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Original article

Occupational Injuries Among Construction Workers by Age and Related Economic Loss: Findings From Ohio Workers' Compensation, USA: 2007–2017

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ABSTRACT

Background: This study examined age-group differences in the rate, severity, and cost of injuries among construction workers to support evidence-based worker safety and health interventions in the construction industry.

Methods: Ohio workers' compensation claims for construction workers were used to estimate claim rates and costs by age group. We analyzed claims data auto-coded into five event/exposure categories: transportation incidents; slips, trips, and falls (STFs); exposure to harmful substances and environments; contact with objects and equipment (COB); overexertion and bodily reaction. American Community Survey data were used to determine the percentage of workers in each age group.

Results: From 2007–2017, among 72,416 accepted injury claims for ~166,000 construction full-time equivalent (FTE) per year, nearly half were caused by COB, followed by STFs (20%) and overexertion (20%). Claim rates related to COB and exposure to harmful substances and environments were highest among those 18–24 years old, with claim rates of 313.5 and 25.9 per 10,000 FTE, respectively. STFs increased with age, with the highest claim rates for those 55–64 years old (94.2 claims per 10,000 FTE). Overexertion claim rates increased and then declined with age, with the highest claim rate for those 35–44 years old (87.3 per 10,000 FTE). While younger workers had higher injury rates, older workers had higher proportions of lost-time claims and higher costs per claim. The total cost per FTE was highest for those 45–54 years old ($1,122 per FTE).

Conclusion: The variation in rates of injury types by age suggests that age-specific prevention strategies may be useful.

1. Introduction

In the United States (U.S.), construction is ranked among the most hazardous industries and accounts for a disproportionately large percentage of injuries, illnesses, and deaths [1,2]. In 2019, construction workers experienced a rate of 112.3 per 10,000 full-time equivalent (FTE) nonfatal injuries, resulting in days away from work [3]. The medical expenses of nonfatal construction injuries were more than $1.36 billion annually between 1996 and 2002, based on Medical Expenditure Panel Survey data [4].

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According to the U.S. Bureau of Labor Statistics, in 2015, the leading causes of nonfatal injuries with days away from work among construction workers were contact with objects and equipment (COB) (33.2%); slips, trips, and falls (STFs) (29.9%); and overexertion and bodily reaction (27.5%) [5]. Recent years have seen a significant increase in people aged 55 and older working in the construction industry, consistent with all other industries. The proportion of workers in all industries aged 55 and older increased from 18.1% to 20.3% between 2015 and 2019 [6]. The average age of construction workers increased from 36 to 42.5 years between 1985 and 2015 [7].

Given the increasing average age of construction workers and the challenging work conditions of the industry, understanding the health and safety needs of older workers is vital. A study by Dong et al. [8] found that 38% of construction workers who turned 40 years old from 1996 to 2006 experienced injuries resulting in days away from work before they turned 40. Those researchers also found that a year after work injury, construction workers of all ages often lost wages, worked fewer hours, or lost their jobs due to worsened general health and more diagnosed conditions and functional limitations [8].

With aging, some functional capacities needed to complete certain tasks often decrease [9]. Muscle weakness and eyesight and balance problems can make older workers more vulnerable to injuries, reducing their functional capacity and affecting their overall ability to perform physically challenging tasks [10]. Research found older workers (aged 55 and older) have lower injury rates; however, when they do get injured, their injuries tend to be more severe and require longer recovery times than injuries of younger workers [11,12]. The objective of this study was to utilize the most recent Ohio's workers' compensation (WC) data to assess differences among construction worker age groups in the claim rates, cost of injury (an indicator of injury severity), and event/exposure types of occupational injuries. This paper offers age-specific, evidence-based recommendations that can mitigate the risk of workplace injuries for construction workers.

2. Material and methods

For this study, 2007–2017 data for Ohio WC claims from state-insured, single- and multiple-location employers, including some self-employed workers,[a] were used. Ohio is the largest of four states (North Dakota, Ohio, Washington, and Wyoming) with exclusively state-run WC systems. Ohio insures about two-thirds of the state's workforce; only larger employers (generally with 500+ employees) self-insure if fiscally able. Both accept lost-time (LT) claims (those with 8 or more days away from work) and medical-only claims (only medical treatment expenses paid and ≤7 lost workdays). Ohio Bureau of Workers' Compensation (OHBWC) data include information on employer, worker's age and gender, claim cost, lost workdays, and a free-text narrative describing how the injury/illness occurred. OHBWC collects an administrative dataset that lacks certain demographic information such as race/ethnicity."

The North American Industry Classification System classifies the construction industry with code 23. Claims submitted to OHBWC are auto-coded, using methods described previously [13], into these Bureau of Labor Statistics Occupational Injury and Illness Classification System (OIICS) event or exposure categories: (1) violence and other injuries by person or animal; (2) transportation incidents; (3) fires and explosions; (4) STFs; (5) exposure to harmful substances and environments (EHS); (6) COB; (7) overexertion and bodily reaction. For the sake of clarity, we refer to categories 2, 4, 5, 6, and 7 as event/exposure categories of interest. We excluded categories 1 and 3 due to an insufficient number of claims for age-related analysis. The auto-coder also assigns a score value indicating the confidence level in its prediction. LT claims with an auto-code score in the bottom quartile or with high costs were manually reviewed to verify the assigned event/exposure. We defined percent LT claims as the percentage of total claims that were LT. We analyzed claims to compute rates of allowed claims and claim cost by age group. The American Community Survey of the U.S. Census Bureau was used to determine the proportion of construction workers in each age group[b] in Ohio [14]. These proportions were applied to the total employee counts for the insured construction companies in the claims data. Employee counts by individual employers were obtained by OHBWC from state unemployment insurance records. Employee counts in each age group were translated into FTEs using information on hours worked in the construction industry by age group in the American Community Survey, thus providing estimated age group denominators for claim rates (one FTE = 40 hours per week) [13].

2.1. Costs

OHBWC uses a factor-adjusted[c] valuation method to estimate ultimate total claim costs [15] of large groups of claims in a given policy year, including all projected future costs. Factor-adjusted costs include additional costs of claims from an insured population that cannot be predicted based on individual claim characteristics. Factor-adjusted costs are appropriately used only to represent costs of groups of claims of several hundred or more as is done here. However, for analysis, OHBWC provided estimates of factor-adjusted costs of individual claims, reporting indemnity payment costs (to partially replace wages) and medical costs separately. Percent cost indemnity was defined as the percentage of total factor-adjusted cost that was indemnity cost.

Some claims (12%) used in these analyses resulted in zero cost for OHBWC. This might have occurred due to OHBWC programs that allow employers to directly pay medical costs up to $15,000 and indemnity payments without appearing in OHBWC records. A sensitivity analysis was conducted in which claims associated with these programs were removed. In addition, some zero-cost claims may occur if no medical treatment beyond first aid was provided and no indemnity payments were made [13,15].

2.2. Human subjects

This activity was reviewed by the Centers for Disease Control and Prevention and conducted consistent with applicable federal law and Centers for Disease Control and Prevention policy (see, e.g., 45 C.F.R. part 46; 21 C.F.R. part 56; 42 U.S.C.§241(d), 5 U.S.C. §552a, 44 U.S.C. §3501 et seq).

2.3. Statistical analysis

All analyses were conducted using R statistical software [16]. Basic summary statistics on claim costs, including mean, median,

[a] Not all self-employed workers are covered by OHBWC. Coverage is optional for sole proprietorships and partnerships.

[b] We assumed that the age distribution of construction workers insured by OHBWC was the same as the distribution for the overall Ohio construction industry, excluding those who are self-employed who may purchase but are not required to purchase WC insurance.

[c] Most employers and researchers do not have access to factor-adjusted costs. Nonfactor-adjusted costs are better for representing the expected cost of individual claims. Factor-adjusted costs represent a more accurate estimate of costs for large groups of claims.

and 99th percentiles, were calculated and presented by age group and event/exposure categories. Claims related to fatal injuries were also assessed. To assess the uncertainty of these measurements, bootstrapping was performed to calculate 95% confidence intervals. Bootstrapping involves randomly sampling with the replacement of the observed data and recalculating the summary statistics. For this analysis, the data were re-sampled 1,000 times, resulting in the calculation of 1,000 sets of summary statistics. The 2.5th and 97.5th percentiles of each statistic were obtained to represent the 95% confidence interval of that statistic.

Cost data are known to be positively skewed. To investigate the influence of high-cost claims, analyses were rerun after dropping the top two and then the top five highest-cost claims. To assess the severity of injuries, we used the percentage of claims that were LT claims and the percentage of total claim cost represented by indemnity payments for lost wages during lost work time. Furthermore, descriptive analysis was performed to determine the percentage of STFs injuries by age group that were due to falls to a lower level versus falls to the same level. For this study, we used five age categories: 18–24, 25–34, 35–44, 45–54, and 55–64 years. We defined workers aged 55 and above as older workers and those aged 18–24 as young workers. All the data presented in the figures are included in Appendix Tables C and D.

3. Results

From 2007 to 2017, 72,416 WC claims were accepted by OHBWC for construction workers (see Table 1). During this period, OHBWC accepted 87% of claims filed across all industries. Of the accepted claims for construction workers, 71,134 (98%) were related to OIICS event/exposure categories 2, 4, 5, 6, and 7; 63,901 (88%) were nonzero-dollar claims and 119 (0.16%) were fatalities. Of these accepted claims, 34.9% were from people who filed more than one claim during our study period. Of the 57,704 individual claimants (zero-dollar or nonzero-dollar claims), 3,501 (6%) had claims in more than one age group (i.e., some claimants moved from one age category to another during the study period).

3.1. Rate of claims for OIICS event/exposure categories

As shown in Table 1, the claim rate for all OIICS event/exposure categories was 395.9 per 10,000 FTE. Overall, 50% of claims were related to COB, 30% to STFs, and 20% to overexertion. The claim rates of COB- and EHS-related injuries were highest among those aged 18–24 years, with claim rates of 313.5 per 10,000 and 25.9 per 10,000, respectively (Fig. 1). In contrast, STFs tended to increase with age, with the highest claim rate of 94.2 per 10,000 FTE for those aged 55–64. The percentage of STF claims that were same-level falls was highest among those aged 55–64 (38.7%), while the percentage of STF claims that were lower-level falls was highest among young workers (52.7%) (Fig. 2). In the case of overexertion injuries, claim rates tended to increase and then decline with age, with the highest claim rate among those 35–44 (87.3 per 10,000 FTE). We saw no major differences in claim rates by age for transportation-related injuries among construction workers.

3.2. Injury severity

The severity of injuries for all event/exposure categories of interest was highest for those 45–64 years old, as measured by both severity metrics: percentage of claims classified as LT and percentage of total claim cost that was indemnity payments (Fig. 3). The percentage of claims that were LT was highest for transportation-related injuries in all age groups: 47.2% for 55–64 years old, 46.4% for 45–54, and 42.9% for 35–44.

The total cost per FTE and medical cost per FTE for occupational injuries in all OIICS event/exposure categories among construction workers were $846 and $371, respectively (see Table 1). The event/exposure category with the highest cost per FTE was STFs (Fig. 4), and for this type of injury, the cost was highest among those 55–64 years old at $432. Costs of STFs per FTE were slightly lower for ages 45–54 ($419) and 35–44 ($385), but much lower (under $200) for ages 25–34 and 18–24 (Fig. 4). This pattern was driven largely by differences in cost per STF claim by age group rather than differences in STF claim rate by age group. The cost per STF claim for the three oldest age groups was $48,000 to $52,000, but only $23,000 to $29,000 for the two youngest age groups (Fig. 6).

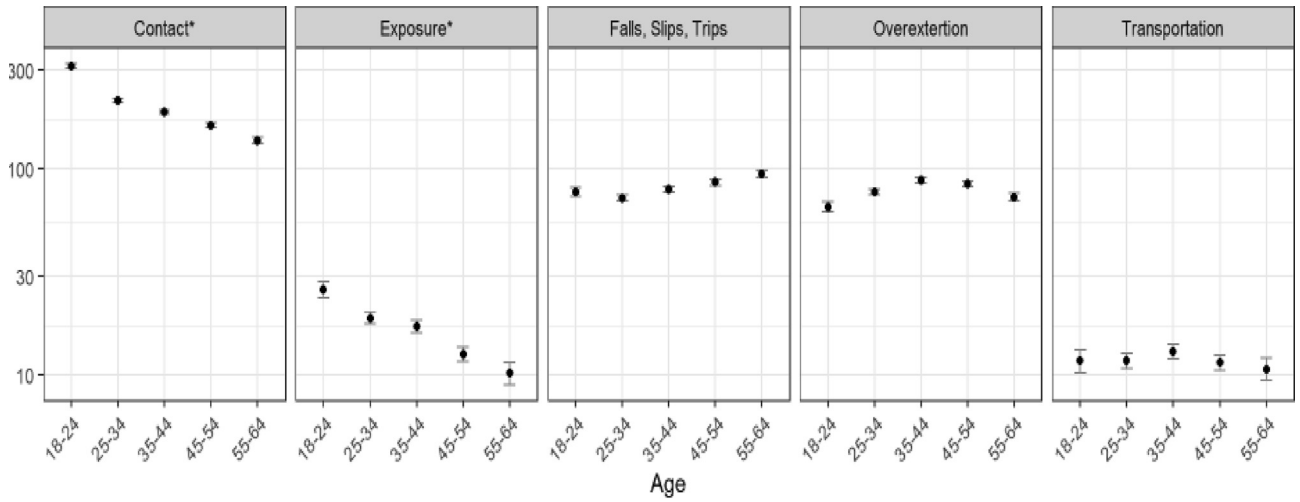
The second most costly event/exposure category was overexertion, which had similar age group patterns as STFs (Figs. 4 and 5). The cost per FTE of the three highest age groups was $215–$283 (peaking at $283 for those 45–54 years old) compared with $108 for those aged 25–34 and $30 for those 18–24. Again, this pattern was driven mostly by differences in cost per claim, which was approximately $27,000 to $36,000 for the three oldest age groups, compared with $16,000 for those 25–34 and $5,000 for those 18–24 (Fig. 6).

The third most costly event/exposure category was COB, for which there were much smaller differences by age group. The 45–54 age group had the highest cost per FTE due to having the highest cost per claim and a higher claim rate than the oldest age group.

Table 1
Age-specific rates of claims for work-related injuries in all OIICS event/exposure categories and associated costs among Ohio construction workers, 2007–2017 combined

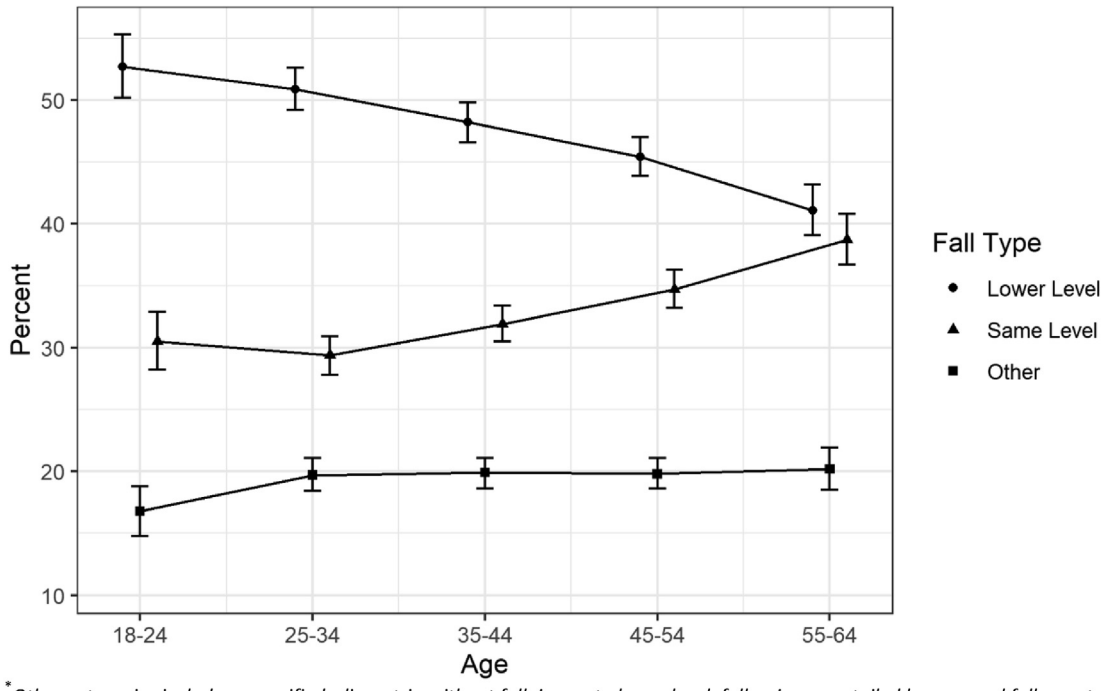
Age group	FTEs[†]	N Claims[‡]	Claim rate[§] (per 10,000 FTE)	Total cost per claim[*]		Cost per FTE		%LT[‖]	%Cost indemnity
				Mean	Median	Total	Medical		
18-24	193,702	9,723	502.0	$7,810	$575	$342	$211	9.2%	38.3%
25-34	463,026	18,563	400.9	$15,996	$675	$567	$266	14.3%	53.2%
35-44	476,862	18,648	391.1	$25,877	$832	$909	$412	20.0%	54.7%
45-54	460,729	16,676	361.9	$33,865	$1,070	$1,122	$457	24.5%	59.2%
55-64	234,751	7,764	330.7	$33,976	$1,226	$1,033	$417	21.0%	59.4%
Overall[¶]	1,829,070	72,416	395.9	$23,797	$793	$846	$371	18.6%	56.1%

[*] Excluding zero-dollar claims.
[†] *Sum of* annual FTEs 2007–2017.
[‡] Total claims from 2007-2017. Including all event and exposure categories, including those of interest: Contact with object and equipment (6), Exposure to harmful substances (5), STFs (4), overexertion (7), and transportation (2), as well as the other, smaller categories (violence and other injuries by persons or animals (1) and fires and explosions (3)).
[§] Claim rate per 10,000 FTE.
[‖] Lost-time claims.
[¶] Including *1,024 claims of an unknown age group*.



*Complete injury category titles: Contact = Contact with object and equipment; Exposure = Exposure to harmful substances and environments

Fig. 1. Claims per 10,000 FTE by injury category and age group among Ohio construction workers, 2007–2017 combined. Note: Bars represents Confidence Intervals. FTE, full-time equivalent.



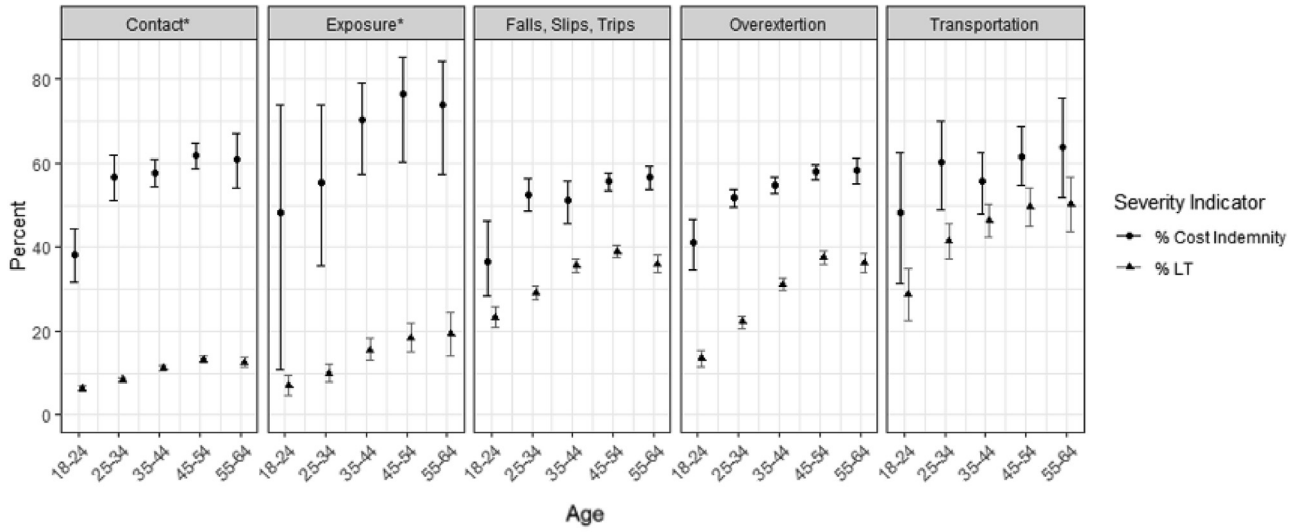
*Other categories include unspecified, slip or trip without fall; jumps to lower level; fall or jump curtailed by personal fall arrest system; not elsewhere classified

Fig. 2. Percentages of falls to lower level, to same level, and other, by age group among construction workers, 2007–2017 combined.

The cost per FTE of transportation-related claims rose with age due to increases with age in the cost per claim (Figs. 4 and 5). Costs per FTE of claims related to EHS were similar for age groups from 25 through 64 but were much lower for those 18–24 due to a much lower cost per claim. For most event/exposure categories, the cost per claim was highest among those 45–54 or 55–64, but for STFs, cost per claim was highest among those 35–44 ($52,426; Fig. 6). This exception was driven by a small number of high-cost claims. After removing the top 2 and 5 most expensive STF claims, cost per claim for the 35–44 group was lower than the older age groups (data not shown). Sensitivity analyses removing claims associated with OHBWC programs had little effect on the results (data not shown).

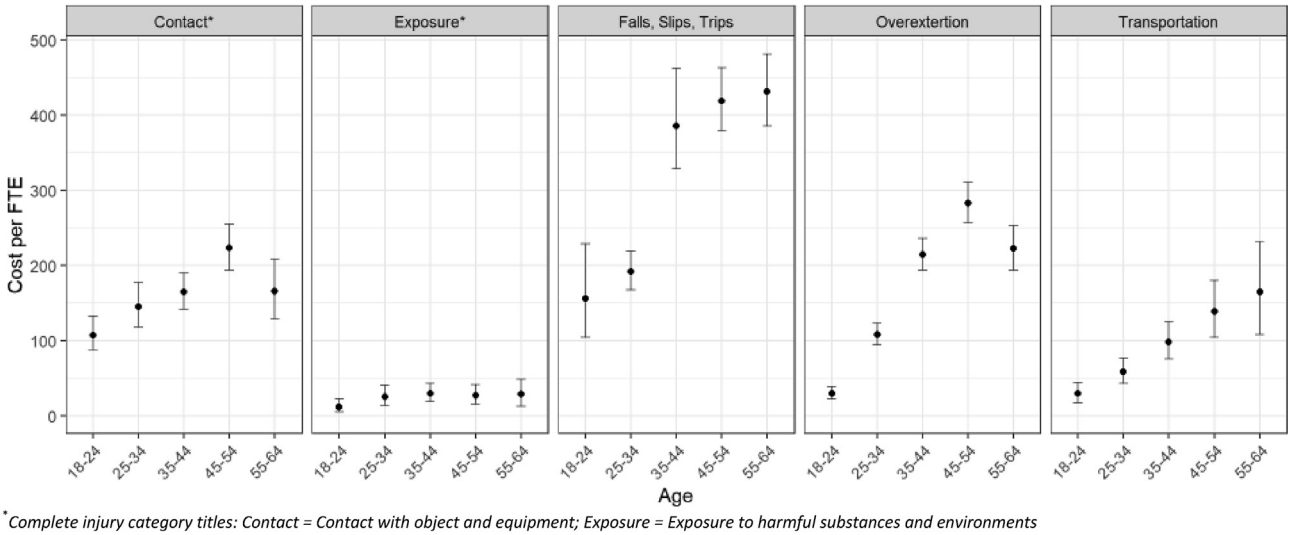
4. Discussion

This study examined WC claims in Ohio among state-insured, single- and multiple-location employers, including some self-employed workers, to estimate claim rates, cost of injury, and injury severity by age group. We found that irrespective of the type of event/exposure, the severity of the injury was highest for those aged 45 and older (Fig. 3). Among workers aged 45 and older, 46.4%



*Complete injury category titles: Contact = Contact with object and equipment; Exposure = Exposure to harmful substances and environments
**95% confidence intervals indicated by bars above and below point estimates

Fig. 3. Two severity indicators: percent of cost indemnity and percent of claims lost time by OIICS event/exposure category in construction industry, 2007–2017 combined. OIICS, Occupational Injury and Illness Classification System.



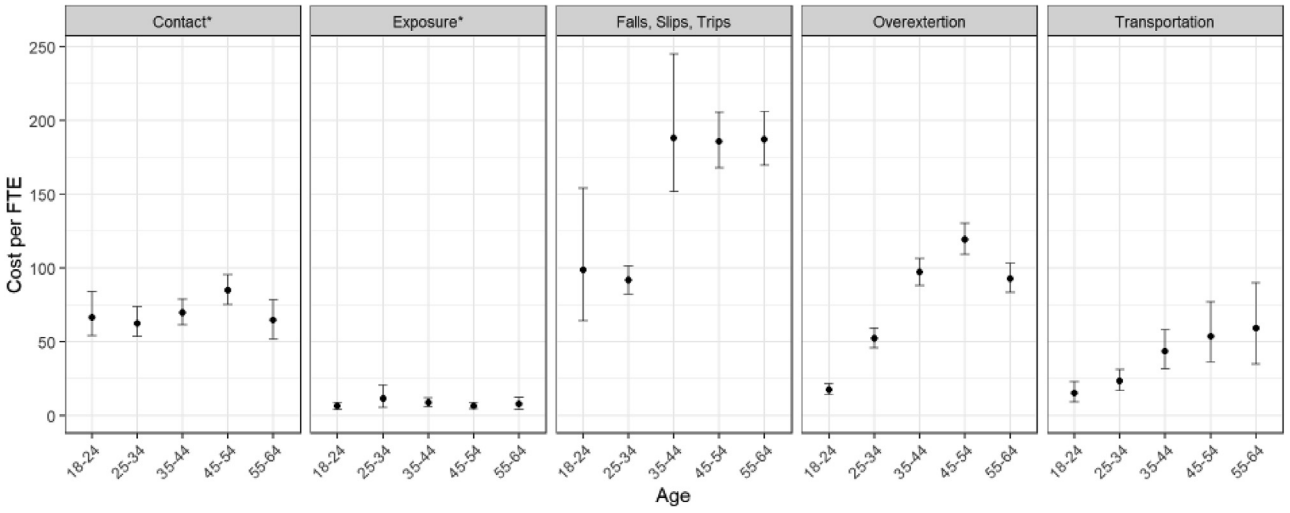
*Complete injury category titles: Contact = Contact with object and equipment; Exposure = Exposure to harmful substances and environments

Fig. 4. Total cost of claims per FTE by OIICS event/exposure category in construction industry, 2007–2017. FTE, full-time equivalent; OIICS, Occupational Injury and Illness Classification System.

of injuries related to transportation resulted in LT claims, followed by STFs (36.6%), overexertion (34.9%), EHS (16.7%), and COB (11.8%). The higher percentage of LT claims in the 45–64 age group suggests that as workers age, injuries might be more severe in the sense that it may take longer to recover than younger workers [17]. The total medical and indemnity cost per claim also tends to be higher for workers aged 45 and older (see Fig. 6 and Appendix Tables A, B). The higher indemnity costs among older workers could be partly due to more days away from work, suggesting injury severity, and partly due to higher wages. Unfortunately, data on days away from work were insufficient for directly measuring severity.

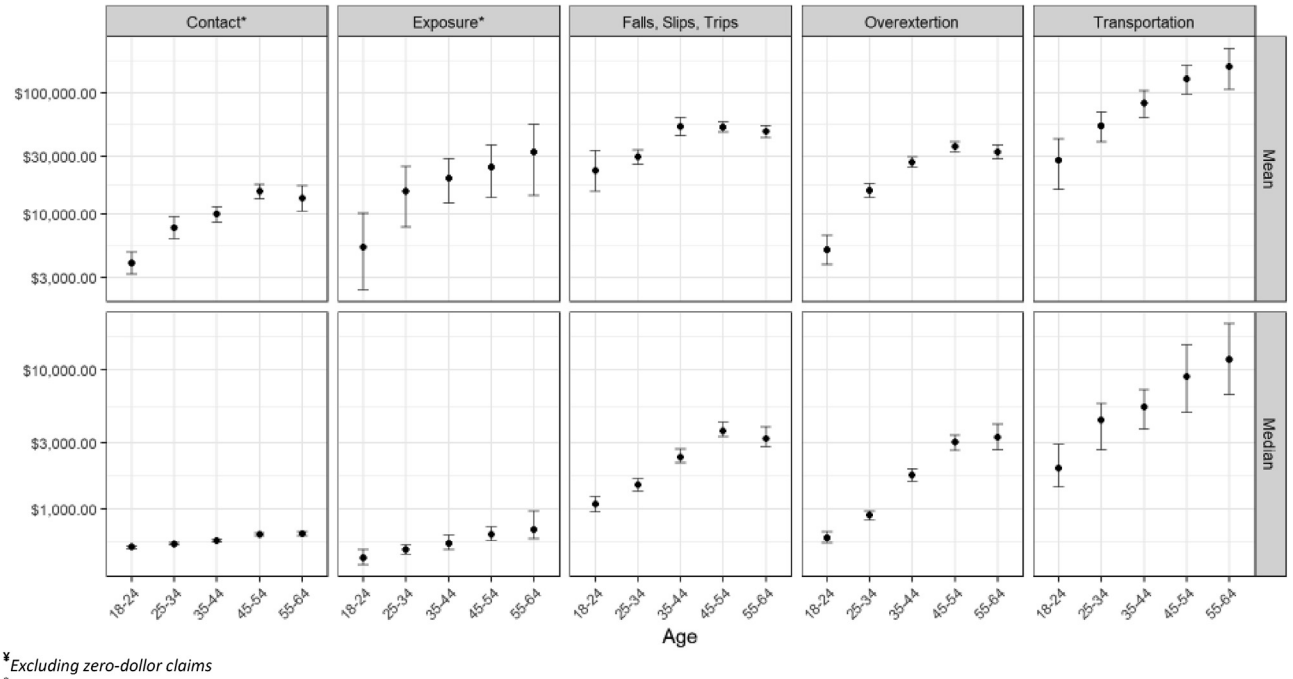
This study found that the injury rates and the associated costs varied by age group and type of event/exposure category. For instance, injury rates due to COB and EHS were highest among young workers aged 18–24 and lowest among older workers. However, the cost per claim of injuries tended to be higher among older workers. Injuries related to COB and EHS might be more common among young workers because they may have limited or no experience or receive little to no training doing required tasks [18]. Also, prior research shows that even when aware of the dangers, younger workers may take risks to get the job done or find it difficult to refuse unsafe working conditions. Their motivation may stem from peer pressure, desire to fit in, or perceiving refusal as a sign of weakness [19,20]. Conversely, older workers have more skills and experience with equipment so may be less likely to get injured [21]. Older workers also might move to less dangerous positions or have less exposure to tools and equipment that would result in injury [22]. However, when older workers do get injured, the injuries tend to be more severe and costly.

From 2007 to 2017, 28.4% (2,212/7,764) of claims filed by construction workers aged 55 and older were STFs, which is slightly higher than the 22% reported by Rosecrance et al. in a study



*Complete injury category titles: Contact = Contact with object and equipment; Exposure = Exposure to harmful substances and environments

Fig. 5. Medical cost per FTE by OIICS event/exposure in construction industry category, 2007–2017 combined. FTE, full-time equivalent; OIICS, Occupational Injury and Illness Classification System.



¥Excluding zero-dollor claims

*Complete injury category titles: Contact = Contact with object and equipment; Exposure = Exposure to harmful substances and environments

Fig. 6. Cost per Claim¥ by OIICS event/exposure category in construction industry, 2007–2017 combined. OIICS, Occupational Injury and Illness Classification System

examining Colorado WC data from 1998–2008 [23].[d] The claim rate of STFs, as well as the associated cost per FTE, was highest among those 55–64 years old (94.2 claims per FTE; $432 per FTE). In addition, the percentage of total claim cost related to indemnity cost for STFs increased with age, consistent with previous studies [23]. Of all the STF-related claims filed by 18–24-year-olds, 52.7% were related to falls to lower levels or falls from height, and 30.5% were related to falls to the same level. For those aged 55–64, 41.1% of STFs claims were related to falls to lower levels and 38.7% were related to same-level falls. Fall injuries might be more common among older workers due to aging-related issues such as worsening vision and hearing impairment, musculoskeletal disorders, and reduced physical functioning. Moreover, with aging, joint mobility decreases with a loss in elasticity of tissue and overall strength, putting older workers at increased risk of STFs [24,25].

The study's findings related to overexertion injuries were consistent with previous reports [26]. This study's results show that the rate of overexertion injuries increases with age up to ages 45–54 and then declines. Two plausible reasons for the lower rate among 55–64 year-olds compared with 45–54 year-olds are that

[d] We calculated the percentage of claims associated with STFs for ages 55 and older from Table 4 in the Rosecrance et al. paper.

older workers with severe pain move out of their jobs, leaving behind a healthy cohort (selective survival bias), or older workers move to tasks with reduced risk of work-related musculoskeletal disorders-painful conditions of muscles, tendons, and nerves caused by overexertion [26].

4.1. Prevention strategies

All injury prevention strategies will tend to benefit most of those workers who are most likely to suffer injuries. A key strategy at the top of the hierarchy of controls is Prevention through Design [27]. This approach emphasizes the incorporation of occupational safety and health considerations in the design of work facilities, processes, equipment, tools, work methods and work organizations. For example, building designers can provide for guardrail supports and roof anchors embedded in concrete building elements to facilitate guardrail and fall restraint installation [28]. Other design approaches involve the use of ergonomic or mechanized tools and equipment, incorporating automation for repetitive and strenuous tasks like laying bricks, overhead drilling, and lifting [29]. Accommodating the limitations of injured workers is another basic prevention strategy. Unfortunately, injured construction workers often have limited opportunities to modify their tasks or duties to sustain employment [30]. Job rotation or modifications are likely to benefit all age groups but may particularly allow older workers to continue to work and stay in the workforce.

Some prevention strategies can be tailored to different age groups. For example, successful programs like the Fall-Safe partnership could be enhanced and adjusted specifically to the needs of older workers [31]. As individuals age, changes in vision become a common occurrence, making it essential to provide better lighting in work areas for older workers [32]. Also, training modification may be necessary. For example, older workers may learn more effectively in hands-on training sessions rather than computer-based or virtual training [33].

Young or inexperienced workers may benefit from mentoring or pairing opportunities with more skilled and experienced older workers. Reverse mentoring may also benefit older workers since younger workers can teach older workers how to use modern technology [34]. Additionally, employers can provide regular training related to the safe use of tools and equipment and to the prevention of workplace injuries, especially for young and inexperienced workers. Implementation of fall prevention training programs that target inexperienced residential construction workers has been shown to result in positive changes in apprentices' fall prevention knowledge, safety behaviors, and perception of the risk posed by fall hazards [35].

It is important to note that the most effective way to reduce injuries and related costs among older workers is to introduce interventions while workers are younger [36]. Especially in the case of overexertion-related injuries, workers might experience relatively low levels of pain early on but have it worsen with age, resulting in more days away from work. A study of roofers found that the odds of leaving the trade were eight times higher for workers with work-related musculoskeletal disorders than for workers without such a disorder [37]. To provide a safe environment for workers and retain older workers, a job safety and health analysis should be performed, keeping in mind the age and physical capacity of the employee [38]. Functional capacity evaluations should be used to fit the job to the worker and not the other way around. Furthermore, rehabilitation services/interventions, such as return-to-work programs and modified duty/activity adaptation, may allow workers who have a temporary or permanent disability to transition back to work [39].

4.2. Limitations

Some limitations should be considered when interpreting these study results. First, the auto-coding methods used to identify claims can result in misclassification. Misclassification is not expected to vary by age if claim records are similar in completeness and accuracy across age groups. However, if misclassification varies by type of event/exposure, this could bias the comparison of the mix of event/exposure category by age group. Find more information on auto-coding accuracy in Bertke et al. (2016) [40]. Second, work-related injuries may not result in WC claims, and underreporting may vary by age group. Significant underreporting of occupational injuries has been described previously [41]. Research shows that reporting increases with age, although older workers might accept injuries as a normal consequence of work more often and have more access to treatment through group health insurance, enabling them to avoid the WC system [42,43]. Younger workers might be less knowledgeable about their rights and the process to file a claim and be afraid of reprisal [44]. Furthermore, there is evidence that individuals of certain race/ethnicity are less likely to file a WC claim. A study by Dong et al. [4] found that Hispanic workers are more likely to have work-related injuries but less likely to receive WC benefits [4]. Hispanic workers may not understand and exercise their workplace rights due to cultural and language barriers, immigration status, and fear of retaliation [4,45]. If the age distribution of Hispanic workers differs from the age distribution of other workers, this could affect the results.

A third limitation is that these data represent only insured companies in Ohio, so it is uncertain how much these results can be generalized. Fourth, the available claim data make it difficult to determine the severity of injuries in terms of the time required for recovery and return to work. It would be helpful to have more direct metrics for pain and suffering, as they are crucial in assessing severity and likely correlate with the number of days away from work and indemnity payments received.

5. Conclusion

The construction work environment often involves hazards—such as performing tasks in proximity to hazardous site conditions, handling materials manually, using heavy equipment, or working on uneven surfaces—that can pose serious risks to workers [46]. This study used the most recent OHBWC data to estimate the rate of injury, injury severity, and costs by age group and event/exposure among construction workers. Nearly 50% of injury claims accepted by the OHBWC among construction workers in our study data were related to COB, followed by STFs (20%) and overexertion (20%). Our findings suggest that overall claim rates and severity of injuries vary by age and that injuries in event/exposure categories vary by age in different ways. For instance, injuries related to COB, EHS, and transportation are more common among younger workers, while STFs are more common among older workers. Moreover, overexertion-related injuries increase with age and then decline.

Although young and inexperienced workers are more likely to be injured, older workers may have more serious injuries or take longer to recover based on the higher proportion of LT claims and higher per claim costs associated with injuries. Older workers may be disadvantaged performing certain tasks. However, they also tend to be more experienced and skilled, less likely to be injured and to have counterproductive work behaviors, and can mentor younger workers in safe work practices [47,48]. For these reasons, workplace policies, procedures, and practices should support retaining older workers [49]. Incorporating safety, ergonomic, return-to-work, reverse mentorship, and wellness programs that align with age

patterns in work injuries might help address the unique needs of both older and younger construction workers, enhance workplace safety, and help keep older workers in the workforce.

Conflicts of interest

There is no conflict of interest.

Financial disclosure

None.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.shaw.2023.10.003.

References

[1] Choi SD. Aging workers and trade-related injuries in the US construction industry. Safety and Health at Work 2015;6(2):151–5.
[2] Trueblood A, Brown S, Harris W. Fatal and nonfatal injuries in the construction industry, vol. 7. M AY(nd); 2022.
[3] Bureau of Labor Statistics. Nonfatal cases involving days away from work: selected characteristics; 2019. Available from: https://www.bls.gov/iif/.
[4] Dong X, Ringen K, Men Y, Fujimoto A. Medical costs and sources of payment for work-related injuries among hispanic construction workers. Journal of Occupational and Environmental Medicine 2007;49(12).
[5] The Center for Construction Research and Training. The construction chart book: the U.S. Construction industry and its workers; 2013.
[6] More NAHB. Young workers join the construction labor force; 2021. Available from: https://eyeonhousing.org/2021/08/more-young-workers-join-the-construction-labor-force/.
[7] Sokas RK, Dong XS, Cain CT. Building a sustainable construction workforce. International Journal of Environmental Research and Public Health 2019;16(21):4202.
[8] Dong XS, Wang X, Largay JA, Sokas R. Long-term health outcomes of work-related injuries among construction workers–findings from the National Longitudinal Survey of Youth. American Journal of Industrial Medicine 2015;58(3):308–18.
[9] Soer R, Brouwer S, Geertzen JH, van der Schans CP, Groothoff JW, Reneman MF. Decline of functional capacity in healthy aging workers. Archives of Physical Medicine and Rehabilitation 2012;93(12):2326–32.
[10] Schwatka NV, Butler LM, Rosecrance JR. An aging workforce and injury in the construction industry. Epidemiologic Reviews 2012;34:156–67.
[11] Centers for Disease Control Prevention. Nonfatal occupational injuries and illnesses among older workers—United States, 2009. Morbidity and Mortality Weekly Report 2011;60(16):503.
[12] Schwatka NV, Butler LM, Rosecrance JC. Age in relation to worker compensation costs in the construction industry. American Journal of Industrial Medicine 2013;56(3):356–66.
[13] Wurzelbacher SJ, Al-Tarawneh IS, Meyers AR, Bushnell PT, Lampl MP, Robins DC, Tseng CY, Wei C, Bertke SJ, Raudabaugh JA, Haviland TM, Schnorr TM. Development of methods for using workers' compensation data for surveillance and prevention of occupational injuries among State-insured private employers in Ohio. American Journal of Industrial Medicine 2016;59(12):1087–104.
[14] U.S. Census Bureau. American community Survey 2021. updated November 23; 2021. Available from, https://www.census.gov/programs-surveys/acs/data.html.
[15] Wurzelbacher S, Meyers A, Bertke S, Lampl M, Robins D, Bushnell P, Tarawneh A, Childress D, Turnes J. Comparison of cost valuation methods for workers compensation. In: Schnorr T.M. Proceedings of use of workers' compensation data for occupational safety and health workshop utterback DF. NIOSH Pub; 2013.
[16] R Core Team. R. A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2021.
[17] Stoesz B, Chimney K, Deng C, Grogan H, Menec V, Piotrowski C, Shooshtari S, Turner N. Incidence, risk factors, and outcomes of non-fatal work-related injuries among older workers: a review of research from 2010 to 2019. Safety Science 2020;126:104668.
[18] Lipscomb HJ, Schoenfisch AL, Shishlov KS. Non-fatal contact injuries among workers in the construction industry treated in U.S. emergency departments, 1998-2005. Journal of Safety Research 2010;41(3):191–5.
[19] Lavack AM, Magnuson SL, Deshpande S, Basil DZ, Basil MD, Mintz JH. Enhancing occupational health and safety in young workers: the role of social marketing. International Journal of Nonprofit and Voluntary Sector Marketing 2008;13(3):193–204.
[20] Turner N, Deng C, Granger S, Wingate TG, Shafqat R, Dueck PM. Young workers and safety: a critical review and future research agenda. Journal of Safety Research 2022;83:79–95.
[21] National Institute for Occupational Safety and Health. Productive Aging and Work [updated September 11, 2015. Available from: https://www.cdc.gov/niosh/topics/productiveaging/safetyandhealth.html 2015; 2015.
[22] Varianou-Mikellidou C, Boustras G, Dimopoulos C, Wybo J-L, Guldenmund FW, Nicolaidou I, Anyfantis O. Occupational health and safety management in the context of an ageing workforce. Safety Science 2019;116:231–44.
[23] Rosecrance J, Butler L, Schwatka N, Aep M. The role of age on the cause, type, nature and cost of construction injuries. CPWR Small Grant Final Report; 2011.
[24] Lockhart TE, Smith JL, Woldstad JC. Effects of aging on the biomechanics of slips and falls. Human Factors 2005;47(4):708–29.
[25] Welch LS, Haile E, Boden LI, Hunting KL. Age, work limitations and physical functioning among construction roofers. Work 2008;31(4):377–85.
[26] Kaur H, Wurzelbacher SJ, Bushnell PT, Grosch JW, Tseng C-Y, Scholl JC, Meyers AR, Lampl M. Workers' compensation claim rates and costs for musculoskeletal disorders related to overexertion among construction workers - Ohio, 2007-2017. MMWR Morbidity and Mortality Weekly Report 2021;70(16):577–82.
[27] National Institute for Occupational Safety and Health. The state of the national initiative on prevention through design. DHHS/NIOSH Publication No 2014–123); 2013.
[28] McKenzie E, Gillen M, Afanuh S. Preventing falls from heights through the design of embedded safety features; 2014.
[29] Kim HK, Hussain M, Park J, Lee J, Lee JW. Analysis of active back-support exoskeleton during manual load-lifting tasks. Journal of Medical and Biological Engineering 2021;41(5):704–14.
[30] Merkus SL, Lunde L-K, Koch M, Wærsted M, Knardahl S, Veiersted KB. Physical capacity, occupational physical demands, and relative physical strain of older employees in construction and healthcare. International Archives of Occupational and Environmental Health 2019;92(3):295–307.
[31] Becker P, Fullen M, Akladios M, Hobbs G. Prevention of construction falls by organizational intervention. Injury Prevention 2001;7(suppl 1):i64.
[32] Choi SD. Safety and ergonomic considerations for an aging workforce in the US construction industry. Work 2009;33(3):307–15.
[33] Mallett LG. Coaching skills for on-the-job trainers. Department of Health and Human Services, Centers for Disease Control; 2005.
[34] Novak N, English T. Reverse mentorship: a model for the future of the construction workforce: building Design + Construction; 2022. Available from: https://www.bdcnetwork.com/reverse-mentorship-model-future-construction-workforce#:~:text=Reverse%20mentorship%3A%20A%20model%20for%20the%20future%20of,and%20gain%20future-forward%20insights%20for%20life%20and%20business.
[35] Evanoff B, Dale AM, Zeringue A, Fuchs M, Gaal J, Lipscomb HJ, Kaskutas V. Results of a fall prevention educational intervention for residential construction. Safety Science 2016;89:301–7.
[36] Söderbacka T, Nyholm L, Fagerström L. Workplace interventions that support older employees' health and work ability - a scoping review. BMC Health Services Research 2020;20(1):472.
[37] Welch LS, Haile E, Boden LI, Hunting KL. Impact of musculoskeletal and medical conditions on disability retirement-a longitudinal study among construction roofers. American Journal of Industrial Medicine 2010;53(6):552–60.

[38] Philson CS. Graying work force: safety concerns of the aging employee. Professional Safety 1990;35(4):40.
[39] Fisher TF. Industrial Rehabilitation a natural environment for occupational therapy practitioners. Work 1994;4(4):259–63.
[40] Bertke SJ, Meyers AR, Wurzelbacher SJ, Measure A, Lampl MP, Robins D. Comparison of methods for auto-coding causation of injury narratives. Accident Analysis & Prevention 2016;88:117–23.
[41] Leigh JP. Economic burden of occupational injury and illness in the United States. The Milbank Quarterly 2011;89(4):728–72.
[42] Tucker S, Diekrager D, Turner N, Kelloway EK. Work-related injury underreporting among young workers: prevalence, gender differences, and explanations for underreporting. Journal of Safety Research 2014;50:67–73.
[43] Biddle J, Roberts K. Claiming behavior in workers' compensation. Journal of Risk and Insurance 2003;70(4):759–80.
[44] Pransky G, Snyder T, Dembe A, Himmelstein JAY. Under-reporting of work-related disorders in the workplace: a case study and review of the literature. Ergonomics 1999;42(1):171–82.
[45] Brown S, Brooks RD, Dong XS. Injury inequalities among U.S. construction workers. Journal of Occupational and Environmental Hygiene 2021;18(4–5):159–68.
[46] Lipscomb HJ, Glazner JE, Bondy J, Guarini K, Lezotte D. Injuries from slips and trips in construction. Applied Ergonomics 2006;37(3):267–74.
[47] Schwatka NV, Butler LM, JRJEr Rosecrance. An Aging Workforce and Injury in the Construction Industry 2012;34(1):156–67.
[48] Ng TW, Feldman DC. The relationship of age to ten dimensions of job performance. Journal of Applied Psychology 2008;93(2):392–423.
[49] Stalnaker CK. Safety of older workers in the 21st century. Professional Safety 1998;43(6):28.