identify high-risk occupations and industries for AI/AN workers and ultimately how to protect those workers. This work aims to contribute to filling this gap and shows that there is significant variation in mortality for AI/AN workers across occupation and industry groups.

Our results highlight occupations and industries in which a high percent of deaths occurred as well as which occupations and industries were associated with the highest PMR. The results of this study can be used by tribes, tribal organizations, tribal leaders, researchers, and others to develop and implement prevention and control methods. These data can be used to identify risk factors specific to the AI/AN population and reduce injury and death. Further research can help identify gaps in training, knowledge, and more accurate data that can be used to improve the accuracy and reliability of intervention and prevention recommendations. This is critical to reduce and prevent work-related morbidity and mortality among AI/AN workers.

CRediT authorship contribution statement

Kaitlin C. Wingate: Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation, Conceptualization. **Erin McCanlies:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Investigation, Conceptualization. **Andrea L. Steege:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **W. Karl Sieber:** Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Elizabeth Dalsey:** Writing – review & editing, Writing – original draft, Resources, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors thank the following reviewers: Sarah Hatcher, Kyla Hagan-Haynes, Sara Luckhaupt, Ryan Hill, Marie de Perio, Ari Miniño, Robert Anderson.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsr.2025.10.025.

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