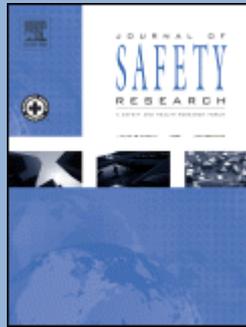


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### **Jin Wang, Jessica B. Cicchino. *Fatal pedestrian crashes on interstates and other freeways in the United States. Pages 1-7.***

**Introduction:** More than 800 pedestrians die annually in crashes on interstates and other freeways in the United States, but few studies have examined their characteristics.

**Method:** Data from the Fatality Analysis Reporting System on pedestrians fatally injured during 2015–2017 were analyzed. Chi-square tests compared characteristics of pedestrians killed on interstates and other freeways with those that died on other roads, and across crash types among freeway deaths. Land use characteristics of locations where pedestrians were killed while crossing freeways in a large state (California) were identified using Google Earth. **Results:** A larger proportion of pedestrians killed on freeways died on dark and unlit roads (48% vs. 32%), were male (78% vs. 68%), or were ages 20–44 (55% vs. 32%) compared with pedestrians killed on other roads. Crossing (42%) was the most common crash type among pedestrian deaths on freeways, followed by disabled-vehicle-related crashes (18%). Pedestrians who died while crossing more often had blood alcohol concentrations  $\geq 0.08$  g/dL (40%) than those in disabled-vehicle-related (22%) or other crashes (34%). Deaths in crossing crashes were more likely than other freeway deaths to occur on urban roads (81%), at speed limits  $\leq 50$  mph (13%), or between 18:00 and 23:59 (49%), and 58% of crossing crashes analyzed for land use were located between residential and other (e.g., commercial, recreational) uses. Over a third (37%) of deaths in disabled-vehicle-related crashes occurred at speed limits  $\geq 70$  mph. **Conclusions:** A surprising proportion of pedestrian deaths occur on controlled-access roads not designed for walking. Countermeasures for these crashes need to be implemented to see meaningful reductions in pedestrian fatalities overall. **Practical applications:** Improving roadway and vehicle lighting, requiring reflective warning devices for marking disabled vehicles, constructing pedestrian overpasses and underpasses in areas frequently crossed, and promoting alternative means of traveling between residential and commercial areas could help.

- **Keywords:** Pedestrian fatalities; Interstates and other freeways; Comparisons; Characteristics; Land use; Contributing factors; Countermeasures

**Francis Tainter, Cole Fitzpatrick, Jennifer Gazillo, Robin Riessman, Michael Knodler. *Using a novel data linkage approach to investigate potential reductions in motor vehicle crash severity – An evaluation of strategic highway safety plan emphasis areas. Pages 9-15.***

**Introduction:** With the significant number of motor-vehicle fatalities occurring on the nation's roadways in recent years, there exists a need to integrate a more complete range of data sources, available at a regional or statewide level, to effectively evaluate existing safety concerns and quantify their impacts. Crash data alone does not provide ample crash-associated citation, injury, and roadway characteristics; therefore, a more cohesive dataset is required to accurately and completely analyze the true impacts of motor-vehicle crashes. Previously developed strategies linked crash data with citation and roadway inventory data to enhance the identification and optimization of highway safety strategies. **Method:** The main objective of this research focused on developing a new deterministic linkage between crash and Emergency Medical Services (EMS) data, by utilizing the Massachusetts Crash Data System (CDS) and the Massachusetts Ambulance Trip Record Information System (MATRIS). **Results:** After several iterations of match criterion, the validated linkage successfully matched 58.3% of MATRIS records (containing an Injury Cause of Motor Vehicle Crash) to a CDS person record (55011 linked pairs, between 2014 and 2016). The data linkage provided significant insight into injury trends in several highway safety emphasis areas such as roadway departure, speeding-related, and distraction-affected crashes. The findings from this research are twofold: (1) an established process for linking previously separate data sets, and (2) a mechanism for analysis that provides decision-makers and safety professionals with a better measure of crash outcomes.

- **Keywords:** Data linkage; Traffic safety; Crash data system (CDS); Emergency medical services (EMS)

**Shaohua Wang, Yanyan Chen, Jianling Huang, Zhuo Liu, Jia Li, Jianming Ma. *Spatial relationships between alcohol outlet densities and drunk driving crashes: An empirical study of Tianjin in China. Pages 17-25.***

**Introduction:** Numerous studies have demonstrated the close relationship between alcohol availability and alcohol-related crashes. However, there is still a lack of spatial empirical analysis regarding this relationship, particularly in large cities of developing countries. Differences in alcohol outlets and drinking patterns in these cities may lead to quite different patterns of crash outcomes. **Method:** 3356 alcohol-related crashes were collected from the blood-alcohol test report of a forensic institution in Tianjin, China. Density of alcohol outlets such as retail locations, entertainment venues, restaurants, hotels, and companies were extracted based on 2114 Traffic Analysis Zones (TAZ) together with the residential and demographic characteristics. After applying the exploratory spatial data analysis, this research developed and compared the traditional Ordinary Least Square model (OLS), Spatial Lag Model (SLM), Spatial Error Model (SEM) and Spatial Durbin Model (SDM) to explore spatial effects of all the variables. **Results:** The results of incremental spatial autocorrelation show that the most significant distance threshold of alcohol-related roadway traffic crashes is 3 km. The SDM is found to be the optimal spatial model to characterize the relationship between alcohol outlets and crashes. The number of alcohol-involved traffic crashes is positively related to population density and retail density, but negatively related to the company density, hotel density, and residential density within the same TAZ. Meanwhile, dense population and hotels have reverse spillover effects in adjacent zones. **Conclusions:** The significant spatial direct effect and spillover effect of alcohol outlet densities on drunk driving crashes should not be neglected. These findings could help improve transportation planning, traffic law enforcement and traffic management for large cities in developing countries.

- **Keywords:** Alcohol availability; Alcohol outlet density; Drunk driving; Traffic crashes; Spatial analysis

**Jerone Dunbar, Juan E. Gilbert, Ben Lewis. *Exploring differences between self-report and electrophysiological indices of drowsy driving: A usability examination of a personal brain-computer interface device. Pages 27-34.***

**Introduction:** Impaired driving has resulted in numerous accidents, fatalities, and costly damage. One particularly concerning type of impairment is driver drowsiness. Despite advancements, modern vehicle safety systems remain ineffective at keeping drowsy drivers alert and aware of their state, even temporarily. Until recently the use of user-centric brain-computer interface (BCI) devices to capture electrophysiological data relating to driver drowsiness has been limited. **Method:** In this study, 25 participants drove on a simulated roadway under drowsy conditions. **Results:** Neither subjective nor electrophysiological measures differed between individuals who showed overt signs of drowsiness (prolonged eye closure) during the drive. However, the directionality and effect size estimates provided by the BCI device suggested the practicality and feasibility of its future implementation in vehicle safety systems. **Practical applications:** This research highlights opportunities for future BCI device research for use to assess the state of drowsy drivers in a real-world context.

- **Keywords:** Driver impairment; Driver drowsiness; BCI; EEG

**Laurel D. Kincl, Jennifer A. Hess, Douglas L. Weeks, Amelia Vaughan, Dan Anton. *Efficacy of text messaging apprentices to reinforce ergonomics and safety voice training. Pages 35-43.***

**Introduction:** Injuries and work-related musculoskeletal disorders (MSDs) are common among masons. SAFETY Voice for Ergonomics (SAVE) integrates training in ergonomic and safety problem-solving skills into masonry apprenticeship training. The purpose of this study was to assess the efficacy of text messaging to reinforce SAVE program content. **Method:** SAVE effectiveness was evaluated at masonry apprenticeship training centers across the United States by comparing three experimental groups: (1) Ergonomics training, (2) Ergonomics and Safety Voice training, and a (3) Control. Apprentices received SAVE training with their standard instruction. To reinforce classroom training, refresher training was implemented by sending weekly text messages for six months. Half of the text messages required a response, which tested knowledge or assessed behavior, while the remaining reiterated knowledge. Apprentices (n = 119) received SAVE text messages. Response rates and percentage of correct responses were compared with chi-square tests and independent group t-tests. Multivariable logistic regression analysis predicted apprentice response with selected demographic and work experience variables. Finally, feedback on the use of text messaging was obtained. **Result:** Of 119 participants, 61% (n = 72) responded to at least one text message. Logistic regression revealed that being a high school graduate and a brick and block mason significantly affected the odds of responding. Sixty-nine percent of apprentices agreed that text messages reinforced SAVE content. **Conclusion:** Even though there was no training center requirement to respond, the high response rate suggests that text messaging can effectively be used to reinforce ergonomics and safety voice training for both knowledge and behavior. **Practical Application:** The prevalent use of text messaging creates opportunities to reinforce health and safety training and engage workers, especially for populations that may be at various locations over time such as construction sites. Instructors and practitioners should consider the utility of text messaging for supporting their training and safety programs.

- **Keywords:** Soft tissue injuries; Texting; Worker rights; Communication; Occupational safety and health

**Moynur Rahman, Min-Wook Kang. *Safety evaluation of drowsy driving advisory system: Alabama case study. Pages 45-53.***

**Introduction:** The present study discusses roles, characteristics, and safety assessment of a drowsy driving advisory (DDA) system, implemented on rural interstates of Alabama. The DDA system is an engineering countermeasure designed to reduce the likelihood of drowsy driving crashes. It consists of a series of roadside signs with warning and advisory messages for drowsy drivers. The DDA system was implemented upstream of rural rest areas based on a comprehensive crash analysis. **Method:** A post-implementation study was conducted three years after the DDA system implementation to assess its safety effects. An empirical bayes (EB) method along with predictive methods of the Highway Safety Manual was used in the safety assessment. To overcome the underreported issue of drowsy driving crashes in the crash analysis, the present study used a concept called, expanded definition of drowsy driving (EDD) crashes. **Result:** The analysis found that the DDA system could reduce total and EDD crashes by 64% and 49%, respectively. It is important to note that such huge crash reduction effects are due to a combined effect of both rest areas and the DDA system, not because of a single treatment. The safety effect of a rest area itself, without considering the effect of the DDA system, was also investigated. Results show that total and EDD crashes would increase about 12–45% and 5–33%, respectively if there is no presence of a rest area. **Conclusion:** Our findings conclude that the DDA system could significantly reduce both total and drowsy driving crashes when it cooperates with a rest area facility. **Practical Application:** The findings also provide the guidance of using the DDA system on high-speed roads as a safety countermeasure of drowsy driving crashes. Readers can find details of the DDA system used in this study with its layout, dimension, and roadside safety messages.

- **Keywords:** Drowsy driving; Roadside signage; Engineering countermeasure; Rest area

**Hanchu Zhou, Chen Yuan, Ni Dong, S.C. Wong, Pengpeng Xu. *Severity of passenger injuries on public buses: A comparative analysis of collision injuries and non-collision injuries. Pages 55-69.***

**Introduction:** Although public buses have been demonstrated as a relatively safe mode of transport, the number of injuries to public bus passengers is far from negligible. Existing studies of public bus safety have focused primarily on injuries caused by collisions. Surprisingly, limited effort has been devoted to identifying factors that increase the severity of passenger injuries in non-collision incidents. **Method:** Our study therefore investigated the injury risk of public bus passengers involved in collision incidents and non-collision incidents comparatively, based on a police-reported dataset of 17,383 passengers injured on franchised public buses over a 10-year period in Hong Kong. A random parameters logistic model was established to estimate the likelihood of fatal and severe injuries to passengers as a function of various factors. **Results:** Our results indicated substantial inconsistencies in the effects of risk factors between models of non-collision injuries and collision injuries. The severity of passenger injuries tended to increase significantly when non-collision incidents occurred due to excessive speed of bus drivers, on double-decker buses, in less urbanized areas, in winter, in heavy rains, during daytime, and at night without street lighting. Elderly female passengers were also found more likely to be fatally or severely injured in non-collision incidents if they lost their balance while boarding, alighting from, or standing on a bus. In comparison, the following factors were associated with a greater likelihood of fatal or severe injuries in collision incidents: elderly female passengers, standing passengers who lost balance, buses out of driver control, double-decker buses, collisions with vehicles or objects, and

less urbanized areas. **Practical Applications:** Based on our comparative analysis, more targeted countermeasures, namely "4E" (engineering, enforcement, emergency, and education) and "3A" (awareness, appreciation, and assistance), were recommended to mitigate collision injuries and non-collision injuries to public bus passengers, respectively.

- **Keywords:** Public bus; Injury severities; Collision injuries; Non-collision injuries; Random parameters

**Amirfarrokh Iranitalab, Aemal Khattak, George Bahouth. *Statistical modeling of cargo tank truck crashes: Rollover and release of hazardous materials.* Pages 71-79.**

**Introduction:** Cargo Tank Trucks (CTTs) are a primary surface transportation carrier of hazardous materials (hazmat) in the United States and CTT rollover crashes are the leading cause of injuries and fatalities from hazmat transportation incidents. CTTs are susceptible to rollover crashes because of their size, distribution of weight, a higher center of gravity, and the surging and sloshing of liquid cargo during transportation. This study identified and quantified the effects of various factors on the probability of rollover and release of hazmat in traffic crashes where a CTT was involved. **Method:** Bayesian Model Averaging (BMA)-based logistic regression models were estimated with rollover and hazmat release as the binary response variables, and crash, truck, roadway, environment, and driver characteristics as the explanatory variables. 2010–2016 police-reported CTT-involved crash data from Nebraska and Kansas was utilized. Receiver Operating Characteristic (ROC) curves confirmed appropriateness of the modeling approach for inference and prediction on the crash dataset. **Results:** CTTs are more likely to rollover in crashes while turning and changing lanes relative to going straight; side impacts (side collisions) and severe crosswinds increased the likelihood of rollovers; tractor and semi-trailer body style decreased the probability of rollover, while truck tractors are more prone to rollovers; collisions with fixed objects and higher posted speeds increased the rollover probability; rollovers and intersection crash locations increased the likelihood of hazmat release. **Conclusions:** The findings can assist stakeholders (policy-makers, private shippers, and CTT drivers) in restricting CTTs' operations for safety; scheduling, routing, and fleet planning; and low-level decision-making (e.g., emergency stopping or local routing). **Practical Applications:** This study identified and quantified the effects of different factors on the conditional probability of rollover and release of hazmat in CTT-involved crashes. The findings may assist stakeholders in decision-making towards safe operations of CTTs for transportation of hazmat.

- **Keywords:** Bayesian Model Averaging; Logistic regression; Receiver Operating Characteristics; Nebraska; Kansas

**Jonathan F. Antin, Brian Wotring, Miguel A. Perez, Daniel Glaser. *Investigating lane change behaviors and difficulties for senior drivers using naturalistic driving data.* Pages 81-87.**

**Introduction:** Lane changes can be a complicated maneuver occurring a dynamic environment requiring the integration of many streams of information. Older drivers may struggle with lane changes which may elevate crash risk. **Methods:** Real-world lane change behaviors were examined using the Second Strategic Highway Research Program Naturalistic Driving Study database. A total of 393 lane changes were observed for two age groups: middle-aged (30–49), and older (70+) drivers. **Results:** Older drivers were highly likely to fail to execute an over-the-shoulder glance prior to initiation of a lane change (in 98% of left lane changes and 92% for right lane changes). Older drivers also showed higher rates of OTS glance errors at any point during the lane change in 95% of left lane changes and 86% of right-lane changes. Additionally, older drivers frequently failed to activate the turn signal prior to lane change initiation (60% of lane changes for

right changes and 59% for left lane changes). Of the older drivers that made side mirror glances, many occurred after the initiation of the maneuver (46% of left lane changes and 58% of right lane changes) suggesting glances were occurring while changing lanes. **Conclusions:** Results for older drivers showed that many key glances (particularly side mirror checks) and turn signal actuations observed in the current study occurred after the initiation of the lane change, ostensibly when this action may be too late to gather relevant information and avoid a conflict. **Practical Applications:** Knowledge of glance patterns during lane changes for older drivers can help older drivers maintain travel mobility as they age. Either through training to reinforce OTS and side mirror glances, or supplemental devices like convex mirrors or oversized rearview mirrors, older drivers can reduce high-risk lane change maneuvers and help older drivers to maintain their mobility and independence longer.

- **Keywords:** Senior drivers; Older drivers; Lane change; Glance; Behavior

**Emma Sartin, Catherine C. McDonald, D. Leann Long, Despina Stavrinos, Jessica Hafetz Mirman. *Variations in booster seat use by child characteristics*. Pages 89-95.**

**Introduction:** Child weight and height are the basis of manufacturer and best practice guidelines for child restraint system use. However, these guides do not address behavioral differences among children of similar age, weight, and height, which may result in child-induced restraint use errors. The objective of this study was to characterize child behaviors across age in relation to appropriate restraint system use during simulated drives. **Methods:** Fifty mother-child (4-8 years) dyads completed an installation into a driving simulator, followed by a simulated drive that was video-recorded and coded for child-induced errors. Time inappropriately restrained was measured as the total amount of the simulated drive spent in an improper or unsafe position for the restraint to be effective divided by the total drive time. Kruskal-Wallis tests were used to determine differences across age in the frequency of error events and overall time inappropriately restrained. **Results:** Children in harnessed seats had no observed errors during trips. Within children sitting in booster seats there were differences in time inappropriately restrained across age ( $p=0.01$ ), with 4 year-olds spending on average 67% (Median=76%) of the drive inappropriately restrained, compared to the rest of the age categories spending less than 28% (Medians ranged from 3% to 23%). **Conclusion:** Some children may be physically compatible with booster seats, but not behaviorally mature enough to safely use them. More research is needed that examines how child behavior influences child passenger safety. **Practical Applications:** Not all children physically big enough are behaviorally ready to use belt positioning booster seats. Primary sources of information should provide caregivers with individualized guidance about when it is appropriate to transition children out of harnessed seats. Additionally, best practice guidelines should be updated to reflect what behaviors are needed from children to safely use specific types of child restraint systems.

- **Keywords:** Child passenger safety; Child restraint systems; Injury prevention; Child occupant protection; Human factors

**Joshua Klieger, Ian Savage. *Motor-vehicle drivers' behavioral response to increased bicycle traffic*. Pages 97-102.**

**Introduction:** This paper investigates whether motor-vehicle driver behavior changes when there are more bicycles on the road. **Method:** Data on trips on a rapidly expanding public bike share scheme in Chicago are combined with speed violations captured by a network of 79 cameras. Using weekly data from July 2014 to December 2016, violations at 26 sites where there was a considerable increase in bicycle traffic are compared with a control group of 53 locations where rental bicycles are not available. **Results:** An increase in rental bicycle usage is statistically related to a reduction in the number of

speeding violations, with an estimated elasticity of  $-0.04$ . **Conclusion:** The increased presence of bicyclists makes at least some motorists drive more cautiously. **Practical Application:** This research provides some insight into the mechanism behind the observed reduction in crash rates as bicyclists become more numerous. Some motorists moderate their speeds allowing more time to avoid collisions and a reduction in the severity of the vehicle-bicyclist collisions that still occur.

- **Keywords:** Bicycles; Speeding; Chicago

**Yudan Chen Wang, Robert D. Foss, Arthur H. Goodwin, Allison E. Curry, Brian C. Tefft. *The effect of extending graduated driver licensing to older novice drivers in Indiana. Pages 103-108.***

**Introduction:** Graduated driver licensing (GDL) systems have been shown to reduce rates of crashes, injuries, and deaths of young novice drivers. However, approximately one in three new drivers in the United States obtain their first driver's license at age 18 or older, and thus are exempt from most or all provisions of GDL in most states. **Method:** In July 2015, the state of Indiana updated its GDL program, extending its restrictions on driving at night and on carrying passengers during the first 6 months of independent driving, previously only applicable to new drivers younger than 18, to all newly-licensed drivers younger than 21 years of age. The current study examined monthly rates of crashes per licensed driver under the affected conditions (driving at night and driving with passengers) among Indiana drivers first licensed at ages 18, 19, and 20 under the updated GDL system compared with drivers licensed at the same ages under the previous GDL system. We used Poisson regression to estimate the association between the GDL system and crash rates, while attempting to control for other factors that might have also influenced crash rates. We used linear regression to estimate the association between the GDL system and the proportion of all crashes that occurred under conditions restricted by the GDL program. **Results:** Results showed, contrary to expectations, that rates of crashes during restricted nighttime hours and with passengers were higher among drivers licensed under the updated GDL system. This mirrored a statewide increase in crash rates among drivers of all ages over the study period and likely reflected increased overall driving exposure. The proportions of all crashes that were at night or with passengers did not change. **Practical Applications:** More research is needed to understand how older novice drivers respond when GDL systems originally designed for younger novice drivers are applied to them.

- **Keywords:** GDL; Older novices; Motor vehicle crashes

**Wenrui Qu, Tao Tao, Qun Zhao, Qiao Sun, Yi Qi. *Two-way left turn lane or raised median? A truck safety based study. Pages 109-117.***

**Introduction:** Due to their size and weight, trucks require more space and time to make left turns when exiting or entering a roadway. Therefore, appropriate median treatments are critical for roadways with substantial truck traffic. The two-way left-turn lane (TWLTL) and raised median (RM) are the two types of median most commonly used to improve roadway mobility and manage roadway accessibility. However, previous studies on these median treatments have focused primarily on the general traffic conditions and geometric roadway features without considering the truck traffic impact. **Method:** To fill this gap, this study investigates the truck impacts on TWLTL and RM by considering two major influencing factors – truck percentage and roadway access point density. First, a negative binomial regression is developed to analyze the relationship between crash frequency and various influencing factors. Next, the crash rate difference analysis between the TWLTL and RM is conducted to identify critical points for these two factors. **Results:** The findings indicate that, compared with RM, TWLTL has significantly higher crash frequency, especially for roadways with a higher percentage of trucks. This

suggests that the percentage of trucks should be taken into consideration when selecting an appropriate type of roadway median.

- **Keywords:** Truck safety; Two-way left-turn lane; Raised median; Crash rate difference analysis; Regression model

**Sacha Dubois, Dylan Antoniazzi, Rupert Klein, Michel Bédard. *Age and engine displacement are associated with unsafe motorcycle rider actions.* Pages 119-124.**

**Background:** Our goal was to examine the relationship between age and engine displacement in cubic centimeters (CCs) and crash responsibility. **Methods:** Male motorcyclists, aged 16–94, involved in a fatal crash in the United States (1987–2015) who tested negative for both drugs and alcohol were included. Employing a case control design, cases had committed one or more Unsafe Motorcyclist Actions (UMAs), the proxy measure of responsibility; controls had no UMAs recorded. Odds ratios were computed via multinomial regression examining the effect of motorcyclists' age and motorcycle displacement (up to 1500 CCs, in 250 CC increments) on crash responsibility by any UMA and top three individual UMAs committed. **Results:** A total of 19,166 motorcyclists met our inclusion criteria. Increased displacement was observed in older motorcyclists and in more recent crashes. Fifty-six percent of motorcyclists committed one or more UMAs (n = 10,743). The top three individual UMAs were: Speeding (35%, n = 6,728), Weaving (24%, n = 3,269), and Erratic Operation (6%, n = 1,162). Odds ratios for committing any UMA were the greatest for riders on 750 CC motorcycles, followed closely by 500 and 1000 CC motorcycles. By 1250 CCs the effect of displacement on rider crash responsibility (any UMA) was no longer statistically significant. Typically, younger ages (e.g., 20–30) on motorcycles with 500–1000 CCs were associated with the highest odds of either speeding, weaving, or erratic riding compared to similar aged riders on 250 CC motorcycles. Exceptions were observed, for example riders at 70 years of age on 1500 CCs having higher odds of speeding than younger riders on equivalent CC motorcycles. **Conclusion:** Education and legislative measures should be considered. Educationally, the development of training interventions focusing on control, stability, and breaking differences with more powerful motorcycles (750 to 1250 CCs) is needed. Legislatively, licensing tiers could be employed based on displacement and educational requirements. Education and legislative measures could help to curb the trend seen between high-powered motorcycles and crash responsibility.

- **Keywords:** Crash responsibility; Engine size; Fatal Crash; Motorcycle; Speeding; Weaving

**Iju Shakya, Gwen Bergen, Yara K. Haddad, Ramakrishna Kakara, Briana L. Moreland. *Fall-related emergency department visits involving alcohol among older adults.* Pages 125-131.**

**Problem:** Falls are the leading cause of injury deaths among adults aged 65 years and older. Characteristics of these falls may vary with alcohol use. **Objective:** Describe and compare characteristics of older adult fall-related emergency department (ED) visits with indication of alcohol to visits with no indication. **Methods:** Using nationally-representative 2015 National Electronic Injury Surveillance System-All Injury Program data, we compared demographic characteristics for fall-related ED visits by indication of alcohol consumption. Alcohol-indicated ED visits were matched on age group, sex, treatment month, and treatment day to ED visits with no alcohol indication using a 1:4 ratio and injury characteristics (i.e., diagnosis, body part injured, disposition) were compared. **Results and discussion:** Of 38,640 ED records, 906 (1.9%) indicated use of alcohol. Fall-related ED visits among women were less likely to indicate alcohol (1.0%) compared to ED visits among men (3.8%). ED visits indicating alcohol decreased with age from 4.1% for those 65–74 years to 1.5% for those 75–84 and <1% for those 85+.

After controlling for age-group, sex, and month and day of treatment, 17.0% of ED visits with no alcohol indication had a traumatic brain injury compared to 34.8% of alcohol-indicated ED visits. **Practical applications:** Alcohol-indicated fall ED visits resulted in more severe head injury than those that did not indicate alcohol. To determine whether alcohol use should be part of clinical risk assessment for older adult falls, more routinely collected data and detailed information on the amount of alcohol consumed at the time of the fall are needed.

- **Keywords:** Aged; Accidental falls; Alcohol drinking; Wounds and injuries; Emergency service; Hospital

**Jill Daugherty, Lara DePadilla, Kelly Sarmiento. *Assessment of HEADS UP online training as an educational intervention for sports officials/athletic trainers.* Pages 133-141.**

**Background:** Sports- and recreation-related concussions are a common injury among children. Sports officials (SOs) and athletic trainers (ATs) are integral to setting the stage for safe play and managing concussions when they occur, and significant numbers of both groups have completed the Centers for Disease Control and Prevention's HEADS UP online concussion training course. However, the utility of the course for these audiences has not been assessed. We hypothesized that sports officials' and athletic trainers' concussion-related knowledge, attitudes, and behavioral intentions will improve from pre- and post-test after completing CDC's HEADS UP online concussion training course. **Method:** Respondents' concussion-related knowledge, attitudes, and behavioral intentions were assessed both before and after taking the training course. Differences between pre- and post-test scores were calculated based on the Wilcoxon Signed Rank Test Z-score or McNemar's test. Effect sizes were interpreted. **Results:** The SOs and ATs who participated in the HEADS UP online training had a high level of concussion knowledge before taking the course: 90% or more of respondents could identify the correct response for at least seven of the 13 knowledge questions in the pre-test. Still, the course was effective at improving the respondents' knowledge about return-to-play protocols and concussion reporting. Further, SOs and ATs demonstrated improvement in their concussion-related attitudes and behavioral intentions between the pre- and post-test. **Conclusion:** SOs' and ATs' concussion knowledge, attitudes, and behavioral intentions improved immediately following completion of the CDC HEADS UP online training. Future research could also focus on the long-term retention of this type of training. **Practical Applications:** This study provides insight into how to better focus concussion-related educational programs to fit SOs' and ATs' needs.

- **Keywords:** Concussion; Youth athletes; Sports officials; Athletic trainers; Concussion education

**Dawn N. Castillo, Christine R. Schuler, Cammie Chaumont Menéndez, Sydney Webb, Sergey Sinelnikov. [2018 National Occupational Injury Research Symposium: Advancing worker safety in the 21st century through research and practice.](#) Pages 145-147.**

The National Occupational Injury Research Symposium (NOIRS), held October 16–18, 2018 in Morgantown, West Virginia, was the 7th in a series that was initiated in 1997. NOIRS is the only regularly held research forum in the United States dedicated to occupational injury and prevention research. We are appreciative of the Journal of Safety Research partnering on this and previous special issues that highlight some of the high-quality research presented at NOIRS, making the research available to a larger audience than symposium attendees.

- **Keywords:** Injury prevention; Occupational; Conference

**Joel M. Haight.** [\*Adaptive automation and its health and safety challenges.\*](#) Pages 149-152.

The world continues to become more automated every day. It is more common today to see, for example, autonomous cars, auto-mated control systems, and manufacturing robots than ever before. Autonomous systems possess more functionality than ever and technology is being developed at an ever-increasing rate. Artificial intelligence yields powerful systems that are becoming increasingly able to operate with no human intervention. With accurate programming and adequate training, systems conduct their functions reliably, efficiently, effectively, and accurately without fatigue, error, or salary. The transition, however, is likely to lead to operational uncertainty, confusion, skill decay, errors, and thus, potentially, to injuries.

- **Keywords:** Adaptive automation; Societal automation concerns; Function allocation

**Carole S. Franklin, Elena G. Dominguez, Jeff D. Fryman, Mark L. Lewandowski.** [\*Collaborative robotics: New era of human-robot cooperation in the workplace.\*](#) Pages 153-160.

Collaborative robotics is paradigm shift in industrial robot system safety. Collaborative robotics can permit closer work between people and robots. Risk assessment is a crucial tool for collaborative robot system safety. There are four types of collaborative robotic operations. ANSI/RIA R15.06-2012 and its TRs specify safety requirements for industrial robots.

- **Keywords:** Robot; Industrial robot system safety; Risk assessment; Collaborative; Safety standards

**Thomas R. Cunningham, Pamela J. Tinc, Rebecca J. Guerin, Paul A. Schulte.** [\*Translation research in occupational health and safety settings: Common ground and future directions.\*](#) Pages 161-167.

The research arm of the occupational safety and health (OSH) field has historically focused on the etiologic end of the research continuum rather than the workplace adoption and impact end. There has been a call to increase efforts to investigate factors that limit or enhance transfer, adoption, and sustained use of OSH risk information, interventions, and technology (collectively referred to as innovations); i.e. there has been a call for greater efforts in the far-reaching field of Translation Research for OSH (NAS, 2009). A central idea behind Translation Research for OSH is that as we improve our understanding of these limiting and enhancing factors at the individual worker, organizational, and societal level, we increase the likelihood that OSH research outputs lead to improvements in workers' safety, health, and wellbeing. Topic areas such as occupational hearing loss, lead toxicity, and occupational stress are only three examples of persistent OSH issues that would benefit from greater work on the adoption and impact end of the spectrum. In order to meaningfully decrease OSH injury, illness, and fatality rates related to these and other issues, it is imperative that innovations are not only developed, but widely adopted and sustained.

- **Keywords:** Translation research; Dissemination; Implementation science

**Mariana G. Figueiro, David Pedler. *Red light: A novel, non-pharmacological intervention to promote alertness in shift workers.* Pages 169-177.**

**Introduction:** Night work requires inversion of the natural, diurnal human activity-rest cycle and is associated with decreased alertness and some measures of performance, reduced safety, adverse health effects, and chronic disruption of the melatonin cycle that has been associated with increased risk for several major diseases. Previous studies show that red light exposures at night can promote alertness and improve performance while not negatively affecting melatonin secretion. **Method:** This ongoing crossover, mixed (within- and between-subjects) design field study is testing the efficacy and acceptance of red light delivered to day-shift and night-shift workers using personal light glasses while they are at work. Each participant experienced three lighting interventions at the eyes: red light (50 lx, 630 nm, the treatment intervention), blue light (50 lx, 460 nm, the positive control intervention), and dim white light (10 lx, 3,000 K, the placebo control). During the interventions, participants underwent visual performance testing, submitted salivary melatonin and cortisol samples, and provided subjective reports of sleepiness, sleep disturbance, and general health over the 20-week protocol. Due to the ongoing nature of the study, only the performance and subjective reports are presented here. **Results:** Preliminary results indicate that response times were improved by the red and blue interventions, but not accuracy and hit rates. Blue light was associated with improvements to self-reported sleep disturbances compared to dim light. **Conclusions:** These field results partially support our laboratory results that showed a positive effect of red light for promoting alertness and certain performance outcomes during the day and at night. **Practical Applications:** Red light may be used to improve response times in shift workers. Continued research will elucidate the lighting interventions' effects on melatonin and objective sleep measures (actigraphy).

- **Keywords:** Alertness; Circadian stimulus; Health; Healthcare workers; Red light; Shift work; Sleep; Visual performance testing

**Patrick L. Yorio, Emily J. Haas, Jennifer L. Bell, Susan M. Moore, Lee A. Greenawald. *Lagging or leading? Exploring the temporal relationship among lagging indicators in mining establishments 2006–2017.* Pages 179-185.**

**Problem:** Safety management literature generally categorizes key performance indicators (KPIs) as either leading or lagging. Traditional lagging indicators are measures related to negative safety incidents, such as injuries, while leading indicators are used to predict (and therefore can be used to prevent) the likelihood of future negative safety incidents. Recent theory suggests that traditional lagging indicators also possess characteristics of leading indicators, and vice versa, however empirical evidence is limited. **Method:** The current research investigated the temporal relationships among establishment-level injuries, near misses, and fatal events using injury and employment data from a sample of 24,910 mining establishments over a 12-year period. **Results:** While controlling for employee hours worked, establishment-level reported injuries and near misses were associated with future fatal events across the sample of mines and over the time period studied. Fatal events were also associated with increases in future reported near misses, providing evidence of a cyclic relationship between them. **Discussion:** These findings challenge the strict categorization of injuries, near misses, and fatal events as lagging indicators. **Practical applications:** Understanding the KPIs that should be used to manage organizational safety, and how they can be used, is of critical practical importance. The results of the current study suggest that, depending on several considerations, metrics tied to negative safety incidents may be used to anticipate, and possibly prevent, future negative safety events.

- **Keywords:** Key performance indicators; Accident prevention; Leading and lagging

**Jinhua Guan, Hongwei Hsiao, James D. Green, Richard Whisler. *Anthropometric study of emergency medical services providers (EMSP) in the United States. Pages 187-197.***

**Introduction:** Design of next-generation ambulance patient compartment requires up-to-date anthropometric data of emergency medical service providers (EMSP). Currently, no such data exist in the U.S. A large-scale anthropometric study of EMSP in the U.S. were conducted. This report provided the summary statistics (means, standard deviation, and percentiles) of the study's results and examined the anthropometric differences between the EMSP dataset and the U.S. general population, and between the EMSP dataset and U.S. military personnel dataset, respectively. **Method:** An anthropometric study of 471 male and 161 female EMSP from across the continental US was conducted, using a sampling strategy that took into account age, sex, and race strata. **Results:** On average, male EMSP were found to be 18mm taller and 7kg heavier than US male general population, and 19mm taller and 11kg heavier than US male military personnel. Female EMSP were found to be 25mm taller than US female general population, and 10kg heavier than US female military personnel. **Conclusions:** These results showed that it would be inappropriate to apply general population or military data to the design of next-generation ambulance patient compartment. This new dataset provided the most recent and accurate EMSP anthropometric measurements available in the US. **Practical Application:** Data from this study provided an invaluable resource for the design of next-generation ambulances in the US.

- **Keywords:** Emergency medical service providers; Human body measurement; Ambulance patient compartment design

**Natalie V. Schwatka, Linda M. Goldenhar, Stefanie K. Johnson. *Change in frontline supervisors' safety leadership practices after participating in a leadership training program: Does company size matter? Pages 199-205.***

**Introduction:** The majority of construction companies are small businesses and small business often lack the resources needed to ensure that their supervisors have the safety leadership skills to build and maintain a strong jobsite safety climate. The Foundations for Safety Leadership (FSL) training program was designed to provide frontline leaders in all sized companies with safety leadership skills. This paper examines the impact of the FSL training by size of business. **Methods:** Leaders, defined as foremen or other frontline supervisors, from small, medium, and large construction companies were recruited to participate in a study to evaluate the degree to which the FSL changed their understanding and use of the leadership skills, safety practices and crew reporting of safety-related conditions. We used linear mixed modeling methods to analyze pre-post training survey data. **Results:** Prior to the training, leaders from small and medium sized companies reported using safety leadership skills less frequently than those from large ones. After the training, regardless of business size, we observed that the FSL training improved leaders understanding of safety leadership skills from immediately before to immediately after the training. Additionally, leaders reported greater use of safety leadership skills, safety practices, and crew reporting of safety-related conditions from before to two-weeks after the training. However, those from small and medium sized companies reported the greatest improvement in their use of safety leadership skills. **Conclusions:** The FSL training improves safety leadership outcomes regardless of the size company for which the leader worked. However, the FSL may be even more effective at improving the safety leadership skills of leaders working for smaller sized construction companies or those with lower baseline levels of safety leadership skills. **Practical applications:** The majority of construction companies employ a small number of employees and therefore may not have the resources to provide their frontline leaders with the leadership training they need to be effective leaders who can create a strong

jobsite safety climate. The Foundations for Safety Leadership (FSL) training can help fill this gap.

- **Keywords:** Construction; Transformational leadership; Safety climate; Occupational health and safety; Small business

**Ja K. Gu, Luenda E. Charles, Desta Fekedulegn, Claudia C. Ma, John M. Violanti, Michael E. Andrew. *Occupational injury and psychological distress among U.S. workers: The National Health Interview Survey, 2004–2016. Pages 207-217.***

**Introduction:** Injuries at work may negatively influence mental health due to lost or reduced working hours and financial burden of treatment. Our objective was to investigate, in U.S. workers (a) the prevalence of serious psychological distress (SPD) by injury status (occupational, non-occupational, and no injury) and injury characteristics, and (b) the association between injury status and SPD. **Methods:** Self-reported injuries within the previous three months were collected annually for 225,331 U.S. workers in the National Health Interview Survey (2004–2016). Psychological distress during the past 30 days was assessed using the Kessler 6 (K6) questions with Likert-type scale (0–4, total score range: 0–24). SPD was defined as  $K6 \geq 13$ . Prevalence ratios (PR) from fitted logistic regression models were used to assess relationships between injury and SPD after controlling for covariates. **Results:** The prevalence of SPD was 4.74%, 3.58%, and 1.56% in workers reporting occupational injury (OI), non-occupational injury (NOI), and no injury, respectively. Workers with head and neck injury had the highest prevalence of SPD (Prevalence: OI=7.71%, NOI=6.17%), followed by workers with scrape/bruise/burn/bite (6.32% for those with OI). Workers reporting OI were two times more likely to have SPD compared to those without injury (PR=2.19, 95%CI: 1.62–2.96). However, there was no significant difference in SPD between workers with OI and workers with NOI (PR=0.98, 95%CI: 0.65–1.48). **Conclusion:** The prevalence of SPD varied by injury status with the highest being among workers reporting OI. We found that the workers reporting OI were significantly more likely to have SPD than those without injury, but not more than those with NOI. **Practical Applications:** Mental health management programs by employers are necessary for workers who are injured in the workplace.

- **Keywords:** Prevalence; Serious psychological distress; Injury; US workers; NHIS

**Sarah L. Hemler, Erika M. Pliner, Mark S. Redfern, Joel M. Haight, Kurt E. Beschorner. *Traction performance across the life of slip-resistant footwear: Preliminary results from a longitudinal study. Pages 219-225.***

**Introduction:** Slips, trips, and falls are a major cause of injury in the workplace. Footwear is an important factor in preventing slips. Furthermore, traction performance (friction and under-shoe fluid drainage) are believed to change throughout the life of footwear. However, a paucity of data is available for how traction performance changes for naturally worn, slip-resistant footwear. **Method:** The presented research is a preliminary analysis from an ongoing, larger study. Participants wore slip-resistant footwear while their distance walked was monitored. Friction and under-shoe fluid pressures were measured using a robotic slip tester under a diluted glycerol contaminant condition after each month of wear for the left and right shoes. The size of the worn region was also measured. **Results:** Friction initially increased and then steadily decreased as the distance walked and the size of the worn region increased. Fluid pressures increased as the shoes were worn and were associated with increased walking distance and size of the worn region. Discussion: Consistent with previous research, increases in the size of the worn region are associated with increased under-shoe fluid pressures and decreased traction. These trends are presumably due to reduced fluid

drainage between the shoe-floor interface when the shoe becomes worn. **Conclusions:** Traction performance changes with natural wear. The distance walked in the shoe and the size of the worn region may be valuable indicators for assessing loss of traction performance. **Practical Applications:** Current shoe replacement recommendations for slip-resistant shoes are based upon age and tread depth. This study suggests that tools measuring the size of the worn region and/or distance traveled in the shoes are appropriate alternatives for tracking traction performance loss due to shoe wear.

- **Keywords:** Slips, trips, & falls; Biomechanics; Shoe wear; Available coefficient of friction; Footwear

**María Andrée López Gómez, Jessica A.R. Williams, Leslie Boden, Glorian Sorensen, Karen Hopcia, Dean Hashimoto, Erika Sabbath. *The relationship of occupational injury and use of mental health care. Pages 227-232.***

**Introduction:** Symptoms of depression and anxiety are a common consequence of occupational injury regardless of its cause and type. Nevertheless, mental health care is rarely covered by workers' compensation systems. The aim of this study was to assess the use of mental health care post-injury. **Methods:** We used a subsample of patient-care workers from the Boston Hospital Workers Health Study (BHWHS). We matched one injured worker with three uninjured workers during the period of 2012–2014 based on age and job title (nurse or patient-care associate) and looked at their mental health care use pre- and post-injury using medical claims data from the employer sponsored health plan. We used logistic regression analysis to assess the likelihood of mental health care use three and six months post-injury controlling for any pre-injury visits. Analyses were repeated separately by job title. **Results:** There were 556 injured workers between 2012 and 2014 that were matched with three uninjured workers at the time of injury ( $n=1,649$ ). Injured workers had a higher likelihood of seeking mental health care services than their uninjured counterparts during the six months after injury (OR = 1.646, 95% CI: 1.23–2.20), but not three months post-injury (OR = 0.825, 95% CI: 0.57–1.19). Patient-care associates had a higher likelihood to seek mental health care post-injury, than nurses (OR: 2.133 vs OR: 1.556) during the six months period. **Conclusions:** Injured workers have a higher likelihood to experience symptoms of depression and anxiety based on their use of mental health care post-injury and use is more predominant among patient-care associates; however, our sample has a small number of patient-care associates. **Practical Applications:** Treating depression and anxiety as part of the workers' compensation system has the potential of preventing further physical ailment and improving the return to work process regardless of nature of injury.

- **Keywords:** Mental health; Occupational injuries; Medical claims; Workers' compensation; Depression; Anxiety

**Andrea L. Davis, Joseph Allen, Lauren Shepler, Christian Resick, Jin Lee, Richard Marinucci, Jennifer A. Taylor. *Moving FOCUS – The Fire Service Organizational Culture of Safety survey – From research to practice. Pages 233-247.***

**Introduction:** FOCUS, the Fire Service Organizational Culture of Safety survey, has evolved from a research to practice enterprise within the United States fire and rescue service. The FOCUS tool was developed through a FEMA Assistance to Firefighters Research & Development grant. Then it moved to practice in the field. To date over 35,000 firefighters have participated. A current FEMA Fire Prevention & Safety grant can support FOCUS assessment in up to 1,000 fire departments, with the potential of nearly 120,000 respondents. With each funding cycle, the goal of the FOCUS program is to grow and measure its research to practice impact. **Methods:** We describe how FOCUS safety

culture results are disseminated to fire service stakeholders. By utilizing customized reports and a training curriculum we demonstrate how FOCUS is moving research to practice by: (1) illustrating how survey results can be delivered effectively to practitioners, (2) providing examples of how fire departments are using results, and (3) sharing the reactions of the fire service to the FOCUS instrument, reports, and our flagship data training curriculum – Culture Camp. Results' **Conclusions:** Qualitative and quantitative data are analyzed to demonstrate the impact and acceptance of the FOCUS report and Culture Camps. Stakeholders reflect on the report and the experience of having quantitative safety culture data. Culture Camps are evaluated qualitatively and quantitatively using a matching game exercise, pre/post-test, a fire department teach back, and a Qualtrics evaluation. **Practical Applications:** Traditionally, the fire service has focused on reducing negative safety outcomes. FOCUS is helping shift their attention further upstream in the prevention pathway through the measurement of important organizational outcomes. The research to practice evolution of the FOCUS program may hold utility for other occupational groups when considering how to steadily move occupational health and safety research to practice in the field for measurable impact.

- **Keywords:** Safety climate; Firefighter; Injury prevention; Research to practice

**Regan M. Murray, Joseph A. Allen, Andrea L. Davis, Jennifer A. Taylor.** *Meeting science meets public health: Results from the "Stress and Violence in fire-based EMS Responders (SAVER)" Systems Checklist Consensus Conference (SC3).* Pages 249-261.

**Introduction:** In order to implement a systems-level Emergency Medical Services (EMS) workplace violence intervention, input from end users was critically needed. We convened the two-day Stress and Violence in fire-based EMS Responders (SAVER)" Systems Checklist Consensus Conference (SC3) using methods from meeting science (i.e., ThinkLets) to comprehensively and efficiently gather feedback from stakeholders on the completeness and utility of the draft checklist that would comprise the intervention. **Methods:** ThinkLets, a codified facilitation technique was used to aid brainstorming, convergence, organization, evaluation, and consensus building activities on the SAVER Systems Checklist among 41 national stakeholders during a two-day conference. A qualitative and quantitative process evaluation was conducted to measure the effectiveness of conference procedures. To verify checklist feasibility results from the conference, a second feasibility assessment was conducted with the four implementation sites. **Conclusions:** The quantitative conference evaluation results indicated most participants viewed the conference process favorably. Emergent themes reflecting on conference effectiveness and suggestions for improvements are described. The re-evaluation of the checklist's feasibility completed by the SAVER study sites confirmed prior feasibility findings. SAVER study sites cast 45.5% of votes on checklist items to be most feasible, 34.9% as less feasible, and 19.6% as extremely difficult. **Practical Applications:** Multidisciplinary collaboration between public health, occupational health psychology, and meeting science led to the development of the SAVER Systems Checklist. The checklist underscores important needs for EMS policy and training development critical to responder safety as identified and supported by over 41 diverse subject matter experts. The incorporation of a widely used meeting science method, ThinkLets, into public health intervention design proved an effective and well-received approach to bring assessment, evaluation, and consensus to the SAVER Systems Checklist. These methods may hold benefit for other industries and disciplines that may not be familiar with such facilitation and consensus-building techniques.

- **Keywords:** Emergency Medical Services (EMS); Workplace violence; Intervention; SAVER Systems Checklist; ThinkLets

**Brandy Brown, Douglas Myers, Carrie Casteel, Kimberly Rauscher.** *Exploring differences in the workplace violence experiences of young*

**workers in middle and late adolescence in the United States. Pages 263-269.**

**Problem:** Young workers, typically characterized as 15–24 years of age, are commonly employed in jobs where the risk of workplace violence is high. It is unknown how these young workers, at varying stages of development, might understand and respond to workplace violence differently. We set out to explore whether the experiences and understandings of young workers varied between those in middle (ages 15–17) and late (ages 18–24) adolescence. **Method:** Separate focus groups were conducted with working students ( $n = 31$ ), ages 15–17 and ages 18–24, who had either experienced or witnessed workplace violence. A focus group guide was used to facilitate the sessions which were recorded, transcribed, and content analyzed for themes. **Results:** Those in the older group experienced more severe episodes of sexual harassment and physical assault, reported using formal mechanisms for reporting, and noticed an employer focus on customer satisfaction over employee safety, while the younger participants tended to report to their parents. Both groups reported negative effects of experiencing workplace violence including depression, anxiety, feelings of worthlessness, and spill over into personal life. **Discussion:** Findings suggest that young workers at different developmental stages may experience and respond to workplace violence differently. Further research is needed to see if these results are generalizable. **Summary:** It is imperative that we understand the distinct differences between these subsets of young workers and how they experience and respond to workplace violence in order to improve research, policy development, and prevention/intervention mechanisms. **Practical Applications:** Understanding that differences exist among young workers based on age due to developmental stage, lack of experience, education, and social awareness can enable employers, companies, policy makers, and researchers the opportunity to better address the issue of workplace violence in this population.

- **Keywords:** Young workers; Adolescent development; Workplace violence; Qualitative methods

**Lynda S. Robson, Hyunmi Lee, Benjamin C. Amick III, Victoria Landsman, Peter M. Smith, Cameron A. Mustard. Preventing fall-from-height injuries in construction: Effectiveness of a regulatory training standard. Pages 271-278.**

**Introduction:** A regulatory training standard for construction workers using fall protection equipment became mandatory in 2015 in the province of Ontario, Canada. By the end of the transition period in 2017, 418,000 workers had been trained to the new standard. Two primary research questions were posed: (1) To what extent does the WAH training affect practices at the worksite? and (2) Has there been a change in the incidence of fall-from-height injuries coincident with the introduction of the WAH Training Standard? **Materials and methods:** A longitudinal survey of 633 learners was conducted in 2017 at one-, four- and seven-week post-training. A quasi-experiment estimated the incidence of lost-time injuries attributed to falls from heights in 2017 compared to 2012–2014 for a census of construction workers insured for work disability in Ontario, Canada. **Results:** Learners self-reported substantial increases in knowledge of and improvements in safe work practices when working at heights. The incidence rate of lost-time claim injuries attributed to falls targeted by the training declined by 19.6% (95% CI: 10.7, –27.6), compared to corresponding declines of 2.1% (95% CI: –6.3, 9.9) for other fall injuries and 7.2% (95% CI: 1.8, 12.3) for non-fall traumatic injuries. The observed decline was largest among the smallest employers (<5 full-time equivalent employees). **Conclusion:** The evaluation findings provide consistent support for a conclusion that the mandatory training standard was effective in reducing the incidence of injuries targeted by the training. However, the effects were modest and did not eliminate the problem. **Practical application:** A mandatory training standard should be considered as one

approach to preventing traumatic injuries. However, other approaches higher in the hierarchy of risk controls should also be considered.

- **Keywords:** Evaluation; Fall prevention; Injury prevention; Regulation; Safety training

**Ann Marie Dale, Ryan Colvin, Marco Barrera, Jaime R. Strickland, Bradley A. Evanoff. *The association between subcontractor safety management programs and worker perceived safety climate in commercial construction projects. Pages 279-288.***

**Problem:** Safety management programs (SMPs) are designed to mitigate risk of workplace injuries and create a safe working climate. The purpose of this project was to evaluate the relationship between contractors' SMPs and workers' perceived safety climate and safety behaviors among small and medium-sized construction subcontractors. **Methods:** Subcontractor SMP scores on 18 organizational and project-level safety items were coded from subcontractors' written safety programs and interviews. Workers completed surveys to report perceptions of their contractor's safety climate and the safety behaviors of coworkers, crews, and themselves. The associations between SMP scores and safety climate and behavior scales were examined using Spearman correlation and hierarchical linear regression models (HLM). **Results:** Among 78 subcontractors working on large commercial construction projects, we found striking differences in SMP scores between small, medium, and large subcontractors ( $p < 0.001$ ), related to a number of specific safety management practices. We observed only weak relationships between SMP scales and safety climate scores reported by 746 workers of these subcontractors ( $\beta = 0.09$ ,  $p = 0.04$  by HLM). We saw no differences in worker reported safety climate and safety behaviors by contractor size. Discussion: SMP only weakly predicted safety climate scales of subcontractors, yet there were large differences in the quality and content of SMPs by size of employers. Summary: Future work should determine the best way to measure safety performance of construction companies and determine the factors that can lead to improved safety performance of construction firms. **Practical applications:** Our simple assessment of common elements of safety management programs used document review and interviews with knowledgeable representatives. These methods identified specific safety management practices that differed between large and small employers. In order to improve construction safety, it is important to understand how best to measure safety performance in construction companies to gain knowledge for creating safer work environments.

- **Keywords:** Leading indicators; Injury prevention; Construction; Safety climate; Safety management systems