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Topics in Construction Safety and Health
Older Workers:
An Interdisciplinary Annotated Bibliography

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Older Workers: An Interdisciplinary Annotated Bibliography

Bacharach, S., et al. (2008). "Aging and drinking problems among mature adults: the moderating effects of positive alcohol expectancies and workforce disengagement." *J Stud Alcohol Drugs* 69(1): 151-159.

OBJECTIVE: This article examines the relationship between aging and drinking problems among mature workers and the moderating effects of positive alcohol expectancies (PAEs) and workforce disengagement. **METHOD:** This longitudinal study collected data on mature adults (i.e., retirement eligible) in three employment sectors (i.e., construction, manufacturing, and transportation) over five periods: T1 was 6 months before their retirement eligibility date and T5 was 4 years afterward. At T1, 1,122 subjects participated in the survey; at T5, 917 participated in the survey. Problem drinking was assessed in all five waves by the Drinking Problems Index. PAEs were measured at T4 and T5 by the Alcohol Outcomes Expectancies Scale. Workforce disengagement was assessed by subjects' employment status at T5 (i.e., still working despite eligibility versus fully retired/not working). Control variables were employment sector, age at T1, and gender. **RESULTS:** PAEs moderated the relationship between aging and drinking problems: High PAEs were associated with an increase in drinking problems, whereas low PAEs were associated with a decrease in drinking problems. With regard to disengagement, continuing to work amplified the moderating effects of PAEs on the relationship between aging and drinking problems, whereas the moderating effects of PAEs were attenuated for the fully retired. **CONCLUSIONS:** This study provides further evidence of the significance of PAEs and drinking problems among mature adults, particularly as they are conditioned by disengagement from work. Implications for employee/member assistance program are discussed.

Calkins, M. M., et al. (2019). "A case-crossover study of heat exposure and injury risk among outdoor construction workers in Washington State." *Scand J Work Environ Health* 45(6): 588-599.

Objectives The primary objective of this study was to assess the relationship between heat exposure and occupational traumatic injuries among construction workers. **Methods** We assessed the relationship between humidex, a measure of apparent temperature, and Washington State Fund workers' compensation injuries among outdoor construction workers using a case-crossover design with time-stratified referent selection. Warm month (March-October) adult outdoor construction traumatic injury claims from 2000-2012 were spatiotemporally joined with high-resolution meteorological data. We used conditional logistic regression with linear splines to assess the association between maximum daily humidex and injuries. **Results** There were 63 720 occupational traumatic injury claims in construction that met our eligibility criteria during the study period. The traumatic injury odds ratio (OR) was 1.005 [95% confidence interval (CI) 1.003-1.007] per one degrees C change in humidex. In the spline analyses, we observed a nearly linear association of humidex with the risk of a traumatic injury. Effect estimates were higher among younger (18-24 years) and older (>54 years) workers, workers with lower extremity injuries, workers with less job experience, smaller employers, workers working in Western Washington, and time of injury before 12:30 hours, although CI of effect estimates overlapped in stratified analysis categories. **Conclusions** In this study of Washington outdoor construction workers, increasing maximum daily humidex was associated with increasing traumatic injury risk. Further work should explore mechanisms of the association

between heat exposure and traumatic injuries. Injury prevention efforts targeted at construction should address heat-related risk factors. In addition, heat awareness campaigns should address outcomes beyond heat-related illness.

Chin, D. L., et al. (2013). "Heavy and light/moderate smoking among building trades construction workers." *Public Health Nursing* 30(2): 128-139.

Objective: The purpose of the study was to identify the correlates of heavy smoking (defined as more than one pack of cigarettes per day) in building trades construction workers. Design and Sample: This study used cross-sectional data from the MassBUILT smoking cessation intervention study at Massachusetts building trades unions with the sample of 763 smokers. Measures: Data collected included information about smoking behavior, individual, psychological, interpersonal, and occupational factors obtained through self-reported questionnaires. Results: Approximately 21% of smokers were heavy smokers. Significant factors related to heavy smoking were: older age (OR = 1.10; 95% CI: 1.06-1.14), male gender (OR = 4.55; 95% CI: 1.62-12.79), smoking the first cigarette of the day within 30 min of waking (OR = 4.62; 95% CI: 2.81-7.59), smoking initiation at earlier age (OR = 0.93; 95% CI: 0.87-1.00), higher temptation to smoke (OR = 1.55; 95% CI: 1.17-2.05), household smoking (OR = 1.90; 95% CI: 1.18-3.06) or living alone (OR = 4.11; 95% CI: 1.70-9.92), and exposure to chemicals at work (OR = 1.61; 95% CI: 1.06-2.53). Conclusion: Addressing the influence of these factors on heavy smoking could lead to the development of targeted, multiple components in comprehensive cessation strategies for blue-collar smokers. © 2012 Wiley Periodicals, Inc.

Choi, S. D. (2009). "Safety and ergonomic considerations for an aging workforce in the US construction industry." *Work* 33(3): 307-315.

The US construction workforce is aging as millions of baby boomers move toward retirement age. Older workers make a substantial contribution to construction in terms of skills and experience. However, construction is still one of the most physically demanding occupations, hence the health implications for older workers. Descriptions of injuries, illnesses and fatalities among older workers in the US construction industry from recent literature are presented along with the practical health and safety interventions that have been proposed including: ergonomic interventions, wellness programs, worksite housekeeping, training, and safety climate. Understanding the risks and hazards in specific industries could help identify training and intervention requirements to meet the challenges facing aging workers in these occupational groups.

Choi, S. D. (2015). "Aging Workers and Trade-Related Injuries in the US Construction Industry." *Saf Health Work* 6(2): 151-155.

The study was designed to identify any trends of injury type as it relates to the age and trade of construction workers. The participants for this study included any individual who, while working on a heavy and highway construction project in the Midwestern United States, sustained an injury during the specified time frame of when the data were collected. During this period, 143 injury reports were collected. The four trade/occupation groups with the highest injury rates were laborers, carpenters, iron workers, and operators. Data pertaining to injuries sustained by body part in each age group showed that younger workers generally suffered from finger/hand/wrist injuries due to cuts/lacerations and contusion, whereas older workers had increased sprains/strains injuries to the ankle/foot/toes, knees/lower legs, and multiple body

parts caused by falls from a higher level or overexertion. Understanding these trade-related tasks can help present a more accurate depiction of the incident and identify trends and intervention methods to meet the needs of the aging workforce in the industry. © 2015, Occupational Safety and Health Research Institute.

Dement, J., et al. (2015). "A case-control study of airways obstruction among construction workers." *Am J Ind Med* 58(10): 1083-1097.

Background: While smoking is the major cause of chronic obstructive pulmonary disease (COPD), occupational exposures to vapors, gases, dusts, and fumes (VGDF) increase COPD risk. This case-control study estimated the risk of COPD attributable to occupational exposures among construction workers. **Methods:** The study population included 834 cases and 1243 controls participating in a national medical screening program for older construction workers between 1997 and 2013. Qualitative exposure indices were developed based on lifetime work and exposure histories. **Results:** Approximately 18% (95%CI=2-24%) of COPD risk can be attributed to construction-related exposures, which are additive to the risk contributed by smoking. A measure of all VGDF exposures combined was a strong predictor of COPD risk. **Conclusions:** Construction workers are at increased risk of COPD as a result of broad and complex effects of many exposures acting independently or interactively. Control methods should be implemented to prevent worker exposures, and smoking cessation should be promoted. © 2015 Wiley Periodicals, Inc.

Dement, J., et al. (2018). "Hearing loss among older construction workers: Updated analyses." *Am J Ind Med* 61(4): 326-335.

BACKGROUND: A prior study of this construction worker population found significant noise-associated hearing loss. This follow-up study included a much larger study population and consideration of additional risk factors. **METHODS:** Data included audiometry, clinical chemistry, personal history, and work history. Qualitative exposure metrics for noise and solvents were developed. Analyses compared construction workers to an internal reference group with lower exposures and an external worker population with low noise exposure. **RESULTS:** Among participants (n = 19 127) an overall prevalence of hearing loss of 58% was observed, with significantly increased prevalence across all construction trades. Construction workers had significantly increased risk of hearing loss compared to reference populations, with increasing risk by work duration. Noise exposure, solvent exposure, hypertension, and smoking were significant risk factors in multivariate models. **CONCLUSIONS:** Results support a causal relationship between construction trades work and hearing loss. Prevention should focus on reducing exposure to noise, solvents, and cigarette smoke.

Dement, J. M., et al. (2020). "Lung cancer mortality among construction workers: implications for early detection." *Occup Environ Med* 77(4): 207-213.

OBJECTIVES: This study examined predictors of lung cancer mortality, beyond age and smoking, among construction workers employed at US Department of Energy (DOE) sites to better define eligibility for low-dose CT (LDCT) lung cancer screening. **METHODS:** Predictive models were based on 17 069 workers and 352 lung cancer deaths. Risk factors included age, gender, race/ethnicity, cigarette smoking, years of trade or DOE work, body mass index (BMI), chest X-ray results, spirometry results, respiratory symptoms, beryllium sensitisation and personal history of cancer. Competing risk Cox models were used to obtain

HRs and to predict 5-year risks. RESULTS: Factors beyond age and smoking included in the final predictive model were chest X-ray changes, abnormal lung function, chronic obstructive pulmonary disease (COPD), respiratory symptoms, BMI, personal history of cancer and having worked 5 or more years at a DOE site or in construction. Risk-based LDCT eligibility demonstrated improved sensitivity, specificity and positive predictive value compared with current US Preventive Services Task Force guidelines. The risk of lung cancer death from 5 years of work in the construction industry or at a DOE site was comparable with the risk from a personal cancer history, a family history of cancer or a diagnosis of COPD. LDCT eligibility criteria used for DOE construction workers, which includes factors beyond age and smoking, identified 86% of participants who eventually would die from lung cancer compared with 51% based on age and smoking alone. CONCLUSIONS: Results support inclusion of risk from occupational exposures and non-malignant respiratory clinical findings in LDCT clinical guidelines.

Dement, J. M., et al. (2003). "Surveillance of respiratory diseases among construction and trade workers at Department of Energy nuclear sites." *Am J Ind Med* 43(6): 559-573.

BACKGROUND: Medical screening programs were begun in 1996 and 1997 at three Department of Energy (DOE) nuclear weapons facilities (Hanford Nuclear Reservation, Oak Ridge, and the Savannah River Site) to evaluate whether current and former construction workers are at significant risk for occupational illnesses. The focus of this report is pneumoconiosis associated with exposures to asbestos and silica among workers enrolled in the screening programs through September 30, 2001. METHODS: Workers provided a detailed work and exposure history and underwent a respiratory examination, which included a respiratory history and symptom questionnaire, a posterior-anterior (P-A) chest radiograph, and spirometry. Both stratified and multivariate logistic regression analyses were used to explore the risk of disease by duration of DOE employment and frequency of exposure, while controlling for potential confounders such as age, race, sex, and other work in the construction and building trades. RESULTS: Of the 2602 workers, 25.2% showed one or more chest X-ray changes by ILO criteria and 42.7% demonstrated one or more pulmonary function defects. The overall prevalence of parenchymal changes by ILO criteria (profusion 1/0 or greater) was 5.4%. In the logistic regression models, the odds ratio for parenchymal disease was 2.6 (95% confidence interval (CI) = 1.0-6.6) for workers employed 6 to 20 years at Hanford or Savannah River and increased to 3.6 (95% CI = 1.1-11.6) for workers employed more than 35 years, with additional incremental risks for workers reporting routine exposures to asbestos or silica. CONCLUSIONS: Continued surveillance of workers is important given their increased risk of disease progression and their risk for asbestos related malignancies. Smoking cessation programs should also be high priority and continued abstinence for former smokers reinforced. Although the observed respiratory disease patterns are largely reflective of past exposures, these findings suggest that DOE needs to continue to review industrial hygiene control programs for work tasks involving maintenance, repair, renovation, and demolition.

Dement, J. M., et al. (2017). "Longitudinal decline in lung function among older construction workers." *Occup Environ Med*.

BACKGROUND: Occupational exposures to vapours, gasses, dusts and fumes (VGDF) and chest X-ray abnormalities by the International Labour Office (ILO) classification system are associated with reduced lung function, with the majority of published studies being cross-

sectional. We examined the effects of VGDF exposures, as well as ILO parenchymal changes, pleural plaque and diffuse pleural thickening (DPT) on reduction in lung function in a longitudinal study. **METHODS:** Chest radiographs and spirometry for 3150 ageing construction workers enrolled in a medical screening programme with a baseline and at least one follow-up examination were studied. Indices for VGDF exposure, parenchymal changes, pleural plaque and DPT severity were developed and used in longitudinal mixed models of lung function. **RESULTS:** Smoking and VGDF exposure were associated with decreased FEV1 and FVC at baseline as well as accelerated rates of annual decline. High VGDF exposure was associated with a yearly decline of -19.5 mL for FEV1 and -15.7 mL for FVC. Parenchymal abnormalities, pleural plaque and DPT were more strongly associated with reduced FVC. An increase of one unit in the pleural plaque severity index resulted in approximately -5.3 mL loss of FVC and -3.3 mL loss of FEV1, with a possible non-linear effect of plaque on FEV1. **CONCLUSIONS:** Increasing pleural plaque severity was associated with progressively greater loss of FVC and FEV1, supporting a causal association. VGDF exposures were associated with reduced FVC and FEV1 at baseline as well as accelerated annual loss of lung function.

Dong, X. S., et al. (2020). "Prescription opioid use and associated factors among US construction workers." *Am J Ind Med* 63(10): 868-877.

BACKGROUND: Construction workers are among the segments of the US population that were hit hardest by the opioid prescription and overdose deaths in the past decades. Factors that underlie opioid use in construction workers have been compartmentalized and isolated in existing studies of opioid use and opioid overdose, but they ignore the overall context of their use. This study examines prescription opioid use and its association with a variety of occupational and nonoccupational factors in construction workers in the United States. **METHODS:** Data from the 2011-2017 Medical Expenditure Panel Survey (n = 7994) were analyzed. The prevalence of prescribed opioid use and the association with occupational and nonoccupational characteristics among construction workers were examined in four multiple logistic regression models. **RESULTS:** The odds of prescription opioid use for workers with occupational injuries was more than triple that of their noninjured counterparts when demographics and occupational factors were controlled (odds ratio = 3.38, 95% confidence interval: 2.38-4.81). Odds of prescription opioid use were higher in older construction workers, workers who were white, non-Hispanic, working part-time, and in poorer health, while Hispanic workers and those without health insurance were much less likely to report prescription opioid use. **CONCLUSIONS:** Prescription opioid use among construction workers encompasses both occupational and nonoccupational factors. As an insight into opioid use among construction workers becomes clearer, effectively responding to the opioid crisis remains a challenge.

Dong, X. S., et al. (2022). "Pain and Prescription Opioid Use Among US Construction Workers: Findings From the 2011–2018 Medical Expenditure Panel Survey." *Am J Public Health* 112(S1): S77-S87.

Objectives. To examine prescription opioid and nonopioid analgesic use among US construction workers and their associations with pain conditions and sociodemographic factors. **Methods.** We analyzed data for about 9000 (weighted 11.5 million per year) construction workers who responded to the Medical Expenditure Panel Survey from 2011 to 2018. We applied both descriptive statistics and multiple logistic regression procedures in the analyses.

Results. An estimated 1.2 million (10.0%) of construction workers used prescription opioid analgesics annually. The adjusted odds of prescription opioid use were significantly higher for workers suffering from work-related injuries (adjusted odds ratio [AOR] = 3.82; 95% confidence interval [CI] = 2.72, 5.37), non-work-related injuries (AOR = 3.37; 95% CI = 2.54, 4.46), and musculoskeletal disorders (AOR = 2.31; 95% CI = 1.80, 2.95) after we controlled for potential confounders. Adjusted odds of prescription opioid use were also higher among workers with poorer physical health (AOR = 1.95; 95% CI = 1.42, 2.69) or mental health disorders (AOR = 1.95; 95% CI = 1.41, 2.68). Conclusions. Work- and non-work-related injuries and musculoskeletal disorders significantly increased prescription opioid use among construction workers. To prevent opioid use disorders, multipronged strategies should be approached. (*Am J Public Health.* 2022;112(S1):S77-S87. <https://doi.org/10.2105/AJPH.2021.306510>).

Dong, X. S., et al. (2013). "Fatal falls from roofs among US construction workers." *J Safety Res* 44: 17-24.

This study examined trends and patterns of fatal falls from roofs in the U.S. construction industry over an 18-year period (1992–2009), with detailed analysis for 2003–2009. Roof fatalities accounted for one-third of fatal falls in construction in 1992–2009. A disproportionately high percentage (67%) of deaths from roof falls occurred in small construction establishments (1–10 employees). Roofers, ironworkers, workers employed with roofing contractors, or working at residential construction sites, had a higher risk of roof fatalities. A higher rate of roof fatalities was also found among younger (< 20 years) and older (> 44 years) workers, Hispanics, and immigrant workers.

Dong, X. S., et al. (2012). "Fatal falls among older construction workers." *Hum Factors* 54(3): 303-315.

OBJECTIVE: This study examines recent trends and patterns in fall fatalities in the U.S. construction industry to determine whether fatal falls among older workers are different from younger workers in this industry. **BACKGROUND:** Falls are the leading cause of fatalities in the U.S. construction industry. Given the increasingly aging workforce in construction, it is important to assess the risk of falls among older construction workers. **METHODS:** Fatality data were obtained from the Census of Fatal Occupational Injuries for the years 1992 through 2008. Denominators for death rates were estimated from the Current Population Survey. Stratified and multivariate analyses were performed to examine whether there are differences in fatal falls between older workers (> or = 55 years) and younger workers (16-54 years). Fatal falls in nonconstruction industries were excluded from this study. **RESULTS:** Older workers had higher rates of fatal falls than younger workers; results were significant in 11 of 14 construction occupations. Regression analysis indicated that older decedents had a higher likelihood that work-related death was caused by a fall, after controlling for major demographic and employment factors (odds ratio = 1.50, confidence interval [1.30, 1.72]). Falls from roofs accounted for one third of construction fatal falls, but falls from ladders caused a larger proportion of deadly falls in older decedents than in younger decedents. **CONCLUSION:** Older workers have a higher likelihood of dying from a fall. Roofs and ladders are particularly risky for older construction workers. **APPLICATION:** As the construction workforce ages, there is an urgent need to enhance fall prevention efforts, provide work accommodations, and match work capabilities to job duties.

Dong, X. S., et al. (2011). "Chronic diseases and functional limitations among older construction workers in the United States: a 10-year follow-up study." *J Occup Environ Med* 53(4): 372-380.

OBJECTIVES: To examine the health status of older construction workers in the United States, and how occupation and the aging process affect health in workers' later years.

METHODS: We analyzed six waves (1998 to 2008) of the Health and Retirement Study, a longitudinal survey of US residents age 50+. The study sample totaled 7200 male workers (510 in construction trades) in the baseline. Multiple logistic regression and paired t tests were conducted to compare health outcomes across occupations and within individuals over time.

RESULTS: Compared with white-collar workers, construction workers had increased odds of arthritis, back problems, chronic lung disease, functional limitations, work disability, and work-related injuries after controlling for possible confounders. **CONCLUSIONS:** Safety and health interventions, as well as retirement and pension policy, should meet the needs of older construction workers, who face increasingly chronic health conditions over time.

Dong, X. S., et al. (2012). "Chronic back pain among older construction workers in the United States: a longitudinal study." *Int J Occup Environ Health* 18(2): 99-109.

This study assessed chronic back pain among older construction workers in the United States by analyzing data from the 1992-2008 Health and Retirement Study (HRS), a large-scale longitudinal survey. Fixed-effects methods were applied in the multiple logistic regression model to explore the association between back pain and time-varying factors (e.g., employment, job characteristics, general health status) while controlling for stable variables (e.g., gender, race, ethnicity). Results showed that about 40% of older construction workers over the age of 50 suffered from persistent back pain or problems. Jobs involving a great deal of stress or physical effort significantly increased the risk of back disorders and longest-held jobs in construction increased the odds of back disorders by 32% (95% CI: 1.04-1.67). Furthermore, poor physical and mental health were strongly correlated with back problems. Enhanced interventions for construction workers are urgently needed given the aging workforce and high prevalence of back disorders in this industry.

Dong, X. S., et al. (2014). "Fatal falls in the U.S. residential construction industry." *Am J Ind Med* 57(9): 992-1000.

Background: Falls from heights remain the most common cause of workplace fatalities among residential construction workers in the United States. **Methods:** This paper examines patterns and trends of fall fatalities in U.S. residential construction between 2003 and 2010 by analyzing two large national datasets. **Results:** Almost half of the fatalities in residential construction were from falls. In the residential roofing industry, 80% of fatalities were from falls. In addition, about one-third of fatal falls in residential construction were among self-employed workers. Workers who were older than 55 years, were Hispanic foreign-born, or employed in small establishments (1-10 employees) also had higher proportions of fatal falls in residential construction compared to those in nonresidential construction. **Conclusions:** The findings suggest that fall safety within the residential construction industry lags behind commercial construction and industrial settings. Fall prevention in residential construction should be enhanced to better protect construction workers in this sector. *Am. J. Ind. Med.* 57:992-1000, 2014. © 2014 Wiley Periodicals, Inc.

Dong, X. S., et al. (2017). "Baby boomers in the United States: Factors associated with working longer and delaying retirement." *Am J Ind Med* 60(4): 315-328.

Objectives: This study estimated the self-reported probability of working full-time past age 62 (P62) or age 65 (P65) among four cohorts of Americans born between 1931 and 1959. **Methods:** Data from the Health and Retirement Study (HRS) were analyzed. Respondents in four age cohorts were selected for comparison. Multivariable linear regression models were used to assess cohort differences in P62 and P65 while adjusting for covariates. **Results:** P62 and P65 increased among boomers despite worsened self-rated health compared to the two preceding cohorts, with 37% and 80% increases among mid-boomers in construction trades. Cohort differences in P62 and P65 remained after controlling for covariates. Changes in pensions, income inequity, and education were significantly associated with work expectations, but SSA policy was not. **Conclusions:** Baby boomers expect to work longer than their predecessors. Efforts to improve work quality and availability for older workers are urgently needed, particularly in physically demanding occupations. *Am. J. Ind. Med.* 60:315–328, 2017. © 2017 Wiley Periodicals, Inc. © 2017 Wiley Periodicals, Inc.

Duffy, S. A., et al. (2011). "Health behaviors of Operating Engineers." *AAOHN J* 59(7): 293-301.

Operating Engineers (heavy equipment operators in construction) may be at particular risk for heart disease and cancer related to their exposure to environmental dust and smoking, the sedentary nature of their job, and long hours of exposure to the sun. The aim of this study was to characterize the health behaviors of Operating Engineers. This cross-sectional survey from a convenience sample of Operating Engineers (N = 498) used validated instruments to measure smoking, drinking, diet, exercise, sleep, and sun exposure. Univariate and bivariate analyses to detect differences by age were conducted. The sample scored significantly worse on all five health behaviors compared to population norms. Those who were older were less likely to smoke and chew tobacco and more likely to eat fruits and vegetables. Many were interested in services to improve their health behaviors. Health behavior interventions are needed and wanted by Operating Engineers.

Janicak, C. A. (2008). "Occupational fatalities due to electrocutions in the construction industry." *J Safety Res* 39(6): 617-621.

INTRODUCTION: Occupational fatalities due to contact with electricity account for approximately 9% of all deaths in the construction industry and is the fourth leading cause of death in this industry. **METHOD:** Differences in the proportions of electrocutions in the construction industry are significantly different from other industries based upon the age of the worker and the source of the electricity. **RESULTS:** This study found that, in the construction industry, the proportion of occupational fatalities due to contact with electric current is significantly higher for workers in the 16 to 19 years old age group. Contact with overhead power lines occurred more frequently with younger workers, while contact with electric wiring, transformers, and related equipment was found to occur more frequently with older workers. The proportion of fatalities due to this event was also found to account for a significantly greater proportion of fatalities in the construction industry overall. **IMPACT ON INDUSTRY:** The proportions of electrocution fatalities in the construction industry were found to be significantly higher for younger workers when compared to all other industries. Focusing

prevention measures toward younger workers who work near overhead power lines could have a significant impact upon death rates. For older workers, the focus should be on those who work on or near transformers, electrical wiring, and components. Across the construction industry, implementation of effective lockout-tagout programs, and verification of energy isolation, can prevent approximately 125 fatalities per year in the construction industry.

Kaur, H., et al. (2021). "Workers' Compensation Claim Rates and Costs for Musculoskeletal Disorders Related to Overexertion Among Construction Workers - Ohio, 2007-2017." *MMWR Morb Mortal Wkly Rep* 70(16): 577-582.

Overexertion is a leading cause of work-related musculoskeletal disorders (WMSDs) among construction workers. Nearly 90% of construction jobs require manual handling of materials for approximately one half of the worker's time (1). In 2015, overexertion from lifting and lowering materials caused 30% of WMSDs among construction workers; overexertion involving pushing, pulling, holding, carrying, and catching materials caused an additional 37% of WMSDs (1). This study examined the rate and cost of WMSD claims from overexertion among Ohio construction workers during 2007-2017. Workers' compensation claims related to overexertion that were submitted to the Ohio Bureau of Worker's Compensation (OHBWC) by workers in the construction industry for injuries and illnesses occurring during 2007-2017 were analyzed. Rates and costs of allowed claims were measured by age group. Workers aged 35-44 years experienced the highest claim rate: 63 per 10,000 full-time employees (FTEs) for WMSDs from overexertion. However, claims by workers aged 45-54 years and 55-64 years were more costly on average and resulted in more days away from work. Ergonomic design improvements and interventions are needed to ensure that the majority of construction workers can safely perform jobs throughout their careers. Age-specific WMSD prevention and risk communication efforts also might be helpful.

Konda, S., et al. (2016). "Fatal traumatic brain injuries in the construction industry, 2003-2010." *Am J Ind Med* 59(3): 212-220.

Background: Research on fatal work-related traumatic brain injuries (TBIs) is limited. This study describes fatal TBIs in the US construction industry. Methods: Fatal TBIs were extracted from the Bureau of Labor Statistics Census of Fatal Occupational Injuries. Results: From 2003 to 2010, 2,210 fatal TBIs occurred in construction at a rate of 2.6 per 100,000 full-time equivalent (FTE) workers. Workers aged 65 years and older had the highest fatal TBI rates among all workers (7.9 per 100,000 FTE workers). Falls were the most frequent injury event (n=1,269, 57%). Structural iron and steel workers and roofers had the highest fatal TBI rate per 100,000 FTE workers (13.7 and 11.2, respectively). Fall-related TBIs were the leading cause of death in these occupations. Conclusions: A large percentage of TBIs in the construction industry were due to falls. Emphasis on safety interventions is needed to reduce these fall-related TBIs, especially among vulnerable workers. *Am. J. Ind. Med.* 59:212-220, 2016. Published 2016. This article is a U.S. Government work and is in the public domain in the USA. © 2016 Wiley Periodicals, Inc.

LeMasters, G., et al. (2006). "Functional impairment and quality of life in retired workers of the construction trades." *Exp Aging Res* 32(2): 227-242.

This cross-sectional study compared the quality of life and physical health of retirees from the construction industry to that of retirees from more sedentary occupations. The

feasibility of cooperation from the unions and their retirees for a larger health study was also examined. The mailed health survey assessed current physical functioning, role limitations as a result of poor health, pain, and past and current problems with falls and injuries. The survey was completed by 77 construction and 174 nonconstruction retirees. Results were striking with 42.1% of the construction retirees, compared to 12.9% of the male and 14.3% of female nonconstruction retirees reporting significantly poorer health. A multiple regression analysis comparing male construction to male nonconstruction retirees showed male construction retirees were almost five times more likely to report their health as being fair or poor. Further, significantly more male construction, versus male nonconstruction retirees, reported that their physical health reduced the time they were able to spend on daily activities. Almost one in five (19.4%) construction retirees described themselves as having severe to very severe pain versus 3.1% of the male nonconstruction retirees. Construction retirees reported significantly greater problems with their vision, neck and shoulders, hands and wrists, hips, knees, and ankle/feet joints. These findings suggest that with our rapidly aging population, there will be enormous physical, emotional, and financial costs related to construction work and that prevention and intervention measures are needed for current employees in this profession.

Lipscomb, H. J., et al. (2013). "Work-related injuries involving a hand or fingers among union carpenters in Washington state, 1989 to 2008." *J Occup Environ Med* 55(7): 832-838.

Objective: We evaluated work-related injuries involving a hand or fingers and associated costs among a cohort of 24,830 carpenters between 1989 and 2008. Methods: Injury rates and rate ratios were calculated by using Poisson regression to explore higher risk on the basis of age, sex, time in the union, predominant work, and calendar time. Negative binomial regression was used to model dollars paid per claim after adjustment for inflation and discounting. Results: Hand injuries accounted for 21.1% of reported injuries and 9.5% of paid lost time injuries. Older carpenters had proportionately more amputations, fractures, and multiple injuries, but their rates of these more severe injuries were not higher. Costs exceeded \$21 million, a cost burden of \$0.11 per hour worked. Conclusions: Older carpenters' higher proportion of serious injuries in the absence of higher rates likely reflects age-related reporting differences. Copyright © 2013 by American College of Occupational and Environmental Medicine.

Lipscomb, H. J., et al. (2014). "How well are we controlling falls from height in construction? Experiences of union carpenters in Washington State, 1989-2008." *Am J Ind Med* 57(1): 69-77.

Background: Falls from height (FFH) continue to cause significant morbidity and mortality across the construction industry. Methods: By linking data on work hours with workers' compensation records, rates of work-related injuries resulting from FFH and associated days away from work were evaluated among a large cohort (n=24,830) of union carpenters in Washington State from 1989 to 2008. Using Poisson regression we assessed rates of FFH over the 20-year period while adjusting for temporal trend in other work-related injuries. Patterns of paid lost days (PLDs) were assessed with negative binomial regression. Results: Crude rates of FFH decreased 82% over the 20-year period. Reductions were more modest and without demonstrable change since 1996 when adjusting for the temporal reduction in other injuries. Younger workers had higher injury rates; older workers lost more days following falls. Rates of PLDs associated with falls decreased over time, but there was not a consistent decline in mean lost days per fall. Conclusion: These patterns are consistent with

decreased FFH for several years surrounding state (1991) and then federal (1994) fall standards; the decline during this time period exceeded those seen in injury rates overall in this cohort. While crude rates of FFH have continued to decline, the decline is not as substantial as that seen for other types of injuries. This could reflect a variety of things including more global efforts designed to control risk (site planning, safety accountability) and changes in reporting practices. *Am. J. Ind. Med.* 57:69-77, 2014. © 2013 Wiley Periodicals, Inc.

Lipscomb, H. J., et al. (2014). "Twenty years of workers' compensation costs due to falls from height among union carpenters, Washington State." *Am J Ind Med* 57(9): 984-991.

Background: Falls from height (FFH) are a longstanding, serious problem in construction. Methods: We report workers' compensation (WC) payments associated with FFH among a cohort (n=24,830; 1989-2008) of carpenters. Mean/median payments, cost rates, and adjusted rate ratios based on hours worked were calculated using negative-binomial regression. Results: Over the 20-year period FFH accounted for \$66.6 million in WC payments or \$700 per year for each fulltime equivalent (2,000hr of work). FFH were responsible for 5.5% of injuries but 15.1% of costs. Cost declines were observed, but not monotonically. Reductions were more pronounced for indemnity than medical care. Mean costs were 2.3 times greater among carpenters over 50 than those under 30; cost rates were only modestly higher. Conclusions: Significant progress has been made in reducing WC payments associated with FFH in this cohort particularly through 1996; primary gains reflect reduction in frequency of falls. FFH that occur remain costly. *Am. J. Ind. Med.* 57:984-991, 2014. © 2014 Wiley Periodicals, Inc.

Lombardi, D. A., et al. (2011). "Work-related falls from ladders--a follow-back study of US emergency department cases." *Scand J Work Environ Health* 37(6): 525-532.

OBJECTIVES: Ladder falls comprise 16% of all US workplace fall-related fatalities, and ladder use may be particularly hazardous among older workers. This follow-back study of injured workers from a nationally representative sample of US emergency departments (ED) focused on factors related to ladder falls in three domains of the work environment: work equipment, work practices, and worker-related factors. Risk factors for fractures, the most frequent and severe outcome, were also evaluated. METHODS: Workers injured from a ladder fall, treated in one of the 65 participating ED in the occupational National Electronic Injury Surveillance System (NEISS) were asked to participate. The questionnaire included worker demographics, injury, ladder and work equipment and environment characteristics, work tasks, and activities. Multivariate logistic regression models estimated odds ratios and 95% confidence intervals of a work-related fracture. RESULTS: Three-hundred and six workers experiencing an injury from an--on average--7.5-foot-fall from a step, extension, or straight ladder were interviewed primarily from construction, installation, maintenance, and repair professions. Injuries were most frequently to the arm, elbow or shoulder; head, neck, or face with diagnoses were primarily fracture, strain, sprain, contusion or abrasion. Workers were most frequently standing or sitting on the ladder while installing, hanging an item, or performing a repair when they fell. Ladder movement was the mechanism in 40% of falls. Environmental conditions played a role in <10% of cases. There was a significant association between fracture risk and fall height while working on the ladder that was also influenced by older work age. CONCLUSIONS: This study advances knowledge of falls from ladders to support those who specify means and methods, select equipment, and plan, supervise, or manage the performance of employees working at heights.

Mehta, R. K. and M. J. Agnew (2010). "Analysis of individual and occupational risk factors on task performance and biomechanical demands for a simulated drilling task." *International Journal of Industrial Ergonomics* 40(5): 584-591.

The purpose of this study was to evaluate age- and gender-dependent effects of shoulder fatigue on task performance and muscular responses of a drilling task commonly observed within the construction industry. Twelve younger (18-35 years) and ten older (45-60 years) participants, balanced by gender, were recruited from the local community. Task performance (task completion times and errors made), muscle activity of the anterior deltoid (static, mean, and peak amplitude probability density function), coactivity indices of the upper and lower arm, and perceived discomfort ratings were obtained for a series of drilling tasks at three levels of task difficulty, before and after manifestation of shoulder fatigue. To induce fatigue, participants performed a sustained sub-maximal fatigue task at 40% of their maximum voluntary shoulder exertion. Fatigue decreased task completion times, irrespective of age and gender. Higher errors were observed in the fatigued condition, especially for younger participants. Females showed higher shoulder muscle activity compared to men. Additionally, fatigue resulted in lower shoulder APDF measures compared to the no-fatigue condition. Muscle recruitment patterns differed within the fatigue condition, with higher coactivity indices in the upper and lower arm muscles compensating for decreases in shoulder muscle activity. Task difficulty was not found to affect any dependent measures. Participants reported higher discomfort in the fatigued state; this effect was more prominent in females. Overall, this study demonstrated, through objective and subjective measures, that task performance and biomechanical demands are affected by fatigue, and that this effect varies with individual factors such as gender and age. Relevance to industry: This paper explored the influence of task demands (fatigue and task difficulty) and individual factors (gender and age) of a drilling task on the development of musculoskeletal injuries of construction workers. The results may contribute towards an understanding of the interplay of certain occupational task demands and worker characteristics on common construction tasks. © 2010 Elsevier B.V.

Morse, T. F., et al. (2007). "A population based survey of ergonomic risk factors in Connecticut: Distribution by industry, occupation, and demographics." *Connecticut Medicine* 71(5): 261-268.

Background: Risk factors for upper-extremity musculoskeletal disorders (MSD) include biomechanical factors (force, repetition, posture) and psychosocial factors (job stress). A population-based telephone survey of workers in Connecticut characterized these risk factors by industry, occupation, gender, and age. Findings: Risk factors were highly prevalent in the Connecticut workplace, but varied considerably by industry, occupation, gender, and age. Risk factors clustered based on (a) physically active occupations/industries (pushing/pulling, reaching, bent wrists, and tool use), (b) physically passive occupations/industries (static postures, stress, and computer use), and (c) repetitive motion exposures. Physically active patterns had the highest prevalence in construction/agriculture/mining, followed by (in order) wholesale/retail trade, utilities, manufacturing, services, government, and finance/insurance. Physically passive patterns tended to reverse this order, and repetitive motion followed a third pattern. Physically active risk factors were typically higher for males, though this varied by industry and occupation. All risk factors except for stress show a steady decrease with age. Conclusion: Almost 1,000,000 Connecticut workers are estimated to be exposed to repetitive

work, bent wrists, and job stress. Workers in high exposure industries and occupations should be closely evaluated for risks, with outreach to industries for preventive ergonomic interventions as preferred to treatment for conditions that arise.

Mundt, D. J., et al. (2009). "A review of changes in composition of hot mix asphalt in the United States." *J Occup Environ Hyg* 6(11): 714-725.

This review researched the materials, methods, and practices in the hot mix asphalt industry that might impact future exposure assessments and epidemiologic research on road paving workers. Since World War II, the U.S. interstate highway system, increased traffic volume, transportation speeds, and vehicle axle loads have necessitated an increase in demand for hot mix asphalt for road construction and maintenance, while requiring a consistent road paving product that meets state-specific physical performance specifications. We reviewed typical practices in hot mix asphalt paving in the United States to understand the extent to which materials are and have been added to hot mix asphalt to meet specifications and how changes in practices and technology could affect evaluation of worker exposures for future research. Historical documents were reviewed, and industry experts from 16 states were interviewed to obtain relevant information on industry practices. Participants from all states reported additive use, with most being less than 2% by weight. Crumb rubber and recycled asphalt pavement were added in concentrations approximately 10% per unit weight of the mix. The most frequently added materials included polymers and anti-stripping agents. Crumb rubber, sulfur, asbestos, roofing shingles, slag, or fly ash have been used in limited amounts for short periods of time or in limited geographic areas. No state reported using coal tar as an additive to hot mix asphalt or as a binder alternative in hot mix pavements for high-volume road construction. Coal tar may be present in recycled asphalt pavement from historical use, which would need to be considered in future exposure assessments of pavers. Changes in hot mix asphalt production and laydown emission control equipment have been universally implemented over time as the technology has become available to reduce potential worker exposures. This work is a companion review to a study undertaken in the petroleum refining sector that investigated current and historical use of additives in producing petroleum-derived asphalt cements.

Rietdyk, S., et al. (2005). "Work experience mitigated age-related differences in balance and mobility during surface accommodation." *Clin Biomech (Bristol, Avon)* 20(10): 1085-1093.

BACKGROUND: Locomotor behavior at the roofing worksite is challenged by factors such as sloped surfaces, wind gusts and handling loads. Chronic exposure to this environment may result in enhanced locomotor strategies that are resistant to aging effects. The purpose of this study was to determine if roofers demonstrated enhanced locomotor strategies and if the strategies were maintained with age. **METHODS:** The gait of ten younger roofers (mean age 27.2 years), eight older roofers (55.4 years), ten younger controls (25.4 years) and nine older controls (57.6 years) was examined during level gait and stepping up onto a wooden surface (0.15m high). Subjects either carried no load, an empty box or the same box loaded to the equivalent of 5% body mass. **FINDINGS:** Work by age interactions were observed for toe clearance, step width, net angular momentum of the head, arms and trunk segment and gait speed ($P < 0.0001$). Younger roofers demonstrated the greatest toe clearance; older roofers had a smaller lead clearance but decreased variability. Older control groups had the greatest risk of tripping due to low lead toe clearance and high variability, and were least likely to recover if

they did trip due to faster gait speed and increased net angular momentum. Work experience resulted in enhanced changes in lead toe clearance and mitigated age-related changes in step width and net angular momentum. INTERPRETATION: Challenging environments show promise for maintaining balance skills in older adults; however care should be taken when introducing inexperienced older adults to a challenging environment.

Ringen, K., et al. (2019). "Mortality of older construction and craft workers employed at department of energy nuclear sites: Follow-up through 2016." *Am J Ind Med* 62(9): 742-754.

BACKGROUND: To determine if construction and trades workers employed at U.S. Department of Energy (DOE) nuclear sites facilities are at significant risk for diseases associated with occupational exposures, we compared the mortality experience of participants in the Building Trades National Medical Screening Program (BTMed) to that of the US population. METHODS: The cohort includes 24,086 BTMed participants enrolled between 1998 and 2016 and 5203 deaths. Cause-specific standardized mortality ratios were calculated based on US death rates. RESULTS: Mortality was elevated for all causes, all cancers, cancers of the trachea, bronchus, and lung and lymphatic and hematopoietic system, mesothelioma, chronic obstructive pulmonary disease, asbestosis, transportation injuries, and other injuries, particularly those caused by accidental poisoning, suggesting a possible effect of the opioid epidemic. CONCLUSIONS: Apart from other injuries, mortality patterns were very similar to those reported in the past in this population. Construction workers employed at DOE sites have a significantly increased risk for occupational illnesses. Risks are associated with employment during all time periods covered including possibly after 1990. The cancer risks closely match the cancers identified for DOE compensation from radiation exposures. The high risk of lung cancer supports the value of early lung cancer detection. Continued medical surveillance is important.

Ringen, K., et al. (2014). "Risks of a lifetime in construction: Part II: Chronic occupational diseases." *Am J Ind Med* 57(11): 1235-1245.

Background: We developed working-life estimates of risk for dust-related occupational lung disease, COPD, and hearing loss based on the experience of the Building Trades National Medical Screening Program in order to (1) demonstrate the value of estimates of lifetime risk, and (2) make lifetime risk estimates for common conditions among construction workers. Methods: Estimates of lifetime risk were performed based on 12,742 radiographic evaluations, 12,679 spirometry tests, and 11,793 audiograms. Results: Over a 45-year working life, 16% of construction workers developed COPD, 11% developed parenchymal radiological abnormality, and 73.8% developed hearing loss. The risk for occupationally related disease over a lifetime in a construction trade was 2-6 times greater than the risk in non-construction workers. Conclusions: When compared with estimates from annualized cross-sectional data, lifetime risk estimates are highly useful for risk expression, and should help to inform stakeholders in the construction industry as well as policy-makers about magnitudes of risk. © 2014 Wiley Periodicals, Inc.

Schwatka, N. V., et al. (2013). "Age in relation to worker compensation costs in the construction industry." *Am J Ind Med* 56(3): 356-366.

BACKGROUND: A better understanding of how workers' compensation (WC) costs are affected by an aging US workforce is needed, especially for physically demanding industries,

such as construction. **METHODS:** The relationship between age and injury type on claim costs was evaluated using a database of 107,064 Colorado WC claims filed between 1998 and 2008 among construction workers. **RESULTS:** Mean WC costs increased with increasing age for total cost ($P < 0.0001$), medical costs ($P < 0.0001$), and indemnity costs ($P < 0.0001$). For each one-year increase in age, indemnity, and medical costs increased by 3.5% and 1.1%, respectively. For specific injury types, such as strains and contusions, the association between age and indemnity costs was higher among claimants aged ≥ 65 compared to claimants aged 18-24. **CONCLUSIONS:** Our findings suggest that specific injury types may be partially responsible for the higher indemnity costs among older construction workers, compared with their younger coworkers.

Schwatka, N. V., et al. (2012). "An aging workforce and injury in the construction industry." *Epidemiol Rev* 34: 156-167.

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 physical job demands are high. This paper reviews the epidemiologic literature on the impact of age on injury among workers in the construction industry in terms of cause, type, and cost. PubMed was searched by using 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 by older workers. Identification of injury trends and subsequent analytical research efforts designed to ascertain 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.

Schwatka, N. V. and J. C. Rosecrance (2016). "Safety climate and safety behaviors in the construction industry: The importance of co-workers commitment to safety." *Work* 54(2): 401-413.

BACKGROUND: There is growing empirical evidence that as safety climate improves work site safety practice improve. Safety climate is often measured by asking workers about their perceptions of management commitment to safety. However, it is less common to include perceptions of their co-workers commitment to safety. While the involvement of management in safety is essential, working with co-workers who value and prioritize safety may be just as important. **OBJECTIVE:** To evaluate a concept of safety climate that focuses on top management, supervisors and co-workers commitment to safety, which is relatively new and untested in the United States construction industry. **METHODS:** Survey data was collected from a cohort of 300 unionized construction workers in the United States. The significance of direct and indirect (mediation) effects among safety climate and safety behavior factors were evaluated via structural equation modeling. **RESULTS:** Results indicated that safety climate was associated with safety behaviors on the job. More specifically, perceptions of co-workers commitment to safety was a mediator between both management commitment to safety climate factors and safety behaviors. **CONCLUSIONS:** These results support workplace health and

safety interventions that build and sustain safety climate and a commitment to safety amongst work teams. © 2016 - IOS Press and the authors.

Shishlov, K. S., et al. (2011). "Non-fatal construction industry fall-related injuries treated in US emergency departments, 1998-2005." *Am J Ind Med* 54(2): 128-135.

BACKGROUND: There is a growing recognition that common occupational injury surveillance systems in the US fail to reflect true injury risk; this failure limits efforts to accurately monitor efforts to prevent work-related injuries on a national level. **METHODS:** Data from the National Electronic Injury Surveillance System occupational supplement (NEISS-Work) were used to describe fall-related injuries treated in US emergency departments among workers in the construction industry (1998-2005). These data do not require workers' compensation as the payer in order to be classified as work-related. **RESULTS:** Based on NEISS-Work estimates, a total of 555,700 (95% confidence interval (CI): 390,700-720,800) non-fatal work-related injuries among workers in the construction industry were the result of a fall, resulting in an annual rate of 70 (95% CI: 49-91) per 10,000 full-time equivalents. Younger workers had higher rates of falls, whereas older workers were more likely to suffer serious injuries. The majority of the injuries (70%) were precipitated by falls to a lower level from roofs, ladders, and scaffolding. **CONCLUSIONS:** The patterns of fall-related injuries identified in these data are consistent with other reports. In contrast to the declining rates of falls requiring days away from work reported through the Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses, construction industry fall-related injury rates estimated through NEISS-Work remained unchanged from 1998 to 2005 providing another perspective on this serious cause of morbidity in the construction industry.

Simeonov, P., et al. (2011). "Postural stability effects of random vibration at the feet of construction workers in simulated elevation." *Appl Ergon* 42(5): 672-681.

The risk of falls from height on a construction site increases under conditions which degrade workers' postural control. At elevation, workers depend heavily on sensory information from their feet to maintain balance. The study tested two hypotheses: "sensory enhancement"--sub-sensory (undetectable) random mechanical vibrations at the plantar surface of the feet can improve worker's balance at elevation; and "sensory suppression"--supra-sensory (detectable) random mechanical vibrations can have a degrading effect on balance in the same experimental settings. Six young (age 20-35) and six aging (age 45-60) construction workers were tested while standing in standard and semi-tandem postures on instrumented gel insoles. The insoles applied sub- or supra-sensory levels of random mechanical vibrations to the feet. The tests were conducted in a surround-screen virtual reality system, which simulated a narrow plank at elevation on a construction site. Upper body kinematics was assessed with a motion-measurement system. Postural stability effects were evaluated by conventional and statistical mechanics sway measures, as well as trunk angular displacement parameters. Analysis of variance did not confirm the "sensory enhancement" hypothesis, but provided evidence for the "sensory suppression" hypothesis. The supra-sensory vibration had a destabilizing effect, which was considerably stronger in the semi-tandem posture and affected most of the sway variables. Sensory suppression associated with elevated vibration levels on a construction site may increase the danger of losing balance. Construction workers at elevation, e.g., on a beam or narrow plank might be at increased risk of fall if they can detect vibrations under their feet. To reduce the possibility of losing balance, mechanical vibration to supporting structures used as

walking/working surfaces should be minimized when performing construction tasks at elevation.

Sokas, R. K., et al. (2019). "Building a Sustainable Construction Workforce." *Int J Environ Res Public Health* 16(21).

The average U.S. construction worker is aged 42.6 years, and will not be eligible for full Social Security retirement benefits until age 67. Delayed retirement is largely driven by economic need, but construction workers face considerable challenges in remaining on the job. This study explores trade-specific age trends within the construction industry, and the experiences of building trade unions with aging membership. A mixed-methods approach used trade-specific age statistics from the Current Population Survey and key informant interviews with labor leaders, in order to identify union experiences and interventions. Mean and median ages for all subgroups in construction increased from 2003 to 2017. Immigrant construction workers were significantly younger than workers who were born in the U.S. (41 vs. 43, $p < 0.001$). Union workers were older than non-union workers (42 vs. 39 in 2017, $p < 0.001$); the age differential between self-employed and wage-and-salary workers was wide (49 vs. 40, $p < 0.001$). Union leaders described barriers, such as age discrimination and the loss of previously available light tasks, as well as current and potential solutions through union contract language requiring the inclusion of older workers, or establishing limits for lifting. Other solutions included career pathways for training and safety, with their attendant limitations; mentoring/pairing opportunities with apprentices; and the potential opportunities and training needs for site management positions.

Welch, L., et al. (2009). "Musculoskeletal disorders among construction roofers--physical function and disability." *Scand J Work Environ Health* 35(1): 56-63.

OBJECTIVES: This study investigated the relationships between work demands, chronic medical and musculoskeletal conditions, aging, and the ability to remain on the job in a longitudinal study of 979 construction roofers between the ages of 40 and 59 years.

METHODS: In a phone interview at baseline and 1 year later, the participants were asked about the presence of medical conditions and musculoskeletal disorders, work limitations and work accommodations, and social and economic functioning. **RESULTS:** Among the workers for whom a musculoskeletal disorder was their most serious condition at baseline, 8% left roofing due to a health condition during the first year of follow-up. A comparison between those who left and those who stayed identified older age and lower physical functioning as statistically significant predictors of leaving the trade. Workers with a musculoskeletal disorder and who, in the baseline interview, reported receiving some type of job accommodation for their musculoskeletal disorder had an odds ratio of 0.24 ($P=0.07$) for leaving work by the time of the 1-year follow-up when compared with workers with a musculoskeletal disorder and no job accommodation. The workers with three or more work limitations were also more likely to leave roofing, but this association disappeared after adjustment for other factors.

CONCLUSIONS: Musculoskeletal conditions among roofers are strongly associated with work limitation, missed work, and reduced physical functioning, factors that are predictive of premature departure from the workforce. Job accommodation was provided for 31% of the roofers with a musculoskeletal disorder, and it was associated with a reduced likelihood of subsequently leaving roofing for health-related reasons.

Welch, L., et al. (2004). "Screening for beryllium disease among construction trade workers at Department of Energy nuclear sites." *Am J Ind Med* 46(3): 207-218.

BACKGROUND: To determine whether current and former construction workers are at significant risk for occupational illnesses from work at the Department of Energy's (DOE) nuclear weapons facilities, screening programs were undertaken at the Hanford Nuclear Reservation, Oak Ridge Reservation, and the Savannah River Site. **METHODS:** Medical examination for beryllium disease used a medical history and a beryllium blood lymphocyte proliferation test (BeLPT). Stratified and multivariate logistic regression analyses were used to explore the risk of disease by age, race, sex, trade, duration of DOE employment, reported work in buildings where beryllium was used, and time since last DOE site employment. **RESULTS:** Of the 3,842 workers included in this study, 34% reported exposure to beryllium. Overall, 2.2% of workers had at least one abnormal BeLPT test, and 1.4% were also abnormal on a second test. Regression analyses demonstrated increased risk of having at least one abnormal BeLPT to be associated with ever working in a site building where beryllium activities had taken place. **CONCLUSIONS:** The prevalence of beryllium sensitivity and chronic beryllium disease (CBD) in construction workers is described and the positive predictive value of the BeLPT in a population with less intense exposure to beryllium than other populations that have been screened is discussed. The BeLPT findings and finding of cases of CBD demonstrate that some of these workers had significant exposure, most likely, during maintenance, repair, renovation, or demolition in facilities where beryllium was used.

Welch, L. S. (2009). "Improving work ability in construction workers--let's get to work." *Scand J Work Environ Health* 35(5): 321-324.

(Intro to special journal issue on aging, health and work limitations/ability/accommodations in construction.)

Welch, L. S., et al. (2017). "Impact of Secondary Prevention in an Occupational High-Risk Group." *J Occup Environ Med* 59(1): 67-73.

Background: A study of medical outcomes among 6857 elderly construction workers who received an initial and at least one periodic follow-up examination as a result of participating in a medical screening program was undertaken. **Methods:** We compared results from the initial examination to follow-up examinations delivered at least 3 years after the initial examination for the following outcomes: body mass index (BMI); total serum cholesterol; nonhigh-density lipoprotein (non-HDL) cholesterol; hemoglobin A1c, hypertension; current cigarette smoking; and 10-year cardiovascular disease (CVD) risk scores. **Results:** Statistically significant improvements ($P < 0.05$) were observed for all measures except BMI. **Conclusions:** Participation in a periodic medical screening program for elderly construction workers is associated with a favorable impact on common health outcomes. When presented with a program designed for them, blue-collar workers are motivated to seek improvements in their health status. © 2016 American College of Occupational and Environmental Medicine.

Welch, L. S., et al. (2008). "Age, work limitations and physical functioning among construction roofers." *Work* 31(4): 377-385.

BACKGROUND: To investigate the intersection of aging with work limitations, chronic medical and musculoskeletal conditions, and physical functioning we undertook a cross-sectional study of U.S. construction roofers who were current union members between

the ages of 40 and 59. **METHODS:** Participants were asked about the presence of medical conditions and musculoskeletal disorders (MSDs); the Work Limitations Questionnaire, the SF-12, and other validated assessments of social and economic impact of injury were included. **RESULTS:** Sixty-nine percent had at least one of these conditions in the previous two years; 31% missed work. Workers with medical and musculoskeletal conditions were older, had the highest prevalence of work activity limitations, and had the lowest SF-12 scores. **CONCLUSIONS:** Older age was associated with the presence of a medical condition, and with reduced physical functioning. Medical and musculoskeletal conditions were strongly associated with work limitation, missed work, and reduced physical functioning. Older workers may be at higher risk of disability retirement compared to younger workers with similar medical conditions and work limitations.

Welch, L. S., et al. (2010). "Impact of musculoskeletal and medical conditions on disability retirement-a longitudinal study among construction roofers." *Am J Ind Med* 53(6): 552-560.

BACKGROUND: To assess the intersection of work demands, chronic medical and musculoskeletal conditions, aging, and disability, we initiated a longitudinal study of construction roofers who were current union members between the ages of 40 and 59. **METHODS:** Participants were asked about the presence of medical conditions and musculoskeletal disorders; the Work Limitations Questionnaire, the SF-12, and other validated assessments of social and economic impact of injury were included. **RESULTS:** Factors at baseline that predicted leaving for a health-related reason were older age, lower physical functioning, work limitations, and having missed work. Those who left roofing for a health-related reason were much more likely to have a lower economic score at the 1 year interview. **CONCLUSIONS:** Medical and musculoskeletal conditions are strongly associated with work limitation, missed work, and reduced physical functioning; these factors are also associated with premature departure from the workforce.

Yang, L., et al. (2020). "Work-related injuries and illnesses and their association with hour of work: Analysis of the Oregon construction industry in the US using workers' compensation accepted disabling claims, 2007-2013." *J Occup Health* 62(1): e12118.

OBJECTIVES: This study aimed to characterize injuries and illnesses among construction workers in the State of Oregon in the US and examine the association between injury frequency and severity with hour of work by using Workers' Compensation (WC) accepted disabling claims data in the construction industry from 2007 to 2013. **METHODS:** Injury frequency, rate, medical cost, and lost work days were analyzed by year, demographics, employment, injury nature, and temporal factors including hour of work. Multiple linear regression models were used to quantify adjusted associations between hour of work and medical cost and lost work days (indicating injury severity). **RESULTS:** There were a total of 12 222 disabling claims in the Oregon construction industry. The average annual injury rate was 2.21 per 100 workers. Both the count and rate of disabling claims decreased during the study period. Male workers and young workers had higher injury rates, while medical cost and lost work days increased for older workers. Injuries occurring at night were more severe. The distribution of claims frequency by hour of work was bimodal, with peaks in the 4th and 8th hour. Compared with the first hour of work, the 5th and 13th hours corresponded to significantly more severe injuries and illnesses. **CONCLUSIONS:** This study identified the burden and distribution of work-related injuries and illnesses in the Oregon construction

industry. Continued intervention efforts should target certain subpopulations (eg, young workers) and certain working time periods (eg, mid- and end-shift) to protect construction workers' safety and health.

