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An aging workforce and its effect on injury in the construction industry

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Abstract

The relatively large birth cohort between 1946 and 1964 combined with the economic recession in the first decade of the 21st century have led to an increase in the proportion of older workers in the US workplace. Understanding the health and safety needs of an aging workforce will be critical, especially in the construction industry, where the physical job demands are high. The aim of this paper was to review the epidemiologic literature on the impact of age on injury among workers in the construction industry in terms of cause, type and cost. A PubMed search was done with the following terms: older workers, construction, construction industry, injury, and age. The available studies reported that among the construction industry workforce, older age at injury was related to higher injury costs, but not to number of injuries. The higher injury costs associated with worker age are likely due in part to the severity of the injuries sustained among older workers. The identification of injury trends and subsequent analytical research efforts designed to identify factors associated with injury among older construction workers are needed for employers to effectively manage a health and safety program that addresses the needs of the aging worker.

Keywords

Aging workforce; Construction industry; Injury; Injury costs; Older worker; Workers' compensation

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INTRODUCTION

The relatively large birth cohort between 1946 and 1964 combined with the recent economic recession during the first decade of the 21st century have led to an increase in the proportion of older workers in the United States (US) workplace. For example, a reversal of the 20th century trend towards earlier retirement has been observed as a growing number of employees are planning for longer working careers (1–2). As workers continue to delay retirement, understanding the health and safety needs of an older-aged workforce will become increasingly important in the near future.

Why is there a need to address injuries among older workers in the construction industry? First, construction is a physically demanding industry (3). Second, injuries and illnesses among construction workers are among the most costly across all industries (4). Third, construction workers experience increasing chronic health conditions over time, compared to white-collar workers (5). Lastly, workers from about age 50 and older have been considered to be at increased risk of injury, compared to younger workers. This hypothesis was based on the notion that reduced physical capabilities associated with older age in areas such as strength, balance, and processing speed would increase risk of injury (6). In fact, this is not the case. Analyses of workers' compensation claims data indicate that older workers typically have a lower frequency of workplace injuries, but higher injury-related costs, compared to younger workers (1).

The goal of this review is to summarize the published epidemiologic literature that examined the cause and type of injuries and related costs with respect to age for the construction industry. Evaluating injury trends among older workers among the construction industry is a strategic goal for the following agencies: the National Institute of Occupational Safety and Health (NIOSH), the NIOSH National Occupational Research Agenda (NORA) and the Center for Construction Research and Training (CPWR). There is a knowledge gap in the field of occupational injury especially in terms of characterizing the type and cause of construction worker injuries among older workers. These data are needed to design targeted interventions aimed at preventing work-related injuries among older construction workers in order to keep them employed, as well as to reduce injury costs (7–8).

A PubMed search was conducted that included combinations of the following terms: older workers, construction, construction industry, injury, and age to identify original research articles published from 1998 through June 2011 among US populations. We did not include articles that were published prior to 1998, because there was a major shift that occurred in the early to mid 1990's that included the development of a national construction safety and health research agenda that makes studies conducted prior to this time less representative of the present-day construction industry environment (9). When construction, injury and age were searched together, one hundred and ninety-one papers were identified but only ten were used (10–16). When construction industry and older workers were searched together, twenty-two papers were identified and only eight were used (12, 14, 17–18). Articles were excluded if they did not pertain to the construction industry, older workers and included at least one of the following topics: injury cause, injury type or injury cost. Once the first author (NVS) completed the search, the second author (LMB) conducted the same search to ensure that no relevant papers were missed. We identified an additional nine relevant articles that were either seminal papers in the field based on the authors' knowledge, or were articles included in the reference list of one of the articles identified by the PubMed search (4–5, 7, 19–22), some of which were studies based outside of the US (23–28).

AN AGING US WORKFORCE

The proportion of US workers who are 55 years and older will increase as the participation rate of workers 16 to 24 years of age declines within the next decade. The participation rate of US workers 55 years and older has increased from 31.3 percent in 1998 to 39.4 percent in 2008, and is estimated to reach 43.5 percent by 2018 (29). According to analyses of data from the Health and Retirement Study, possible reasons for the increase in retirement age include decreases in Social Security benefits, diminishing value of private pension portfolios, and increasing health and longevity (30).

Prior to the mid-1980's there were incentives to retire early. Retirement was a planned phase of life in the early 1900's that was encouraged by the government and private sectors. The Social Security Act of 1935 legislated a social insurance program that provided income for retired workers over the age of 65. Then in 1961, the retirement age requirement was lowered to 62 years. In addition, corporate pension plans designed to supplement Social Security benefits only needed to provide income until around age 70.2, the average life expectancy in 1961 (31–32). As of 2008, the average life expectancy in the US has reached 78.4 years (33). Overall, the legislative and corporate climate until recently has encouraged retirement as early as 55 years of age (34).

Within the past few decades, a typical retirement age has become less defined. Legislative changes, such as the Age Discrimination in Employment Act of 1986 and the Pension Protection Act of 2006 have enabled workers to delay retirement without penalties. In addition, delaying retirement has in some cases become an economic necessity. Defined contribution retirement plans have become more popular than defined-benefit plans for some, while Social Security may be the only means of retirement for others (35). Thus, workers are encouraged to stay on the job longer in order to maximize retirement benefits (29).

An aging workforce in the US construction industry

The US non-profit Center for Construction Research and Training (CPWR) reported a 70 percent increase in the number of paid construction workers from 1977 to 2002 (36). The number of jobs in the construction industry is expected to continue to grow by 19% from 2008 to 2018, compared to a projected 11% for all industries combined (37). The growth of the construction industry is expected to be hindered in the future by a shortage of skilled workers (38). Thus, keeping skilled workers employed in the industry for as long as possible is a high priority in the US (11).

The increasing average age of the construction industry workforce is consistent with the national trend observed for all industries, where the median age of the workforce has steadily increased from 39.4 years in 2000 to 42 years in 2010. In the construction industry, the median worker age was 37.9 years in 2000 and 40.4 years in 2010 (39). As described above, increases in the average workforce age may be explained in part by the decreasing rates of younger workers entering the workforce, as well as changes in the financial resources of older workers.

Chronic disease and functinal impairment cause serious limitations for construction workers as they age (10, 19). Dong et al. (5) analyzed data from a 10-year follow-up study (1998-2008) of older construction workers and found a persistent disparity in health status between construction and white-collar workers as they age. For example, the risk was higher for older construction workers, compared to white-colar workers for back problems (OR=1.54, 95% CI=1.10, 2.14) and functional limitations, such as not being able to reach/ extend arms up (OR=2.18, CI=1.40, 3.39) or to lift/carry ten or more pounds (OR=1.67, 95% CI=1.03, 2.72). The disparity reported for musculoskeletal diseases by Dong et al. (5) is likey related to the physically demanding tasks required in the construction trades (3, 26).

Susceptibility to injury among an aging workforce

Benjamin, et al. (16) contend that older workers may not be able to reduce work hours or switch to less physically demanding work without risking the loss or reduction in pension and or health benefits. Thus, older workers may find themselves in a difficult financial situation when making a decision whether to remain in the workforce. If they continue working for financial reasons, they may be unable to perform the same tasks as well, or as safely as their younger counterparts.

The aging process involves many physical changes that can make construction work tasks more difficult for older workers. For example, physically demanding work may be difficult due to decreased cardiac output and reduced tolerance to physical activity (40). Older workers are also susceptible to loosing muscle mass and subsequent decreases in strength (41). Bone density decreases with age resulting in a greater propensity for fractures (42). Older adults are also more susceptible to chronic inflammatory disorders, which are associated with arthritis and other conditions that can limit joint range of motion and function (43–44). Body composition and weight also tend to change with age in a way that predisposes workers to diabetes, hypertension, and reduced flexibility and mobility (45). Overall, the aging process can involve significant physical changes that challenge a worker’s ability to perform physically demanding tasks, such as those in construction, without incurring injury.

AGE-RELATED INJURY IN THE CONSTRUCTION INDUSTRY

Due to the nature of the trade, most construction workers experience a physically demanding work environment on a daily basis. The industry is characterized by stressful environmental conditions (e.g., harsh weather) (46), long work hours (47), irregular work periods (48–49), unpredictable workplaces and non-continuous employment (50). The physical demands of the job involve exposure to heavy lifting and materials handling, use of vibrating tools, awkward postures, prolonged static positions, and working while injured or in pain (51). These demands can eventually result in injury, missed work, and disability (19, 52–53). Additionally, most construction tasks involve a combination of multiple physical exposures further increasing the probability of injury and disability (3). Therefore, one method to reduce the burden of injury among construction workers is to identify susceptible populations, such as older workers, and characterize the their injuries in terms of cause, type and severity (i.e. cost) in order to appropriately focus on the best available prevention strategies.

In Table 1 the most relevant studies related to the cause, type and/or cost of injuries in the construction industry, with respect to age are shown. In summary, the findings from these studies indicate that injuries are less frequent but more severe among older construction workers, thus requiring older workers to take a longer to recover compared to injuries that occur among younger workers (3, 7, 26). These injury characteristics among older workers translate into higher compensation costs, due in part to longer lost work time and disability.

Causes of injuries in the construction industry

Injuries due to falls are a major concern for the construction industry. Falls are the most common cause of fatal injury and are ranked among the top three most common causes of non-fatal injuries (e.g., 22, 36, 54). However, the data regarding frequency of fall-related injuries among older workers are inconsistent.

Kemmlert and Lundholm (27) reported that the proportions of slip, trip and fall incidents were greater among male workers aged 45 years and older, compared to workers less than 45 years of age. The study consisted of 1,620 reports of slip, trip and fall incidents from the Swedish Occupational Injury Information System and included construction work as well as electrical, agricultural, metal machine work, building metal work, and material handling work (27). Coantonio, McVittie, and Lewko (24) analyzed workers' compensation data from Ontario, Canada and found that 76% of the traumatic brain injury claims of construction workers aged 55-64 were from falls, compared to 45% of claims from workers aged 17-24. In contrast, Shishlov, et al. (18) reported a two-fold decrease in the fall-injury rate among workers 55 years and older [45/10,000 full-time equivalents (FTE)], compared to workers less than 20 years of age (114/10,000 FTE). The study by Shishlov, et al. used data from the National Electronic Injury Surveillance System collected by NIOSH to obtain US hospital emergency department data for construction-related injuries (*N*=555,700). Possible reasons for the inconsistent results between the Kemmlert (27), Colantonio (24) and Shishlov (18) studies may be due in part to differences in record keeping practices between the two countries, occupations included in the study, or that the focus was on severe injuries (e.g. those requiring an emergency department visit) in the US study, but not in the Swedish study.

Injuries due to falls are categorized in terms of fall location (e.g. same or different level) and contributing factor (e.g. ladder, scaffold, snow, grease). Falls from elevations have been cited as the most frequent types of falls in the construction industry as a whole. However, among older workers in the carpentry trade, falls from the same level have been found to be most frequent (15). In a study using self-reported data from injured carpentry workers (*N*=4,429), the contributing factors to falls from the same level were found to be tripping over debris, difficult work terrain (rocky, muddy, uneven), the slope of the lot, lack of backfill around the foundation, and difficult access and/or egress from the building (55). Studies involving construction-related falls treated in the emergency department indicated that older workers were more likely to be hospitalized due to falls, indicating a greater severity of injury among older workers (7, 18, 56).

Motor vehicle incidents occur infrequently (22, 57), but result in some of the most severe injuries among construction workers (7, 57) and are the second leading cause of occupationally related deaths in the construction industry (36). Using the National Traumatic Occupational Fatalities Surveillance System (1980-1992), Ore and Fosbroke (58) found that the motor vehicle incident fatality rate for the construction industry was 2.4 per 100,000 workers across all ages but increased to 6.9 for workers over the age of 65. Possible contributing factors in motor vehicle incidents among older workers include age-related degradation in vision, reaction time, cognitive function, muscle strength, and range of motion (59–60). The little knowledge we have on older construction worker's motor vehicle incidents is based on national sources of data. Such data cannot account for exposure (i.e. hours driving), thus caution should be used when interpreting findings from national data. There is a major gap in our knowledge of motor vehicle incidents among older construction workers and factors that affect their abilities to drive should be considered in the development of injury prevention strategies for workers in the construction industry.

Types of injuries in the construction industry

Musculoskeletal disorders (MSDs) are of particular concern for construction workers. Older workers experience a significant burden of musculoskeletal disorder conditions and continue to work with pain and limitations (10). de Zwart et al. (25) utilized the Dutch Periodic Occupational Health Survey (1983-1993) to determine the prevalence of age-related health issues among older construction workers (45–64), compared to younger construction workers (16–30). They found an increased prevalence ratio of complaints related to the upper and lower extremities, back, and neck. Hoonakker and van Duivenbooden (26) utilized the same survey for the years 1989-2003 and found similar results. LeMasters et al. (20) found that the odds of having an MSD of the shoulders, hands/wrists, and knees among union carpenters were greatest among workers with more than 20 years of employment in the industry. Age did not remain a significant predictor in the final multivariate logistic regression model when job duration was added to the model. MSDs among older workers may predispose them to reoccurring injuries. Lipscomb, et al. (61) found that carpenters who experienced a back injury were at an increased risk for a second back injury within three years of the initial injury. Musculoskeletal disorders may also put older workers at risk for retirement from the construction trades earlier than anticipated. Welch, et al. (11) found that the odds of leaving the roofing trade early were eight times higher for workers with a musculoskeletal disorder than workers without a musculoskeletal disorder.

A minimal amount of research has evaluated other types of injuries besides musculoskeletal disorders among older construction workers. Fractures, contusions/abrasions and sprains/strains are the most common injury among construction workers over 40 years of age, while contusions/abrasions and sprains/strains are the most common among workers under 29 years of age (18). Occupational illnesses such as pneumoconiosis (28), mesothelomia, asbestosis (17) and hearing loss (21) are primarily seen among older construction workers, likely due to the well-recognized latency between first exposure and disease onset.

Injury-related costs in the construction industry

Given the precarious and physically challenging work conditions in the construction industry, coupled with the increasing average age of the workforce, it seems inevitable that the cost of occupational injuries among construction workers will also increase. While construction workers represent only six percent of the US workforce, they account for a disproportionate 15 percent of costs related to injuries and fatalities for all US industries (4). Vulnerable populations, such as older workers, contribute to much of these costs. In general, workers' compensation claim costs increase with the age of workers (22). For example, Lipscomb, et al. (15) found that costs associated with falls in construction were three times higher for those over 45 years when compared with those under 30 years of age. Data from Lowery et al. (16) indicated that lost work time and related indemnity costs, increased with age. Schoenfisch et al. (7) determined that, although injury rates among older construction workers were lower than younger workers, the injuries among the more senior workers were more likely to cause more serious problems that required longer hospitalization stays, indicating a decreased ability to recover from an injury. Physical disability among older construction workers is a major concern because of its effect on overall productivity. The ability to fully recover from an injury becomes increasingly difficult with increasing age. Therefore, the proportion of disability is likely to be higher among older, compared to younger workers in the construction industry (11, 23). Relative to younger workers, older workers miss more days of work when injured (7, 62).

Previous research has found that older construction workers are more likely to die from an occupational injury than younger construction workers. For example, CPWR utilized the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) and found that 44% occupationally related fatalities in 2005 occurred among construction workers over the age of 45 (36). Jackson et al. (14) utilized the North Carolina Medical Examiner's database of occupational fatalities for the construction industry and found that the crude death rate was highest among workers aged 65-74 and lowest among workers aged 18-24, with rates of 31.8 and 18.3 per 100,000 person years, respectively. There may be differences in cause of death among different aged construction workers. Janicak (12), for example, found that construction workers aged 16-19 (PMR=144.72, $M\text{-}H\,\chi^2=4.74$, $p<0.05$) had a greater proportion of electrocution fatalities than expected and construction workers aged 65+ (PMR=75.69, $M\text{-}H\,\chi^2=45.75$, $p<0.05$) had a lower than expected proportion of electrocution fatalities.

Promotion of work ability

The promotion of work ability can enable older construction workers to remain employed and injury free. The Finish work ability index (WAI) was developed in order to understand how long workers are able to work and whether job demands and job content affects their ability to continue work (63). Previous research has used the WAI to predict sickness absence (64) and disability among older workers (65) in the construction industry. A work ability promotion program was developed and modeled around four different actions: 1) adjustments to the physical environment, 2) adjustments in the psycho-social environment, 3) health and lifestyle promotion and 4) updating professional skills (66). Tuomi et al. (67) utilized data from a 16 year follow-up study of Finish municipal workers and found that the model of work ability was strongly associated with the WAI. In addition, a high WAI score was associated with high quality work, high productivity, the ability to function well and to stay in good health upon retirement (67).

The work ability promotion program has not been studied within the construction industry specifically but the model could be a useful guide for future interventions. Welch (68) reviewed literature pertaining to the WAI and construction work and recommended rehabilitation programs for injured workers, ergonomic programs to prevent musculoskeletal disorders, and comprehensive health promotion programs. In regards to ergonomic programs developed to reduce the risk of injury, contractors could integrate knowledge regarding workstation and task adaptations appropriate for older workers into their commonly held pre-task planning meetings on the construction site. Disseminating information that older workers may need to work at lower elevations, need more breaks during heavy physical work, or need more time to complete a task may enhance the safety at the job site. Employers may consider providing lighter materials to handle or manual material handling equipment and eliminate long or heavy reaches from ladders (3). Providing reasonable accommodations for all older workers may be difficult to achieve in physically demanding industries like construction. Thus, older construction workers may be placed in a difficult situation of having to weigh the costs and benefits of continuing to work in such a physically demanding profession. This may result in a feeling of “job lock” or the inability to leave a job due to financial or benefit needs, or working while ill (e.g. presenteeism) (69) if retirement is not financially feasible. Improving construction work ability for all ages and physical limitations will require a concerted effort from workers, contractors, unions, owners, policy makers, regulators and the occupational health and safety community to implement effective programs that can adapt to the unique challenges facing the construction industry (63, 68).

RECCOMENDATIONS FOR FUTURE RESEARCH

Though older workers may experience physical limitations, their ability to add value to an organization is a notable strength. A recent meta-analysis examined the relation between age and several job performance measures. The worker’s age was not found to be related to core task performance or level of creativity, but it was related to increased safety performance and decreased counterproductive work behavior (70). Employers who resist adapting work to older workers are susceptible to losing valuable workers and paying more in hiring and training costs (71). Given the dominant role that older workers will play in the future, it is critical to understand how to shape work environments in order to take advantage of their talents and to minimize the risk of injury they face on the job (70). For example, researchers have suggested using ergonomic principles to fit the job to the worker (3), wellness programs to keep older workers physically fit (72) and good housekeeping (27).

Despite the increased awareness and epidemiologic research related to construction worker health and safety over the last twenty years, the construction industry remains one of the most dangerous industries in the US (3). Injury trends among vulnerable workers, such as the growing number of older workers, needs to be studied in greater depth to determine specific interventions aimed at preventing age-related injuries and helping older workers remain employed (7–8). The data available on injury trends among older workers is limited in depth (Table 1). The available literature has focused primarily on injuries due to falls and injuries that result in musculoskeletal disorders, but the characteristics of other types of causes and types of injuries have not been reported in as much detail for older construction workers (Table 2). It is important to note that publication bias may contribute to the paucity of publications in this area. However, the larger issue is that there are too few studies that have been conducted that focus on older workers in the construction industry.

In addition to older workers, Hispanic construction workers are another vulnerable population have been found to be at increased risk of injury (73) and death (74–75), compared to non-Hispanic construction workers. Hispanic construction workers are generally younger than non-Hispanic workers (36) but when older Hispanic workers are injured on the job they are more likely to die from the injury. For example, research using the BLS CFOI (1992-2000) has found that the fatality risk index among older (65+) Hispanic construction workers was greater than older non-Hispanic workers, 5.5 versus 2.7, respectively (74). While the topic of injury among Hispanic construction workers was beyond the scope of the present review, it is clearly a topic in need of further research.

Future research should utilize a combination of leading and lagging safety and health performance metrics to determine the relations between safety, injury and age in the construction industry. Safety and health performance metrics can be used to monitor the level of safety or to motivate those in a position of power to take necessary actions to improve safety. These metrics can also be used to determine how to take action (76). Leading indicators of safety (i.e., actions, events and processes that precede the event from occurring) should be tracked by using such metrics as use of personal protective equipment, reporting unsafe conditions/actions, or participation in health and safety meetings. Lagging indicators (i.e., reactive measures of safety) can also be utilized by tracking existing occupational injury data (e.g., workers compensation claims, BLS’s Survey of Occupational Injuries and Illnesses, or National Electronic Injury Surveillance System-Work). By tracking a combination of leading and lagging indicators, the relation between age, safety, and injury can be determined and the appropriate interventions can be developed.

Crawford, et al.’s (77) review of the health and safety needs of older workers found that there were no intervention studies that specifically evaluated strategies to reduce injuries in older workers. The identification of specific injury trends and subsequent analytical research efforts designed to identify risk and protective factors among older construction workers can provide the necessary guidance needed to develop appropriate interventions aimed at maintaining their employment. The American College of Occupational and Environmental Medicine states that it is imperative that more attention and resources be devoted to protecting the employability of older workers to mitigate the impending consequences of the health care crisis brought on by chronic disease among the baby boomers (78). A recommended priority for researchers is to make concerted efforts towards disseminating their research results and translating these results into workable recommendations that have the potential to reduce workplace injury among older workers in the construction industry.

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Abbreviations:

US	United States
BLS	Bureau of Labor Statistics
CPWR	The Center for Construction Research and Training
CI	confidence interval
DIA	Denver International Airport
ED	Emergency department
FTE	Full time equivalents
MSDs	Musculoskeletal disorders
NEISS	National Electronic Injury Surveillance System
NIOSH	National Institute of Occupational Safety and Health
NORA	National Occupational Research Agenda
OR	Odds ratio
PR	Prevalence ratio
RR	Rate ratio
SIR	Standardized incidence ratios
SMR	Standardized mortality ratios
TBI	Traumatic brain injury
CFOI	Census of Fatal Occupational Injuries
WAI	Work Ability Index

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Table 1.

Studies Evaluating Age and Injuries Among Construction Workers

Reference	Study design and population	Research objective	Main findings
Kemmlert, 2001 (27)	Cross-sectional analysis of Swedish Occupational Injury Information System data (N=1,620)	To report and discuss major factors contributing to slip, trip and fall accidents	• 26% of occupational accidents among workers aged 45 years and older were due to slips, trips and falls, compared to 17% of occupational accidents among workers aged 45 years and younger
Shishlov, 2011 (18)	Cross-sectional analysis of NEISS-work database of ER-treated injuries (N=555,700)	Provide national estimates of non-fatal construction industry injuries resulting from falls	• Injury rates were twice as high for workers <45 years than for workers ≥45 years • Workers >50 years had approximately equal frequencies of contusions/abrasion, sprain/strain, and fracture injuries whereas younger workers <29 years and 30-39 years had more contusions/abrasions and strains/sprains than fractures • 10% more injured workers <29 years were treated and released, compared to workers >50 years
Schoenfisch, 2010 (7)	Cross-sectional analysis of NEISS-work database ED-treated injuries (N=3,216,800)	• Identify injuries/illnesses • Estimate number and rate of injuries treated in ED's	• Workers 20-24 years old were injured at a rate of 720 per 100,000 FTE while workers 65+ years old were injured at a rate of 140 per 100,000 FTE • Workers 20-24 years old were treated and released from the ED 97% of the time but workers 65+ years old were released 89% of the time
Hoonakker, 2010 (26)	Cross-sectional health survey among Dutch construction workers (N=174,090)[a]	Compare health and injury characteristics among workers by age group	• Workers >55 years old had fewer injuries (7%) compared to workers <20 years old (20.1%) • 34% of workers >55 years old and 11% workers <20 years old reported back and neck complaints • 47% of workers >55 years old and 13% of workers <20 years old reported upper extremity complaints • 44% of workers >55 years old and 15% of workers <20 years old reported lower extremity complaints • 25% of workers >55 years old and 7% of workers <20 years old reported that their health problems were work related • 45% of workers >55 years old and 60% of workers <20 years old reported being absent because of injury or illness
Welch, 2008 (10)	Cross sectional study of roofers aged 45-59 (N=979)	Investigate the prevalence of medical and MSD conditions among working roofers and examine its relationship with age, physical functioning and work limitations	• 54% of workers reported at least one MSD conditions and 42% reported at least one medical condition. Lower back/sciatica was the most reported type of MSD condition • 50% of subjects with a reported MSD condition were estimated to be younger than 45 when the problem began • 31% reported missing work due to MSD condition two years prior to interview • The most common medical conditions were cancer (55%), heart problems (53%), diabetes (33%), burns (38%) and lower back/sciatica problems (35%) • Increased age was associated with reduced physical functioning, regardless of MSD or medical condition
Colantonio, 2009 (24)	Cross-sectional study of concussion/ intracranial injury that resulted in days off work from the Ontario Workplace Safety and Insurance Board database (N=218)	Examine work-related traumatic brain injuries (TBI) and the associated demographic and injury-related factors	• Workers 25-34 years old experienced the most TBIs (27.5%) and workers 55-64 years old experience the least amount of TBIs (9.7%) • Workers 35-64 years old experienced TBIs by falls more often and workers 17-34 years old experienced TBIs by being struck by/against more often • Compared to all other construction trades, trade helpers/laborers experienced the most TBIs. Trade helpers/laborers aged 17-24 years old were especially susceptible to TBIs.
Friedman, 2009 (22)	Cross-sectional study of injuries in the construction industry using the Illinois Workers' Compensation Commission claims database (N=19,734)	Describe characteristics of injured construction workers filing claims	• Workers 16-24 incurred a mean cost of $17,558 whereas workers 55-64 years old incurred a mean cost of $53,125; compensation decreased among workers >65 years old where mean costs were $31,618 • A $520 increase in total cost for every 10 year increase in age was observed
Suarthana, 2007 (28)	Cross-sectional study of Dutch natural stone and construction	To develop a simple diagnostic model to estimate the probability	• Workers aged >40 years were at 3.3 times the risk of pneumoconiosis, compared to workers ≤40 years of age

Reference	Study design and population	Research objective	Main findings
	workers with potentially high quartz dust exposure (N=1,291)	of individual workers having pneumoconiosis	
Waehrer, 2007 (4)	Cross-sectional study of fatal and non-fatal injuries in the US construction industry using self-reported data from the BLS survey and the National Census database of fatal occupational injuries	Determine the costs of injuries and illnesses in the construction industry	• Workers 25-44 years old were injured the most frequently and incurred the greatest amount of costs • Frequency and cost of injury declined with age after 44 years old except for medical costs. Workers ≥65 years old incurred a mean of $5,831 and workers ≤24 years old incurred a mean of $2,903 medical costs
LeMasters, 2006 (19)	Cross-sectional analysis of self-reported health data among retired union construction workers and retirees from non-construction unions (e.g., Communication Workers of America and American Federation of Teachers) (N=780)	Determine if retired construction workers have poor self-reported quality of life and higher levels of self-reported physical functioning than more sedentary occupations.	• 42% of construction workers reported poor health • Male construction workers were five times more likely to report poor health, compared to non-construction workers • 19% construction workers reporting being in severe pain vs. 3% of non-construction workers
Lipscomb, 2003 (15)	Cross-sectional study of injuries among carpenters using Washington state workers' compensation claims data (N=16,215)	Describe the leading cause of morbidity and mortality due to falls	• Compared to workers ≥45 years old, workers <30 years old were less likely to fall on the same level (RR=0.73, CI=0.58, 0.93) • Compared to workers ≥45 years old, workers <30 years old were less likely to have a fall from the same level that resulted in paid lost time (RR=0.48, CI=0.32, 0.72) • Workers 45-54 years old claims due to falls from a same level cost a mean of $21,621 whereas workers <30 years old cost a mean of $4,638. Mean cost for workers >55 years old declined to a mean of $15,468 • Workers >55 years old had a mean cost of $21,071 for a fall from elevation where as workers <30 years old had a mean cost of $9,034 for a fall from elevation
de Zwart, 1999 (25)	Cross-sectional study of self-reported health of Dutch construction workers (N=44,486)	Identify age-related work and health issues that can be included in a questionnaire of older construction workers health	• Compared to younger workers (16-30 years), older workers (45-64 years) experienced more complaints about their neck (PR=3.44, CI=2.77, 4.28), upper extremities (PR=2.56, CI=2.23-2.94), back (PR=1.75, CI=1.57, 1.96) and lower extremities (PR=1.73, CI=1.53, 1.96)
LeMasters, 1998 (20)	Cross-sectional study of self-reported health among union carpenters in Ohio (N=522)	Determine prevalence and risk factors for work related MSDs	• Age and job duration were strongly correlated • Age was a statistically significant predictor of MSD's shoulders, hands and wrists when age was substituted for job duration in the multivariable model • When job duration was added to the model, the association with age was attenuated and lost statistical significance
Lowery, 1998 (16)	Cross-sectional study of injury at a DIA construction site using workers compensation claims data (N=4,634)	Determine the risk factors for injury	• The rate of injury (20.5 per 100 workers) among older workers (>60 years) was higher than younger workers (15-19 years) rate of injury (6.6 per 100 workers) • The rate of lost work time injury (3.8 per 100 workers) among older workers (>60 years) was higher than younger workers (15–19) rate of injury (0.9 per 100 workers)
Dement, 2009 (17)	Prospective cohort study of building trade workers from nuclear weapons facilities followed from 1998-2004 (N=8,976)	Investigate the mortality among construction and trade workers who work at nuclear weapons facilities who may be exposed to serious hazards.	As a function of length of employment in construction trades, there was an increase in risk of mesothelioma and asbestosis • Workers who started work when <30 years of age had an increased risk for mesothelimoa (SMR=6.59) and asbestosis (SMR=53.35)
Arndt, 2005 (23)	Prospective cohort study of male construction workers given medical exams at baseline and the subsequent recipients of disability pension at a 10 year follow-up (N=14,474)	Study the disability risk of construction workers	• Workers 60-64 years old experienced occupational disability at a rate of 8551 per 100,000 person years whereas workers 25-39 years old experienced a rate of 134 per 100,000 person years • Compared to other non-construction blue collar workers, workers 55-59 years old had a SIR of 2.42 (CI=1.79,3.21) for incidents that caused disability and a SIR of 1.61 (CI=1.47,1.75) for MSDs that caused disability • Compared to other non-construction blue collar workers, workers who had worked for ≥30 years had

Reference	Study design and population	Research objective	Main findings
			a SIR of 2.54 (CI=1.93,3.3) for incidents that caused disability and an SIR of 1.72 (CI=1.59,1.87) for MSDs that caused disability
Welch, 2010 (11)	Prospective cohort of roofers in the United States (N=979)	Describe the characteristics of roofers who left the trade within one year of a baseline interview and the subset who left due to a health condition	Characteristics of roofers who left the trade due to health reasons: • Older (OR=1.18, CI=1.09, 1.27) • Had lower physical functioning (OR=0.91, CI=0.88, 0.94) More diagnosed MSD conditions (OR=7.92, CI=0.98, 64.29) • More diagnosed medical conditions (OR=6.83, CI=0.80, 58.09) • More MSD and medical conditions combined (OR=4.63, CI=0.55, 39.15) • More likely to have missed work in the 2 years prior to baseline (OR=1.97, CI=0.95, 4.10) Moderate economic impact was most common among younger workers (OR=0.87, CI=0.80, 0.95), poor physical functioning (OR=0.93, CI=0.89, 0.97), any missed work (OR=2.8, CI=1.15, 6.81) and former roofers who left for health-related reasons (OR=19.04, CI=4.96, 73.06)
Dong, 2011 (5)	10-year follow-up study (1998-2008) of male workers (N=7,200) that utilized the Health and Retirement Study	To examine the health status of older construction workers in the US and how occupation and the aging process affect health in workers' later years	• Construction trades vs. white-collar workers at follow-up had increases in: • Arthritis (OR=1.93, CI=1.39, 2.67) • Chronic lung disease (OR=1.93, CI=1.17, 3.20) • Stroke (OR=1.67, CI=1.14, 2.44) • Back problem (OR=1.54, CI=1.10, 2.14) • Fair/poor physical health (OR=1.74, CI=1.23, 2.46) • Fair/poor hearing (OR=1.74, CI=1.23, 2.46) • Functional limitations of reach/extended arms up (OR=2.18, CI=1.40, 2.39) and lift/carry 10lbs (OR=1.67, CI=1.03, 2.72) • Health problem limits work (OR=2.05, CI=1.47, 2.87) • Injury at work (OR=3.12, CI=1.10, 8.87) • Construction trades had an increased risk of stroke (OR=1.69, CI=1.13, 2.53) compared to other blue-collar workers at the time of follow-up • At follow-up, the rate of full-time work among construction workers was greater than the rate of all workers combined but many of the construction workers had switched to non-construction industries
Jackson, 2002 (14)	Cross-sectional study of North Carolina Medical Examiner records of construction work related deaths (N=535)	To describe fatal occupational injuries within the construction industry and to identify risk factors	• Crude death rate was highest among workers aged 65-74 and lowest among workers aged 18-24, 31.8 and 18.3 per 100,000 person years, respectively
Janicak, 2008 (12)	Cross-sectional study of construction electrocution fatalities using the BLS Census of Fatal Occupational Injuries (N=492)	Identify differences in the proportion of fatalities by type of electrocution and to identify differences in proportions of fatalities by age of the worker	• Among workers over the age of 65, 56% electrocution fatalities were due to contact with electrical wiring, transformers or other electrical components and 22% were due to contact with overhead power lines • More than 50% of deaths among younger workers (ages 16-19, 20-24, 25-34) were due to contact with overhead power lines • Significantly greater proportions of deaths from electrocutions were observed among younger workers aged 16-19 (PMR=144.72, *M-H* X^2=4.74, p<.05), compared to older workers aged 64 years and older (PMR=75.69, *M-H* X^2=45.75, p<.5)
Dement, 2005 (21)	Cross-sectional study of Department of Energy (DOE) construction workers (N=3,510)	Determine hearing loss among older construction workers who are exposed to high-noise levels	• 92.7% of workers over the age of 65 had hearing loss • Compared to the control group (<80 dBA exposures), DOE workers with more than 33 years of trade work had a greater odds of material hearing impairment (OR=2.2, CI=1.5, 3.2)

Abbreviations: Bureau of Labor Statistics, BLS; confidence interval, CI; Denver International Airport, DIA; Department of Energy DOE; Emergency room, ER; Full time equivalents, FTE; Musculoskeletal disorder, MSD; National Electronic Injury Surveillance System, NEISS; Odds ratio, OR; Prevalence ratio, PR; Proportionate Mortality Ratios, PMR; Rate ratio, RR; Standardized incidence ratios, SIR; Standardized mortality ratios, SMR; Traumatic brain injury, TBI; United States, US.

[a] An estimated study size based on information provided in the publication.

Table 2.

Injury and Age Studies Among Construction Workers by Injury Cause, Type, Body Part Affected and Cost

Cause of injury	Type of injury	Body part affected	Associated cost of injuries
Falls, slips and trips (15, 24)	MSD (18–20, 23, 25–26) Fractures (18) Pneumoconiosis (28) Mesothelioma (17) Asbestosis (17) Contusion/abrasion (18) Hearing loss (21)	Back (25–26) Neck (26) Upper extremities (26) Lower extremities (19, 26)	Hospitalization days increased (7, 18) Retirement (11) Lost work days (16) Disability (23) Increased monetary costs (4, 15) Functional Limitations (5, 19) Death (14, 36)

Abbreviations: Musculoskeletal disorder, MSD.