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RESEARCH ARTICLE

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Same-level fall injuries in US workplaces by age group, gender, and industry

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Background: As the workforce ages, occupational injuries from falls on the same level will increase. Some industries may be more affected than others.

Methods: We conducted a cross-sectional study using data from the Bureau of Labor Statistics to estimate same-level fall injury incidence rates by age group, gender, and industry for four sectors: 1) healthcare and social assistance; 2) manufacturing; 3) retail; and 4) transportation and warehousing. We calculated rate ratios and rate differences by age group and gender.

Results: Same-level fall injury incidence rates increase with age in all four sectors. However, patterns of rate ratios and rate differences vary by age group, gender, and industry. Younger workers, men, and manufacturing workers generally have lower rates.

Conclusions: Variation in incidence rates suggests there are unrealized opportunities to prevent same-level fall injuries. Interventions should be evaluated for their effectiveness at reducing injuries, avoiding gender- or age-discrimination and improving work ability.

KEYWORDS
accidental falls, demographic aging, epidemiology, industry, occupational injuries

1 | INTRODUCTION

Falls are a leading cause of non-fatal workplace injuries that require time away from work ("lost-time injuries"). During 2015, an estimated 309 060 lost-time injuries resulted from slips, trips, and falls, more than resulted from contact with objects and equipment (n = 269 910) and nearly as many as resulted from overexertion (n = 376 190). Slips, trips, and falls accounted for 26.8% of all lost-time injuries and illnesses reported in the Bureau of Labor Statistics (BLS) Survey of Occupational Injuries and Illnesses (SOII) in 2015.[1] In the SOII, slips, trips, and falls are grouped into three categories: falls on the same level, falls to a lower level, and slips or trips without a fall. The majority (63.8%) of non-fatal slip, trip, and fall injuries are attributed to falls on the same level.[1]

Federal agencies in the US have devoted considerable attention in recent years to preventing fatal fall injuries from heights, including a national public health campaign,[2] a smartphone application to promote ladder safety,[3] and a recent occupational safety regulation.[4] Fall injuries on the same level cause a much greater number of lost-time injuries but have not received the same level of attention as falls from heights.

Researchers have documented for some time that there is a higher frequency of same-level fall injuries at work among older workers relative to younger workers.[5–11] These data from occupational studies

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are consistent with an extensive literature on older adult fall injuries.[12] Physiological factors that influence fall injury risk change with age, including balance, vision, and cognition.[13] Falls are influenced by environmental conditions, as well, including floor contamination, clutter, lighting, walking surface irregularities, stairs, ice, and snow.[14] Variation in the prevalence of these hazards would be expected to vary considerably between industries and within industries due to the wide variation in working conditions (e.g., indoor vs. outdoor). The frequency of same-level fall injuries does vary considerably between different industries, ranging from 7.1 lost-time injuries per 10 000 full-time equivalents (FTE) in the professional, scientific, and technical services sector to 51.4 among workers in the transportation and warehousing sector during 2015.[1] Industry-specific epidemiological studies of slips, trips, and falls have been carried out in healthcare,[14,15] the postal service,[16] construction,[17] and restaurants,[18] but little research has quantitatively measured exposure to slip or trip hazards. Work by Chang and coworkers is a notable exception.[19–21]

While a positive association between age and same-level fall injury, as well as variation across industries, has been documented, variation in the relationship between fall injury risk and age by industrial sector and gender has not been adequately examined. It might be riskier to be an older worker in certain industries and occupations than others. Studies examining this possibility are scarce. Kemmlert and Lundholm (2001) conducted a textual analysis of approximately 1600 accident reports among workers in occupations at high risk of a same-level fall injury. Their study found that proportions of fall injuries attributed to particular risk factors (e.g., slip on snow or ice) were comparable between workers <45 years and workers ≥45 years of age with the same occupation.[6]

Differences due to sex or gender may complicate the picture even further. Punakallio studied balance ability among individuals grouped by occupation and gender—male construction workers, male fire-fighters, female nursing staff, and female homecare workers. Among workers ≥50 years of age, the construction workers' measure of functional balance was better than that of firefighters; both of these male groups outperformed the female groups.[22] This evidence suggests that if there are differences in fall risk within an age bracket across industries, the difference may be due to the occupation and gender mix in the industry, rather than just the industry itself.

The workforce is aging rapidly in the US and in other countries.[23] Workers 65 years and older are the fastest growing demographic within the labor force and will continue to grow for at least the next decade.[24] Given their high risk for same-level falls, preventive intervention is warranted, though the need for action may be more urgent in some industries and among certain groups than others. In this study, we present same-level fall injury counts and incidence rates during the period 2011-2015 by age group and gender for selected industrial sectors, using data from the Bureau of Labor Statistics. Age group and gender-specific rate ratios and rate differences are calculated for three high-level industrial sectors (healthcare & social assistance, retail, and transportation & warehousing) in relation to manufacturing, to describe the relationship between age group and same-level fall injury by industry. Manufacturing was selected as a reference group because it had the lowest industry-wide rate of same-level fall injuries among the four selected sectors.

2 | MATERIALS AND METHODS

This paper used unpublished data from the BLS SOII for private, local and state government combined. The BLS provided injury counts estimated by age group, gender, and industry in aggregate form without any identifiable information. These aggregate statistics represent national estimates of the frequency and severity of nonfatal lost-time injuries in US workplaces.

Approximately 230 000 private industry establishments in 26 states are required by law to participate in the annual survey. Participation among public sector establishments varies by state and is voluntary. Participation among private sector establishments is approximately 95% and among public sector establishments, approximately 80%, according to the BLS.[25,26] The survey excludes self-employed workers, private households, and agricultural operations with 10 or fewer employees.

The SOII sampling frame is developed from the BLS Quarterly Census of Employment and Wages using a stratified sampling design, in which employers are stratified according to North American Industry Classification System (NAICS) codes. NAICS codes are a system for organizing employers according to the activities in which they are primarily engaged, with codes ranging from 2 to 6 digits, with more digits providing greater specificity. States determine the level of coding at which industries are sampled according to the relative importance of different industries to a given state, so the stratification approach varies by state. In general, states must estimate data at least at the 2-digit NAICS code level.[25] Final sample weights are calculated based on the original sample weight, a non-response adjustment factor, a re-aggregation factor, an outlier adjustment factor, and a benchmarking factor. SOII uses a Taylor series linearization methodology to develop standard error estimates, which are reported as relative standard errors.[25]

An establishment selected for the survey is notified of its selection in the year prior to the survey year, and instructed to record work-related injuries or illnesses that occur during the survey year. Employers track injuries that result in lost workdays, job transfer, restricted work, and particular cases reportable to OSHA.[26] Participating establishments are asked to report information on each qualifying case, including case characteristics, such as the nature of injury, the part of body affected, and the event or exposure; and demographic characteristics, including age, gender, and race/ethnicity.

Data for this study include injuries resulting in at least one lost workday that occurred during 2011-2015 and were reported to SOII. Industry was coded using two-digit NAICS codes. Relative standard errors provided by the BLS were used to estimate variability about the numerator. We followed common practice, in which certain 2-digit NAICS codes are aggregated into a single category (e.g., NAICS codes 31-33 are grouped to represent the manufacturing sector).[27] Variance estimates for these pooled counts were calculated by pooling subgroup variance estimates, under the assumptions that the samples were independent and the underlying variances were equal.[28]

Denominator data—the total number of hours worked in primary or secondary jobs by age group for each industry—were estimated using the Current Population Survey (CPS). The CPS is administered each month by the US Census Bureau to generate information on employment and other characteristics of the US civilian non-institutionalized population. The CPS collects monthly data from about 72 000 occupied households that are drawn from a two-stage probability sample including all 50 States and the District of Columbia. The CPS follows a 4-8-4 rotation panel design in which a household is surveyed four months in a row, ignored for 8, and surveyed again for 4 consecutive months. The CPS includes questions about hours worked in a given week, and about the industry and occupation in which a participant works. Due to the rotation panel design, standard error estimates are difficult to calculate, so the CPS provides generalized variance function parameters that can be used to estimate variance.[29] The parameters used in this analysis were for the US labor force as a whole.[30]

Incidence rates by two-digit industry, age group, and gender were calculated by dividing the estimated counts by the estimated hours worked. As a sensitivity analysis, to assess the robustness of our findings, we also estimated annual counts and rates by sector and age group for 2010. In order to test whether the age-related increase in fall injury incidence is constant across industries, we compared age group-specific incidence rates between workers in four large sectors: manufacturing (NAICS: 31-33), retail trade (NAICS: 44-45), transportation & warehousing (NAICS: 48-49) and health care & social assistance (NAICS: 62). We estimated rate ratios and rate differences for workers within each age group, using workers employed by the manufacturing sector as the reference category because manufacturing had the lowest rate. Confidence intervals (CIs) about the rate ratios[28] and rate differences[31] were calculated using standard approaches. Constant rate ratios between industries and genders, regardless of age group, were considered to indicate the absence of a multiplicative interaction. Constant rate differences between industries, regardless of age group, were considered to indicate the absence of an additive interaction. Heterogeneity in the relative and absolute measures was assessed using the Mantel-Haenszel chi-square test. Statistical analyses were performed in R.[32] We also estimated annual counts and rates by sector, age group and gender for each year from 2011 to 2015, in order to assess whether these were consistent over time.

3 | RESULTS

Same-level fall injury incidence rates, aggregated by gender, are presented by age group and sector in Figure 1. Incidence rates increase with age group in all four sectors. The highest age-group- and sector-specific incidence rates were among workers aged 65 years and older in the healthcare & social assistance sector (39.9 injuries/10 000 FTE, 95%CI: 37.5, 42.3), followed by workers aged 65 years and older in the retail trade sector (34.2 injuries/10 000 FTE, 95%CI: 31.8, 36.6). The lowest reported rate for same-level fall injuries was among workers aged 25-34 years in the manufacturing sector (5.7 injuries/10 000 FTE, 95%CI: 5.5, 5.9).

Counts and rates, stratified by gender, as well as industry and age group are summarized in Table 1. Rates increase with age among males and females. Incidence rates among females are consistently higher than among males in similar age and sectoral categories, with two exceptions (workers aged 16-19 years in retail and transportation & warehousing). The rates in the manufacturing sector tended to be lower across age/gender/sectoral combinations. Findings from the analyses of 2010 data were comparable to results from 2011 to 2015 (not shown). Visual inspection of graphical representations of annual counts and rates for each year, sector, age group and gender from 2011 to 2015 did not reveal any meaningful differences in magnitudes or direction of the associations (not shown).

Age group-, gender-, and industry-specific rate ratios are presented graphically in Figure 2, with manufacturing as the reference group. Almost all rate ratios are greater than 1, indicating that in these data, regardless of gender and age-group, the other three sectors tend to have higher rates of same-level fall injuries compared to the manufacturing sector. Females tend to exhibit higher rate ratios than males in the healthcare & social assistance sector, as well as the retail trade sector, though gender differences in the transportation & warehousing sector are mixed. Patterns across age groups appear somewhat complex. In the retail trade sector, rate ratios relative to manufacturing increase with age, on average, among both men and women. In the healthcare & social assistance sector, as well as transportation & warehousing, workers in their 30s and 40s experience relatively higher rates than workers of similar ages and genders in manufacturing. In the transportation & warehousing sector, the highest observed rate ratio was among female workers 45-54 years of age (RR = 2.8, 95%CI: 2.7, 2.9). The rate ratios among female workers 55-64 years of age and females 65 years of age and older are progressively lower.

Rate differences between manufacturing and the other three industrial sectors (by age group and gender) are presented in Figure 3. Rate differences increase with age in all sectors and are higher among females than males. The largest observed rate difference, which had wide confidence intervals, was between female workers aged 65 and older in retail and manufacturing (24.1 per 10 000 FTE, 95%CI: 17.7, 30.5). In other words, in the retail trade sector, some 24 additional lost-time fall injuries occurred per 10 000 full-time female workers aged 65 and older than would have occurred had the incidence rate been the same as the rate in the manufacturing sector. Based on our CPS employment estimates for retail workers, this translates to approximately 704 additional lost-time injuries each year (or 47.7% of same-level falls among female retail workers 65 years and older). In the transportation and warehousing sector, and the healthcare & social assistance sectors, rate differences were similarly high among female workers 65 years of age and older. Mantel Haenszel chi-square tests demonstrated statistically significant ($P < 0.0001$) heterogeneity of rate ratios between industrial sectors across age groups.

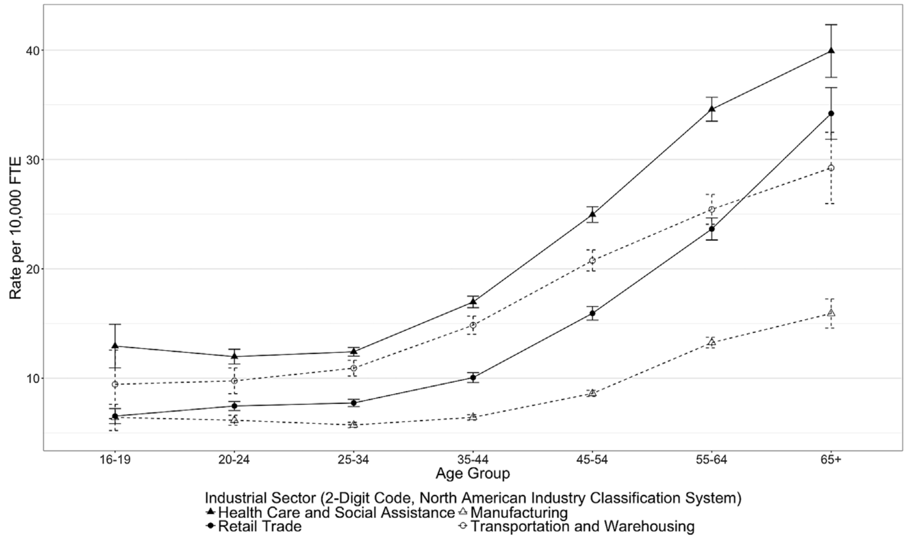

FIGURE 1 Rates of same-level fall injuries in healthcare & social assistance, manufacturing, retail trade, and transportation & warehousing, by Age Group: 2011-2015

4 | DISCUSSION

This study found that, in the four industrial sectors investigated, incidence rates of lost-time, same-level fall injuries increase with age. This finding raises concerns for aging workers and their employers. Additionally, these data indicate that rates are consistently higher among women compared to men; and among workers who are not in the manufacturing sector compared to those who are. Our estimated rates appear comparable to those provided by the BLS.[1]

The patterns of rate ratios and rate differences across age groups and gender were visually and statistically heterogeneous. Consistent with BLS data showing that same-level falls are one of the few types of occupational injury that occurs more frequently among women than men,[1] our study found that incidence rates of same-level falls tended to be higher among women than among men, regardless of age group and industrial sector. The elevated likelihood of lost-time work-related fall injuries among women could be due to differences in functional ability,[22] physical activity,[33] the likelihood of an injury after a fall, [34] patterns in the nature and circumstances of the injury,[35] or gender-based processes whereby women are more likely to enter certain jobs than men (e.g., healthcare).

Heterogeneity might also be explained by the unequal distribution of risk factors in the physical and social environment. A study of limited-service restaurants by Verma et al., for example, reported an increased likelihood of slipping associated with distraction (RR = 1.7; 95%CI = 1.5, 2.0) and rushing (RR = 2.9; 95%CI = 2.5, 3.3), and a 14.6-fold increased likelihood of slipping when walking on a floor that was wet, oily or otherwise contaminated (95%CI = 12.6, 17.0).[36] Environmental conditions that influence the likelihood of a slip or a trip, such as ice, are well-established causal risk factors for falls.[37]

Shorter job tenure has also been associated with a higher likelihood of workplace injury, even among older recent hires.[38] Incidence rates in sectors with high turnover may be somewhat elevated due to the shorter average job tenure. Differences in injury incidence could also reflect the distribution and effectiveness of safety programs and practices in a given industrial sector. Sectors might value and practice safety differently, on average, if targeted regulatory enforcement,[39] differential insurance premiums,[40] safety climate,[41] average establishment size,[42] or labor union involvement in occupational safety[43] are strong enough incentives to influence sector-wide safety practices. It is possible that industries, including manufacturing, with a history of readily apparent hazards likely to cause premature death have, over time, developed hazard mitigation strategies that include same-level fall prevention.

Reporting of same level falls may become more likely with increasing age due to the higher likelihood of a severe injury or for other reasons. If this were true of all injuries, a more consistently positive relationship between all occupational injuries and age would be expected. Injuries resulting from overexertion or contact with objects and equipment do not exhibit the same positive association with age as do same-level falls,[9,11] providing indirect evidence that increases in injury incidence with age are not due to a general tendency of older workers to report injuries more often. That said, researchers have identified significant underreporting of occupational injuries in SOII,[44–49] including differential reporting by workers' race/ethnicity.[45,47] It would be valuable to explore whether SOII data accuracy varies by age and gender, as well as race/ethnicity and industry.

Regardless of the relative contributions of these various factors toward the occurrence of falls and the heterogeneity between industries, age groups and genders, our study suggests that there are unrealized opportunities to prevent fall injuries among aging workers. According to our study, if rates of same-level fall injuries in healthcare & social assistance, retail trade, and transportation & warehousing were as low as the rates in manufacturing, a considerable number of injuries would be avoided. How those lower rates might be achieved is an important question for future research and policy to address.

TABLE 1 Counts and incidence rates[a] of same-level fall injuries requiring one or more days away from work by 2-digit industry code, gender, and age group

	Age (years)													
	16-19		20-24		25-34		35-44		45-54		55-64		65+	
Industry and gender	Count (SE)	Rate (SE)	Count (SE)	Rate (SE)	Count (SE)	Rate (SE)	Count (SE)	Rate (SE)	Count (SE)	Rate (SE)	Count (SE)	Rate (SE)	Count (SE)	Rate (SE)
Health care and social assistance (62)														
Females	960 (52.7)	14.5 (1.3)	6670 (139)	13 (0.4)	22 470 (271.3)	13.9 (0.3)	29 630 (322.6)	19.1 (0.3)	47 010 (431.3)	28.3 (0.5)	50 430 (449.4)	41.4 (0.8)	13 840 (208.7)	49.9 (1.8)
Males	140 (18.6)	7.4 (1.4)	1120 (53.9)	8.2 (0.6)	3710 (108.1)	7.6 (0.3)	4840 (121.9)	10.1 (0.4)	6700 (144.1)	13.6 (0.4)	5370 (129.1)	13.6 (0.5)	2310 (81.2)	18.2 (1.1)
Manufacturing (31-33)														
Females	100 (15.8)	5.6 (1.2)	840 (45)	6.8 (0.5)	2530 (79.1)	6.5 (0.3)	3450 (92.8)	6.9 (0.3)	7270 (137.7)	11.7 (0.3)	8250 (147)	20.5 (0.7)	1790 (65.9)	26.2 (2)
Males	370 (29.3)	6.7 (0.7)	2260 (74.6)	6 (0.3)	6160 (125.7)	5.4 (0.1)	8280 (148.3)	6.2 (0.1)	11 510 (177.1)	7.4 (0.2)	11 150 (173.9)	10.5 (0.2)	2270 (74.8)	12.2 (0.6)
Retail trade (44-45)														
Females	1060 (62.8)	7.1 (0.5)	4470 (133.3)	9.1 (0.4)	6750 (166.9)	9.5 (0.3)	7510 (177.2)	12.9 (0.4)	14770 (262.5)	21.7 (0.6)	17 130 (288.8)	35.8 (1.1)	7380 (175.3)	50.3 (2.6)
Males	920 (58.8)	5.9 (0.5)	3450 (116.6)	6.1 (0.2)	6500 (164)	6.5 (0.2)	6110 (159.1)	7.9 (0.3)	8940 (196.4)	11.1 (0.3)	8100 (186.2)	13.8 (0.4)	4330 (131)	22.1 (1.1)
Transportation and warehousing (48-49)														
Females	30 (9.5)	6.6 (2.7)	510 (39.7)	15.7 (2)	1370 (69.8)	12 (0.9)	2760 (108.3)	19.1 (1.2)	6660 (170.6)	33.2 (1.6)	5290 (155.3)	39.5 (2.2)	1250 (73.1)	48.1 (5.9)
Males	180 (23.8)	10.2 (1.9)	1110 (59.2)	8.3 (0.6)	4900 (134)	10.6 (0.4)	8040 (185.1)	13.8 (0.4)	12 460 (232.9)	17.3 (0.5)	11 090 (218.4)	21.7 (0.7)	2720 (101.1)	24.8 (1.6)

Survey of Occupational Injuries and Illnesses and Current Population Survey, 2011-2015.

[a]Rates are calculated per 10 000 Full Time Equivalents (FTE), i.e. 40 h per week and 50 weeks per year. Standard errors for the counts are based on Bureau of Labor Statistics estimates of relative standard errors. Standard errors for the at-risk experience in FTE are based on the Current Population Survey's general variance function estimates for the US labor force. Industry codes refer to the North American Industry Classification System.

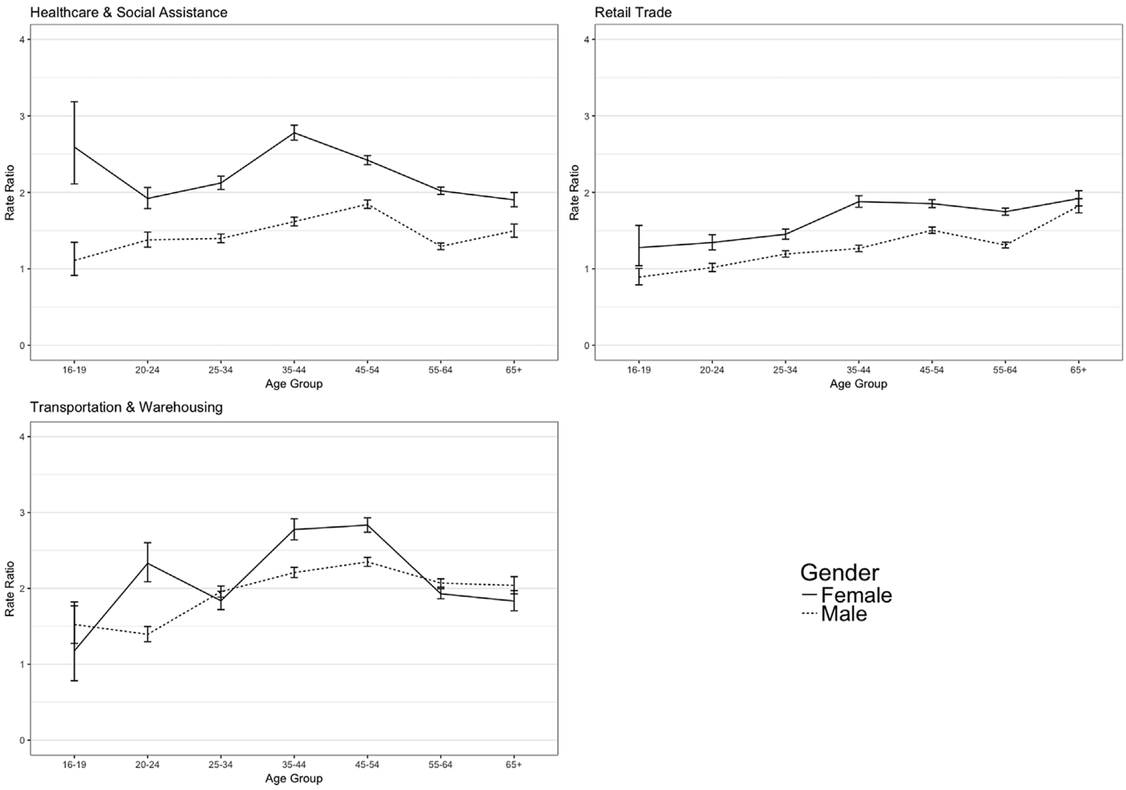

FIGURE 2 Rate ratios of lost-time same level fall injuries by gender, age group, and sector, relative to manufacturing

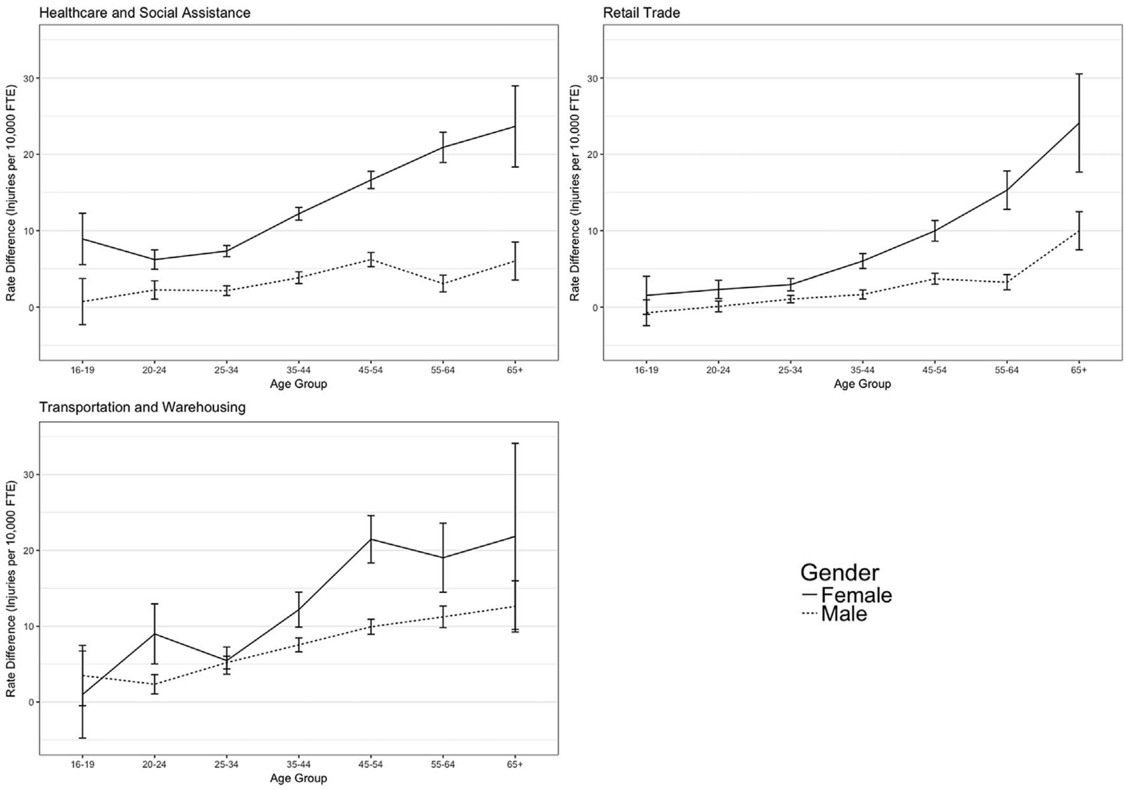

FIGURE 3 Rate differences of lost-time same level fall injuries by gender, age group, and sector, relative to manufacturing

Researchers have identified a variety of interventions, including physical activity programs and clinical services, which have been proven effective at preventing falls among older adults.[50] Intervening through the workplace to address individual-level risk factors, be they related to age or gender, may carry additional risks as well as potential for injury prevention. Attempts to explicitly address age or gender disparities in occupational fall injuries may result in high-risk workers (e.g., females, older workers, workers with disabilities) being treated differently from lower-risk workers. Interventions should, therefore, be designed in accordance with laws that protect workers from discrimination by gender,[51] age,[52] genetic information,[53] health status,[54,55] and disability.[56] It should also be recognized that underlying health and functional abilities that increase fall injury risk might themselves be influenced by working conditions. A 2007 study by Verma et al. identified an association between physical work demands and claims for same-level falls resulting in fractures among female workers 50 years of age and older.[57] It cannot be assumed, given the current scientific evidence, that differences in same-level fall injury incidence by demographic characteristics or functional abilities are unrelated to work.

The between-industry differences we observed in rate ratios and rate differences suggest that the physical and social work environment play an important role at all ages. Interventions modifying the physical work environment have been tested and found to be beneficial for preventing same-level fall injuries.[14] Environmental interventions may be especially beneficial for older adults who are, on average, less able to recover from a perturbation in gait, such as tripping over a cord.[58] The principles of universal design offer guidance for creating age-friendly workplaces.[59] Decades of research on work ability[60] also underscore the view that the promotion of healthy aging at work requires a broad definition, including an appreciation of older workers' value among organizational leaders and enhanced training opportunities for workers to develop new skills, as well as modifications to the physical environment.[61]

4.1 | Limitations and strengths

The SOII excludes self-employed workers, who are more likely to be older, as well as the military, private household workers, workers on small farms and Federal workers, limiting the generalizability of our results. Further, as stated earlier, significant undercounting of both diseases and injuries has been reported in the peer-reviewed literature. This could influence internal validity if undercounting differs by industrial sector.

Rate ratios and rate differences were estimated in order to assess whether working conditions could contribute to the occurrence of same-level falls, after controlling for gender and age group. There is likely substantial variation in individual workers' exposure to same-level fall hazards within industrial sectors, even among age and gender strata. It is therefore difficult to identify, from these data, which particular exposures or conditions may explain differences observed between sectors. That there are such notable differences between sectors' same-level fall incidence rates after controlling for two important potential confounders (age group and gender) is an important finding. Additional research could explore why these differences exist, as well as how they might guide further prevention strategies. It is also important to note that, as with any measure of relative or absolute risk, these rate ratios and rate differences are relative to the specific reference group that was selected; in this case, manufacturing workers. The rate ratios and rate differences would likely differ had a different reference group been selected.

This study is strengthened by the fact that it is based on a nationally representative dataset that is widely used in national policymaking. SOII, while limited in important ways as noted, offers the best available evidence in the US on the national incidence of various occupational injuries.

5 | CONCLUSION

Using national surveillance data from the United States, we have found that age-related patterns in the rates of same-level falls, a leading cause of lost-time workplace injuries, differ across different industrial sectors. As the workforce ages certain industries will likely experience an increase in numbers of same-level falls that outpaces those of other industries. The patterns we identified in our study may be explained by a combination of factors, including sex and gender differences in certain industries, differences in job tenure, differential exposure to physical hazards, the social conditions at work, information bias, and other factors. Intervening to prevent these common and costly injuries should take into account both the effectiveness of the possible interventions, as well as potential unintended consequences such as discrimination in employment. A broad view that focuses on universal design and promoting work ability is likely the best approach for supporting healthy aging at work.

AUTHORS' CONTRIBUTIONS

This work was a component of the lead author's dissertation. All other authors were committee members who participated in all stages of the process including conception, analysis, interpretation, writing, approval, and accountability.

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DISCLOSURE (AUTHORS)

The authors declare no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

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

DISCLAIMER

None.

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