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HISTORICAL PERSPECTIVE

Workplace Injury and Death: A National Overview of Changing Trends by Sex, United States 1998–2022

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ABSTRACT

Women represent a substantial portion of the US workforce. However, injury and fatality rates for female workers have, historically, remained lower than rates for male workers. Fatal occupational data from the Census of Fatal Occupational Injuries (CFOI) and nonfatal injury data from the National Electronic Injury Surveillance System—Occupational Supplement (NEISS-Work) for the years 1998–2022 were examined to produce rate ratios of male to female fatal and nonfatal occupational injury rates for all workers in the United States. Auto-regressive linear models were developed to analyze rate ratios by sex for fatal and nonfatal occupational injuries by age group, injury event, and select industries to determine if female occupational fatal and nonfatal injury rates were following trends comparable to male rates. Over the 25-year study period, male injury and fatality rates were consistently higher than females. Occupational fatality rates for males were more than nine times higher than female rates, and for nonfatal occupational injuries, male rates were 1.4 times higher than female rates. These analyses indicate that the differences in nonfatal injury rates by sex may be attenuating, however, the large gap by sex in workplace fatalities has remained unchanged. Occupational safety and health research with a more specific focus on these sex differences is needed to gain a clearer understanding of how sex differences affect hiring, job training, task assignment and completion, and injury risk, to identify areas where prevention efforts could be most successful.

1 | Introduction

Over the last six decades, women's participation in the labor force has increased significantly. In 1950, women represented just 34% of the United States labor force [1]. By 2023, they represented almost half (47%) of the US workforce [2] and were the majority (59.1%) of part-time workers [3], with over 74 million females aged 16 years and older working in the United States.

Although the female rate of labor force participation has grown, historically, they have experienced lower fatal and nonfatal occupational injury rates than males [4–9]. An analysis of fatal occupational trends from 1983 to 1992 found that males were almost 13 times more likely to be fatally injured at work than females [4]. A later review of data from 1996 to 2000 found males eight times more likely to be fatally injured at work [10]. For nonfatal occupational injuries, a previous study found males accounted for over 66% of injuries in private industry resulting in workday losses and disability [11].

Much of the research on differences in injury sex rates has focused on specific industries or occupations [12–15]. This study examined the rate ratio (RR) of male to female fatal and

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nonfatal occupational injury rates for all workers in the United States. These RRs were further examined by age group, event of the injury or fatality, and select industries. Trends for these ratios were analyzed to explore whether female occupational fatality and nonfatal injury rates are becoming more comparable to male rates. This activity was reviewed by CDC, deemed as not human-subjects research, and was conducted consistent with applicable federal law and CDC policy.[1]

2 | Methods

2.1 | Fatality Data

Data for the number of occupational fatalities in the United States were obtained for the years 1998–2022, inclusively, from the Census of Fatal Occupational Injuries (CFOI). CFOI is operated under the Bureau of Labor Statistics' (BLS) Injuries, Illnesses, and Fatalities program, and collects data on occupational fatalities due to traumatic injuries from all 50 states and the District of Columbia. CFOI includes all employment types, including private industry and the self-employed, and are collected from multiple, cross-referenced sources, including death certificates, workers' compensation records, medical examiner reports, police reports, news media, and follow-up questionnaires. A fatal injury is captured in CFOI if the decedent was employed at the time of the incident, engaged in a legal work activity, and at the incident site as a job requirement. For accuracy, work-relatedness must be substantiated by two or more independent sources [16].

Workplace fatality totals by sex for each year were obtained through the public query system operated by BLS [17]. Further analyses, including the number of workplace fatalities by sex for each year by the decedents' age group, industry, and injury event, were conducted by researchers from the National Institute for Occupational Safety and Health (NIOSH) with restricted access to CFOI utilizing BLS's Virtual Data Enclave. In the CFOI data, sex is coded as either male or female. BLS staff assign codes for each fatality using the Occupational Injury and Illness Classification System (OIICS) [18] for injury event and the North American Industrial Classification System (NAICS) for industry [19]. Due to a break in series for OIICS in 2012, all injury event codes for cases occurring from 1998 to 2011 were cross-walked at the one-digit level to v2.01; this was necessary to allow for an accurate assessment of injury event trends over the entire study period.

A fatality in CFOI was excluded from the analyses if the response to sex was missing, or if the workers were aged 15 years or younger. Cases were limited to deaths that occurred to workers aged 16 years and older to align with employment estimates.

2.2 | Nonfatal Injury Data

Data for nonfatal occupational injuries were obtained for the years 1998–2022 from the National Electronic Injury Surveillance System-Occupational Supplement (NEISS-Work). NEISS-Work[2] is a probability-based sample of approximately 67 US hospital emergency departments (EDs) that provides national estimates of the number of nonfatal work-related injuries and illnesses treated in EDs. For NEISS-Work, injuries or illnesses are determined to be work related when the ED chart indicates that the incident occurred to a civilian noninstitutionalized person while working for pay or other compensation, working on a farm, or volunteering for an organized group. NEISS-Work codes sex as either male, female, or unknown. Each case is assigned a statistical weight based on the probability of selection of the hospital. National estimates are calculated by summing the weights of selected cases. These weights were used to produce national estimates of the number of people treated at EDs due to an occupational injury.

In addition to the demographic and injury variables collected through NEISS-Work, NIOSH staff assign event and industry codes for each injury. Injury event codes were assigned using OIICS [18]. Consistent with the fatality data, all injury event codes for cases occurring from 1998 to 2011 were cross-walked at the one-digit level to v2.01. Industry codes for NEISS-Work data were assigned based on the Bureau of the Census industry code scheme [20] and were available and analyzed from 2015 to 2022.

NEISS-Work cases (1998–2022) were excluded from the analyses if sex was missing or unknown, or the injured workers were aged 15 years or younger. Cases were restricted by age to align with employment estimates. Cases with "unknown" selected for sex did not meet the NEISS-Work minimum reporting requirements, and are not presented.

2.3 | Employment Data

Employment estimates were obtained from the US Current Population Survey (CPS) for workers aged 16 years and older by sex, age, and industry [21]. The CPS, a monthly household survey of the US civilian noninstitutionalized population, is conducted to measure national labor force participation and employment [22]. All employment estimates were based on full-time equivalent (FTE) hours worked, where one FTE is equal to 40 h of work per week for 50 weeks per year, or 2000 working hours.

2.4 | Statistical Methods

Rates for males and females were calculated separately by dividing the number of fatalities or injuries by the corresponding number of FTEs for each year of the study period. Rates by sex for injury and fatality events were calculated using the total FTEs by sex as the denominator. All rates were calculated per 100,000 FTEs. Annual RRs of fatalities and injuries were then constructed by dividing the rate for males by the corresponding rate for females.

Trends in the RRs were analyzed employing separate first order auto-regressive linear models using the annual RR as the dependent variable and year as the independent variable. These models were also used to predict an estimated average annual RR by using the model to predict the rate for 2010 (i.e., the midpoint of the study period), except for nonfatal injuries by industry where the average of the predicted RRs for years 2016 and 2017 were used. The average annual percent change in RRs was calculated by taking the slope of the model and dividing by the average annual RR times 100. For RRs greater than 1, a negative slope or percent change would imply that the rates of male and female occupational fatalities or injuries were converging during the study period. Likewise, for RRs less than 1, a positive slope would imply that the rates between males and females were converging during the study period. All models were calculated in SAS, version 9.4 using PROC AUTOREG [23] employing maximum likelihood estimation. All predicted model graphs are presented as supplemental figures.

3 | Results

3.1 | Occupational Fatalities

Between 1998 and 2022, there were 134,424 occupational fatalities in the United States. Of these, 10,191 occurred to females (7.7%) and 122,233 deaths occurred to males (92.3%). Over this period, the occupational fatality rate for females ranged from a high of 0.93 per 100,000 in 1998 to a low of 0.54 per 100,000 FTE in 2013. The fatality rate for males ranged from a high of 7.59 per 100,000 FTE in 1998 to a low of 5.5 per 100,000 FTE in 2013 (Table SI).

The male to female predicted average annual RR for fatality rates (1998–2022) was 9.3, indicating that male fatality rates were, on average, more than nine times higher than female rates (Figure 1). Over this period, fatal occupational injury rates for females were diverging from male injury rates by 0.14% per year (Table 1). This trend, however, was not significant ($p = 0.51$).

By age group, the RR trends were neither consistent nor statistically significant (Table 1). In the youngest age group (16–24), female occupational fatality rates were approaching young male worker rates by 1.1% each year. For the age groups 25–34, 35–44, and 45–54, female rates were getting further from male rates at various levels, none statistically significant. Female workers aged 55 years and older, had the highest average annual RR at 10.1, with fatality rates that were approaching male rates by 0.5% each year (Figure S1).

Analyses by injury events found RR trends that were statistically significant for males and females were falls, slips and trips, exposure to harmful substances, and violence. However, the direction of these trends was not consistent (Table 1). Female deaths from falls and exposure to harmful substances were converging to the male rates by 1.9% and 4.1% annually, respectively. Female occupational fatalities from violence had the lowest average annual RR of 4.4. The RR trend for violence was also statistically significant, although trending in the opposite way (Figure S2). Fatalities from violence and transportation incidents were the only injury events where female rates were diverging from the male rates each year by 1.6% and 0.64%, respectively. Contact with objects and equipment had the highest average annual RR of 26.9. While this trend was not statistically significant, it is notable that the male fatality rate for this type of injury event was almost 27 times higher than the rate for females.

Occupational fatality results by industry indicated only the transportation and warehousing industry had a statistically significant RR trend (Table 1), where female fatality rates were approaching male rates by 1.4% each year. Retail trade was the only other industry examined that had female rates approaching male rates, although not at a statistically significant level (Figure S3). Manufacturing had the highest average annual RR at 6.4, with RRs diverging by 0.74% annually (Table 1).

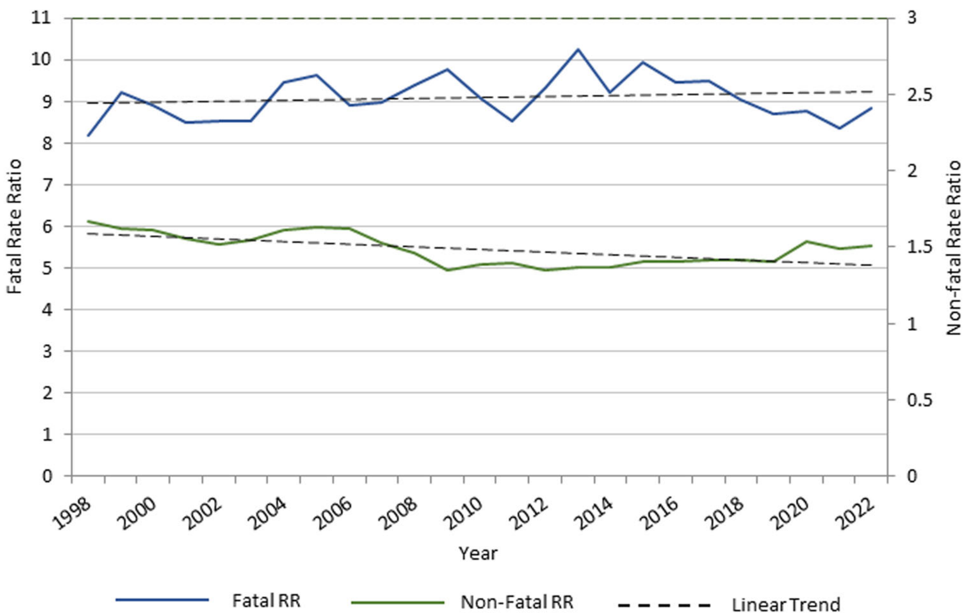

FIGURE 1 | Fatal and Nonfatal injury rate ratios (RR; male rate/female rate) with estimated trend by year, US 1998–2022.

TABLE 1 | Auto-regressive linear model estimation of occupational fatality rate ratios (RR: male rate/female rate) by age group, injury event, and industry, United States 1998–2022.

	Average annual RR[a]	±95% confidence interval	Slope	*p*-value	Annual % change
Total	9.31	1.06	0.0133	0.5149	0.14
Age group					
16–24	9.66	4.34	−0.1017	0.0837	−1.05
25–34	9.84	3.41	0.0214	0.737	0.22
35–44	8.71	2.28	0.0583	0.0706	0.67
45–54	9.17	2.08	0.0290	0.3483	0.32
55+	10.15	2.31	−0.0516	0.0862	−0.51
Injury event					
Contact with object/equipment	26.94	14.85	−0.3129	0.0995	−1.16
Falls, slips, trips	11.38	3.96	−0.2133	0.0171	−1.87
Exposure to harmful substances/ environments	13.26	9.33	−0.5389	< 0.0001	−4.06
Transportation incidents	8.84	1.72	0.0567	0.1255	0.64
Violence and other injuries by persons or animals	4.45	1.05	0.0706	< 0.0001	1.59
Industry					
Retail trade	4.64	1.83	−0.0551	0.0581	−1.19
Transportation/warehousing	5.02	1.71	−0.0686	0.0495	−1.37
Manufacturing	6.45	3.54	0.0477	0.5868	0.74
Agriculture/forestry/fishing	5.56	2.44	0.0025	0.9443	0.05

[a]Average annual rate ratio estimated from the model for year 2010.

Source: Census of Fatal Occupational Injuries, 1998–2022.

3.2 | Nonfatal Occupational Injuries

Over the 25-year period, an estimated 67 million (95% confidence interval [CI]: ±12 million) nonfatal occupational injuries were treated in hospital EDs, with 34% (95% CI: ±1.2) of injuries occurring to females. The nonfatal occupational injury rate for females peaked in 2000 with an estimated 2300 injuries per 100,000 FTE compared to a low in 2020 of 1000 per 100,000 FTE. Male injury rates ranged from a high of 3720 per 100,000 FTE in 2000 to a low of 1530 per 100,000 FTE in 2021 (Table SI).

The predicted male to female average annual RR from 1998 to 2022 was 1.37 (Table 2). Over this period, female rates of nonfatal ED-treated occupational injuries were converging to the male injury rates by 0.6% each year, although this trend was not statistically significant.

By age group, the resulting trends were not consistent. In the younger age groups, 16–24 years and 25–34 years, female rates were converging with those of males at a rate of 1.66% ($p = 0.0001$) and 1.04% ($p < 0.005$) per year, respectively (Table 2). For the 35–44- and 45–54-year age groups, no significant change in trends were detected. Results for those aged 55 years and over showed an average annual RR of 1.2. Nonfatal injury rates for these older female workers were diverging from older male rates with an average annual percentage change of 0.64% (Figure S4).

No significant trends were identified when examining nonfatal RRs by injury event. Although not statistically significant, the predicted average annual RRs for each injury event indicated that differences existed among these categories. The average annual RRs for violence (including sexual assault) and other injuries by persons or animals (0.96), exposure to harmful substances and environments (0.90), and falls, slips and trips (0.94) indicated a higher injury rate for females over the study period. Injury events where males continued to have higher injury rates included transportation incidents (3.17) and contact with objects or equipment (2.67) (Figure S5).

An analysis of nonfatal injury RR trends by industry (analysis limited to data years 2015–2022) found slight differences in predicted average annual RRs. The manufacturing industry had the highest predicted RR at 1.44, followed by the agriculture, forestry, and fishing industry (1.27). Two industries, retail trade (0.93) and transportation and warehousing (0.78), had predicted RRs indicating higher female rates in these sectors. Workers in the education, healthcare and social assistance sector had the only statistically significant change, with male and female rates diverging by almost 2% each year (Table 2). Only the agriculture, forestry, and fishing industry had rates converging over this period, with male and female rates getting closer by 0.1% per year (Figure S6).

TABLE 2 | Auto-regressive linear model estimations of ED-treated injury rate ratios (RR: male rate/female rate) by age group, injury event, and industry[b], United States 1998–2021.

	Average annual RR[a]	±95% confidence interval	Slope	*p*-value	Annual % change
Total	1.37	0.11	−0.0076	0.171	−0.55
Age group					
16–24	1.50	0.19	−0.0249	0.0001	−1.66
25–34	1.53	0.17	−0.0159	0.0046	−1.04
35–44	1.48	0.17	0.0004	0.9002	0.03
45–54	1.29	0.13	0.0062	0.0738	0.48
55+	1.20	0.14	0.0077	0.0555	0.64
Injury event					
Contact with object/equipment	2.67	0.26	0.0063	0.1245	0.23
Falls, slips, trips	0.94	0.12	−0.0006	0.8982	−0.06
Exposure to harmful substances/ environments	0.90	0.12	0.0004	0.8956	0.04
Transportation incidents	3.17	0.66	−0.0011	0.9015	−0.04
Violence and other injuries by persons or animals	0.96	0.15	0.0038	0.086	0.40
Industry[b]					
Retail trade	0.93	0.10	0.0059	0.6915	−0.027
Transportation/warehousing	0.78	0.08	0.0043	0.0976	−1.14
Manufacturing	1.44	0.13	0.0070	0.1416	0.85
Education/healthcare and social assistance	1.09	0.12	0.0080	0.0449	1.95
Agriculture/forestry/fishing	1.27	0.25	0.0190	0.9483	−0.10

[a]Average annual estimated RR from the model for the year 2010 for age group and injury event and the average of years 2016 and 2017 for industry.
[b]Only available for years 2015–2022.
Source: National Electronic Injury Surveillance System-Occupational Supplement (NEISS-Work), 1998–2022.

4 | Discussion

This study examined RRs by sex for fatal and nonfatal occupational injuries to determine if female occupational fatal and nonfatal injury rates are becoming more comparable to male rates. Over our 25-year study period, male overall injury and fatality rates were reliably higher than females, consistent with previous studies [4–9, 24].

For occupational fatalities, our study found that male rates were more than nine times higher than female rates, and for nonfatal occupational injury, male rates were 1.4 times higher than female rates. Although neither overall RR trend was statistically significant, the occupational nonfatal injury RR trend showed female rates getting closer to male rates by 0.6% each year. Whereas the occupational fatality RR trend showed male and female rates generally remaining consistent throughout our study period. Although females represented almost half of the workforce in 2022, they experienced just 8% of occupational fatalities [25]. This proportion is consistent with an earlier study [10] suggesting that additional research is still needed in this area to better understand what additional factors may be impacting the differing proportion of occupation fatal rates.

This study also examined trends for fatal and nonfatal male to female RRs by age group. Both fatal and nonfatal occupational injury RR trends changed with age, one increasing and one declining, respectively. Aligning with previous research showing fatality rates increasing as age increased [4, 26, 27], we found the highest RR among workers aged 55 years and older, with male rates more than 10 times higher than female rates. The oldest and youngest workers were the only age groups where fatal female rates were converging with male rates. Our results for nonfatal injuries also confirmed previous research showing that the difference in injury rates by sex diminished as age increased [28, 29]. RR trends for nonfatal injuries found younger workers (16–24 and 25–34 years) had the highest average RRs; however, younger workers were also the only age groups with converging female and male rates. The converging fatal and nonfatal occupational injury RR trends for younger workers suggest that there may be generational differences in the disparity of injury rates by sex.

Occupational segregation, when males and females are concentrated in certain jobs and fields with differential risks, has often been the traditional explanation for higher male occupational injury rates [10, 30]. Leeth and Ruser [10] found that most of the nonfatal injury rate gap between males and females could be explained by standardizing injury rates by industry and occupation. Our analyses supported this finding with low industry-specific nonfatal RRs. Standardization of rates by industry and occupation in other studies, however, only explained a portion of the fatal injury rate gap indicating that there are other factors influencing rates [10]. Previous research has tried to identify these missing factors by examining differences in occupational injury rates by sex by assessing risk preferences, discrimination, task assignment, physiology, sizing of personal protective equipment (PPE), alcohol and drug use, and job choice [5, 12, 13, 15, 31–33]. Although each of these factors may have an impact, the true underlying causes of occupational injury differences by sex are likely more complex and multicausal.

Employment demographics may also be a factor in workplace injury sex differences. Employment data show that the proportion of females employed in historically low-risk industries has remained relatively constant, while the number of males working in these same industries has increased in concert with decreases in the number of males working in higher-risk industries [32]. Further, research has shown that as females have an increased presence in traditionally male-dominated industries, such as manufacturing, construction, and other manual occupations, the rates for some types of injuries were comparable [5, 6, 13, 14].

The data utilized for this study did not allow for the examination of all possible causes for the disparity in workplace injuries and fatalities by sex. More refined data and enhanced analyses are needed to determine the extent to which unexplained workplace injury differences reflect the impact of discrimination versus the impact of unmeasured task or productivity differences. However, the most recent research related to sex discrimination in hiring has been specific to workers in Europe and Asia [34–37] making comparisons to US workers problematic.

Although the complete reasons for workplace injury sex disparities are not known, injury prevention and safety programs should be aware that males and females in the same occupations do not always perform the same work tasks in the same way [24]. Employers should also be mindful that most PPE and tools were historically designed for the average size male [38] which can pose safety and health risks to workers. For example, females may have difficulty operating tools and equipment that were designed for someone with a bigger stature and larger hands [39].

4.1 | Limitations

Although this study utilized robust occupational injury and fatality data. There are several limitations related to these surveillance systems. NEISS-Work only collects data from EDs and excludes patients who receive medical treatment in other settings (e.g., physician offices and urgent care clinics). Further, the comprehensiveness of NEISS-Work data relies on two factors, the patient communicating the injury is work-related, and the medical records accurately capture this information. These factors may lead to underreporting and conservative injury estimates. CFOI captures data for all fatal work injuries, however, it does not capture fatal occupational illnesses not caused by an acute exposure. Additionally, CFOI data includes all deaths occurring in a given reference year. This may include deaths that resulted from workplace injuries that occur in a prior year [16]. Both NEISS-Work and CFOI coded sex as binary, which may not align with a workers' gender expression. However, major gaps in the collection of gender identity (GI) data exist. Although currently there is no standard for the collection of GI data, recent guidance suggests using either a two-step approach to GI data collection or asking a single, nonbinary gender question [40]. In addition to more precise data collection, research is needed to better understand how societal expectations related to gender expression affect how workers are perceived or treated, which may impact injury risks.

Analyzing surveillance data over long time periods can be challenging due to changes in data coding systems. In this study, the system for coding injury event (i.e., OIICS) underwent a version change which BLS considers a break in series [18]. Most of the changes involved expansion of injury event categories at the three- or four-digit level [41]. To minimize misclassifications, this analysis cross walked injury event at the one-digit level to permit the 25-year trend analyses presented. Another change impacted the coding order of precedence. This modification has the potential to skew data for injuries with multiple contributing injury events and should be interpreted with caution.

Finally, both fatal and Nonfatal industry-specific analyses were restricted to certain industries to align with confidentiality and disclosure guidelines. Nonfatal data were further limited by the lack of industry codes for all available years of NEISS-Work. Also, NEISS-Work does not contain occupation as a variable. Coded occupation data would assist in better assessing the true injury rate trends.

5 | Conclusion

This research provides a national overview of fatal and nonfatal occupational injury trends by sex in the United States. Although differences in nonfatal injury rates by sex may be attenuating, the large gap in workplace fatalities by sex has remained unchanged. Although changing employment demographics may be playing a role in changing injury trends, it will not resolve the underlying social issues that may be affecting different workplace fatal and nonfatal injury risk factors. Additional occupational safety and health research, with a more specific focus on the social issues which can lead to differences in hiring, training, and work expectations by sex, is needed. This research would allow for a clearer understanding of how societal factors associated with worker sex impact employment and injury risks, and to identify areas where prevention efforts could be most successful.

Author Contributions

Kitty Hendricks was responsible for conception of the work, data analysis, data interpretation, writing, and editing of the manuscript. Scott Hendricks contributed to statistical modeling, data analysis, writing, and editing. Suzanne Marsh contributed to the writing and editing of the document. All authors approve of the submitted version and agree to be accountable for all aspects of the work.

Disclosure by AJIM Editor of Record

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

Ethics Statement

All work was performed and reviewed at the Division of Safety Research, National Institute for Occupational Safety and Health. This activity was reviewed by CDC, deemed as not human-subjects research, and was conducted consistent with applicable federal law and CDC policy.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the Bureau of Labor Statistics and the Consumer Product Safety Commission. The data are not publicly available due to privacy or ethical restrictions.

Endnotes

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

[2] NIOSH collects NEISS-Work data in collaboration with the Consumer Product Safety Commission (CPSC), which operates the base NEISS hospital system for the collection of data on consumer product–related injuries. The CPSC product-related injury estimates exclude work-related injuries, whereas NEISS-Work estimates include all work-related injuries regardless of product involvement (i.e., NEISS and NEISS-Work cases are mutually exclusive).

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.