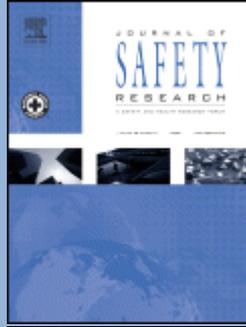


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Tushar Choudhari, Avijit Mají. [*Socio-demographic and experience factors affecting drivers' runoff risk along horizontal curves of two-lane rural highway.*](#) **Pages 1-11.**

Introduction: An improper driving strategy is one of the causative factors for a high probability of runoff and overturning crashes along the horizontal curves of two-lane highways. The socio-demographic and driving experience factors of a driver do influence driving strategy. Hence, this paper explored the effect of these factors on the driver's runoff risk along the horizontal curves. **Method:** The driving performance data of 48 drivers along 52 horizontal curves was recorded in a fixed-base driving simulator. The driving performance index was estimated from the weighted lateral acceleration profile of each driver along a horizontal curve. It was clustered and compared with the actual runoff events observed during the experiment. It yielded high, moderate, and low-risk clusters. Using cross-tabulation, each risk cluster was compared with the socio-demographic and experience factors. Further, generalized mixed logistic regression models were developed to predict the high-risk and high to moderate risk events. **Results:** The age and experience of drivers are the influencing factors for runoff crash. The high-risk event percentage for mid-age drivers decreases with an increase in driving experience. For younger drivers, it increases initially but decreases afterwards. The generalized mixed logistic regression models identified young drivers with mid and high experience and mid-age drivers with low-experience as the high-risk groups. **Conclusions:** The proposed index parameter is effective in identifying the risk associated with horizontal curves. Driver training program focusing on the horizontal curve negotiation skills and graduated driver licensing could help the high-risk groups. **Practical applications:** The proposed index parameter can evaluate driving behavior at the horizontal curves. Driving behavior of high-risk groups could be considered in highway geometric design. Motor-vehicle agencies, advanced driver assistance systems manufacturers, and insurance agencies can use proposed index parameter to identify the high-risk drivers for their perusal.

- **Keywords:** Horizontal curves; Socio-demographic factors; Lateral acceleration; Hierarchical cluster analysis; Driving behavior

David G. Kidd, Jeremiah Singer. [The effects of persistent audible seat belt reminders and a speed-limiting interlock on the seat belt use of drivers who do not always use a seat belt.](#) Pages 13-24.

Introduction: Vehicle technologies that increase seat belt use can save thousands of lives each year. Kidd, Singer, Huey, and Kerfoot (2018) found that a gearshift interlock was more effective for increasing seat belt use than an intermittent audible reminder, but interlocks may not be more effective than persistent audible reminders lasting at least 90 seconds. **Method:** Forty-nine part-time belt users with a recent seat belt citation who self-reported not always using a seat belt drove two vehicles for 1 week each. Thirty-three drove a Chevrolet with an intermittent audible reminder followed by either a BMW with a persistent 90-second audible reminder (n = 17) or a Subaru with an incessant audible reminder (n = 16). The other 16 participants experienced the BMW persistent reminder followed by an interlock that limited speed to 15 mph during unbelted driving. These data were combined with data from 32 part-time belt users in Kidd et al. (2018) who experienced the intermittent reminder for 2 weeks or the intermittent reminder for 1 week and a gearshift interlock the next. **Results:** Relative to the intermittent reminder, seat belt use was significantly increased an estimated 30% by the BMW persistent reminder, 34% by the Subaru incessant reminder, and 33% by the speed-limiting interlock. Belt use was increased an estimated 16% by the gearshift interlock, but this change was not significant. More participants circumvented the speed-limiting interlock to drive unbelted than the audible reminders. Responses to a poststudy survey indicated that interlocks were less acceptable than reminders. **Conclusions:** Audible reminders lasting at least 90 seconds and a speed-limiting interlock were more effective for increasing seat belt use than an intermittent audible reminder, but reminders were found more acceptable. **Practical applications:** Strengthening existing U.S. safety standards to require audible reminders lasting at least 90 seconds for front-row occupants could save up to 1,489 lives annually.

- **Keywords:** Seat belt use; Seat belt reminder; Enhanced reminder; Seat belt interlock; Part-time seat belt user

Siu Shing Man, Alan Hoi Shou Chan, Saad Alabdulkarim. [Quantification of risk perception: Development and validation of the construction worker risk perception \(CoWoRP\) scale.](#) Pages 25-39.

Introduction: The construction sector is leading in the number of accidents and fatalities; risk perception is the key to driving these numbers. Previous construction safety studies on risk perception quantification have not considered affective risk perception of construction workers or conducted comprehensive reliability and validity testing. Thus, this study aims to fill this need by developing a psychometrically sound instrument – the Construction Worker Risk Perception (CoWoRP) Scale – to assess the risk perception of construction workers. **Method:** Four phases of scale development, namely, item development, factor analysis, reliability assessment, and validity assessment were conducted with the collection and testing of data from a group (n = 469) of voluntary construction workers in Hong Kong. **Results:** The CoWoRP Scale with 13 items was shown to have acceptable test-retest reliability, internal consistency reliability, as well as content, convergent, discriminant, and criterion-related validity. Also, the CoWoRP Scale was affirmed to have three dimensions of worker risk perception, namely risk perception – probability, risk perception – severity, risk perception – worry and unsafe. These three dimensions of worker risk perception were negatively correlated with their risk-taking behavior. **Conclusions:** The CoWoRP Scale is a reliable and valid instrument for measuring the risk perception of construction workers and is expected to facilitate the construction safety studies that take risk perception of construction workers into account. **Practical applications:** The CoWoRP Scale could serve as an aptitude test to identify the characteristics of construction workers most likely to perceive lower risk in risky work situations. In turn, this information could help safety management provide

safety training programs to those workers to enhance their risk perception and thereby minimizing their risk-taking behavior, reducing unnecessary training costs, and improving the construction safety performance.

- **Keywords:** Construction industry; Construction workers; Risk perception; Risk-taking behavior; Scale development

Chengcheng Xu, Zijian Ding, Chen Wang, Zhibin Li. [*Statistical analysis of the patterns and characteristics of connected and autonomous vehicle involved crashes.*](#) **Pages 41-47.**

Introduction: This study aimed to investigate the characteristics and patterns of the connected and autonomous vehicle (CAV) involved crashes. **Method:** The crash data were collected from the reports of CAV involved crash submitted to the California Department of Motor Vehicles. The descriptive statistics analysis was employed to investigate the characteristics of CAV involved crashes in terms of crash location, weather conditions, driving mode, vehicle movement before crash occurrence, vehicle speed, collision type, crash severity, and vehicle damage locations. The bootstrap based binary logistic regressions were then developed to investigate the factors contributing to the collision type and severity of CAV involved crashes. **Results:** The results suggested that the CAV driving mode, collision location, roadside parking, rear-end collision, and one-way road are the main factors contributing to the severity level of CAV involved crashes. The CAV driving mode, CAV stopped or not, CAV turning or not, normal vehicle turning or not, and normal vehicle overtaking or not are the factors affecting the collision type of CAV involved crashes.

- **Keywords:** Connected and autonomous vehicle; Crash; Collision type; Crash severity

Hüseyin Onur Tezcan, Mahmoud Elmorssy, Göker Aksoy. [*Pedestrian crossing behavior at midblock crosswalks.*](#) **Pages 49-57.**

Introduction: This study investigated the pedestrian crossing behavior at midblock crosswalks, in Istanbul. **Method:** Data were compiled from field studies at four selected crosswalks that were on one-way streets. Three of the crosswalks were located on three-lane streets while the other one was on a two-lane street. By using two-hour video recordings at each crosswalk, information was collected about pedestrian crossing preferences, pedestrian platoons both at curbside and during the crossing, traffic characteristics including volume, crosswalk occupancy and illegal parking, and pedestrian characteristics comprising age, gender and distraction status. These data were stratified with respect to the number of lanes and two multinomial logit models for platooning and individual crossing behavior was estimated for each stratum. **Results:** The results showed that the likelihood of platooning increases as the traffic volume and platoon size increase. Moreover, pedestrians who waited for little or no at the curbside and started to cross when one or more lanes were occupied generally lost time during the crossing. In terms of policy, the formation of platoons should be prevented by enforcement or demand-responsive traffic signals with push-to-walk buttons, etc. Overall, the study revealed that the presence of midblock crosswalks is questionable.

- **Keywords:** Midblock crosswalk; Pedestrian crossing behavior; Multinomial logit model

Nadya C. Yuris, Mark W. Wiggins, Jaime C. Auton, Leia Gaicon, Daniel Sturman. [Higher cue utilization in driving supports improved driving performance and more effective visual search behaviors.](#) Pages 59-66.

Introduction: Once qualified, drivers rarely receive objective feedback concerning their performance. This is especially the case in the context of cognitive skills such as situation assessment. The aim of this study was to test the construct validity of an online assessment of motor-vehicle driver cue utilization that forms the foundation for situation assessment. **Method:** Seventy-one undergraduate Psychology students with broadly comparable driving experience completed a motor-vehicle driving version of EXPERTise 2.0, an online tool that enables inferences concerning the utilization of cues based on responses to task-related stimuli. They also completed a simulated driving task while fitted with an eye tracking device, during which a range of hazards were presented with participants' responses recorded. **Results:** The results indicated that higher cue utilization was associated with fewer driving errors and collisions, fewer visual fixations, and fewer saccades in comparison to participants with lower cue utilization. **Conclusion:** The results provide support for the construct validity of EXPERTise 2.0 as an effective measure of cue utilization in the context of driving. **Practical applications:** Providing comparative feedback to drivers concerning their development of situation assessment skills may provide opportunities for further training and development, thereby reducing the likelihood of motor-vehicle accidents.

- **Keywords:** Cue utilisation; Driving; Fixations; Saccades; Situation assessment

Caroline Deck, Nicolas Bourdet, Frank Meyer, Rémy Willinger. [Protection performance of bicycle helmets.](#) Pages 67-77.

Introduction: The evaluation of head protection systems needs proper knowledge of the head impact conditions in terms of impact speed and angle, as well as a realistic estimation of brain tolerance limits. In current bicycle helmet test procedures, both of these aspects should be improved. **Method:** The present paper suggests a bicycle helmet evaluation methodology based on realistic impact conditions and consideration of tissue level brain injury risk, in addition to well known headform kinematic parameters. The method is then applied to a set of 32 existing helmets, leading to a total of 576 experimental impact tests followed by 576 numerical simulations of the brain response. **Results:** It is shown that the most critical impacts are the linear-lateral ones as well as the oblique impact leading to rotation around the vertical axis (ZRot), leading both to around 50% risks of moderate neurological injuries. Based on this test method, the study enables us to compare the protection capability of a given helmet and eventually to compare helmets via a dedicated rating system.

- **Keywords:** Bicycle helmet; Helmet test method; Model based head injury criteria; Oblique impacts

Guofa Li, Ying Wang, Fangping Zhu, Xiaoxuan Sui, Ning Wang, Xingda Qu, Paul Green. [Drivers' visual scanning behavior at signalized and unsignalized intersections: A naturalistic driving study in China.](#)

Introduction: Intersections are the most dangerous locations in urban traffic. The present study aims to investigate drivers' visual scanning behavior at signalized and unsignalized intersections. **Method:** Naturalistic driving data at 318 green phase signalized intersections and 300 unsignalized ones were collected. Drivers' glance allocations were manually categorized into 10 areas of interest (AOIs), based on which three feature subsets were extracted including glance allocation frequencies, durations and AOI transition probabilities. The extracted features at signalized and unsignalized intersections were compared. Features with statistical significances were integrated to

characterize drivers' scanning patterns using the hierarchical clustering method. Andrews Curve was adopted to visually illustrate the clustering results of high-dimensional data. **Results:** Results showed that drivers going straight across signalized intersections had more often glances at the left view mirror and longer fixation on the near left area. When turning left, drivers near signalized intersections had more frequent glances at the left view mirror, fixated much longer on the forward and rearview mirror area, and had higher transition probabilities from near left to far left. Compared with drivers' scanning patterns in left turning maneuver at signalized intersections, drivers with higher situation awareness levels would divide more attention to the forward and right areas than at unsignalized intersections. **Conclusions:** This study revealed that intersection types made differences on drivers' scanning behavior. **Practical applications:** These findings suggest that future applications in advanced driver assistance systems and driver training programs should recommend different scanning strategies to drivers at different types of intersections.

- **Keywords:** Intersection safety; Visual scanning behavior; Signalized intersection; Unsignalized intersection; Hierarchical clustering

Nazhakaiti Maimaiti, Jingjing Wang, Xianning Jin, Shijuan Wang, Dongliang Qin, Lihua He, Fujiang Wang, Zhongbin Zhang, Mikael Forsman, Liyun Yang, Qiuyue Yang, Haijiao Wang. [Cervical musculoskeletal disorders and their relationships with personal and work-related factors among electronic assembly workers](#). Pages 79-85.

Electronics assembly workers are reported to have a high prevalence of musculoskeletal disorders (MSDs). This study investigated the prevalence of cervical MSDs and the complex relationships between cervical MSDs and individual, physical, psychosocial factors among electronics assembly workers. **Methods:** In this cross-sectional survey, self-administered questionnaires from 700 workers in electronics manufacturing workshops were analysed. Information concerning musculoskeletal symptoms, personal and work-related factors was collected. Finally, the prevalence of cervical MSDs was computed for different subgroups, and the relationships with different factors were analyzed using logistic regression and structural equation modeling (SEM). **Results:** The total 12 month prevalence of cervical MSDs among the survey population was 29.4%. Variables of gender, job tenure, twisting head frequently, neck flexion/extension for long time and work required to be done quickly showed significant associations with MSDs in a multivariate logistic regression ($P < 0.05$). The SEM analysis showed moderate and significant correlations between postural load ($\gamma = 0.279$), gender ($\gamma = 0.233$) and cervical MSDs, while there were weak but significant correlations between vibration ($\gamma = 0.024$), work stress ($\gamma = 0.126$), job tenure ($\gamma = 0.024$) and cervical MSDs. Both work stress and vibration affected the MSDs indirectly through postural load. **Conclusions:** The logistic regression results support previous general epidemiological MSD studies, and indicates that individual, physical, and psychosocial factors are related to cervical MSDs. The SEM provides a better approximation of the complexity of the relationship between risk factors and cervical MSDs. Improving awkward postures may be effective ways to control the influence of occupational stressors or vibration on MSDs. **Practical Applications:** The study is to improve prevention of MSDs among electronics assembly workers and promote their occupational health.

- **Keywords:** Cervical musculoskeletal disorders; risk factors; structural equation modeling; electronic assembly workers; occupational health

Aimee J. Palumbo, Melissa R. Pfeiffer, Kristina B. Metzger, Allison E. Curry. [*Driver licensing, motor-vehicle crashes, and moving violations among older adults.*](#) Pages 87-93.

Introduction: Driving is important for well-being among older adults, but age-related conditions are associated with driving reduction or cessation and increased crash risk for older drivers. Our objectives were to describe population-based rates of older drivers' licensing and per-driver rates of crashes and moving violations. **Methods:** We examined individual-level statewide driver licensing, crash, and traffic citation data among all New Jersey drivers aged ≥ 65 and a 35- to 54-year-old comparison group during 2010–2014. Rate ratios (RR) of crashes and moving violations were estimated using Poisson regression. **Results:** Overall, 86% of males and 71% of females aged ≥ 65 held a valid driver's license. Older drivers had 27% lower per-driver crash rates than middle-aged drivers (RR: 0.73, 95% CI: 0.73, 0.74)—with appreciable differences by sex—but 40% higher fatal crash rates (RR: 1.40 [1.24, 1.58]). Moving violation rates among older drivers were 72% lower than middle-aged drivers (RR: 0.28 [0.28, 0.28]). **Conclusion:** The majority of older adults are licensed, with substantial variation by age and sex. Older drivers have higher rates of fatal crashes but lower rates of moving violations compared with middle-aged drivers. **Practical applications:** Future research is needed to understand the extent to which older adults drive and to identify opportunities to further reduce risk of crashes and resultant injuries among older adults.

- **Keywords:** Driving; Epidemiology; Elderly drivers; Population aging; Travel behavior; Linked data

Laurent Auzoult, Robert Ngueutsa. [*Attitude to safety rules and reflexivity as determinants of safety climate.*](#) Pages 95-102.

Introduction: We present two studies that focus on the relationship between safety rules and the safety climate. It is expected that a reasoned acceptance, namely one based on an understanding of the bases for the rules and a collective management of the rules, should benefit the climate. **Method:** In an initial study (N = 202) employees replied to a questionnaire that measured the safety climate, the level of the relationship with the safety rules, and the understanding of their bases. The results highlighted the fact that a reasoned acceptance of the rules is associated with an understanding of their bases and predicts the level of safety. In a second study (N = 258) employees replied to a questionnaire measuring team reflexivity, the safety climate, and the level of relationship with the safety rules. We observed that collective management of the rules mediated the relation between team reflexivity and the safety climate. **Results:** The results are discussed from the point of view of their practical implications. Developing safety climate requires that operators are trained to understand the basis of safety rules and team reflexivity.

- **Keywords:** Safety rule violation; Safety climate; Rule related judgement; Basis of rules; Team reflexivity

David P. Bui, Stephanie C. Griffin, Dustin D. French, Chengcheng Hu, Keshia Pollack Porter, Alesia M. Jung, Steve Crothers, Jefferey L. Burgess. [*The use of proactive risk management to reduce emergency service vehicle crashes among firefighters.*](#) Pages 103-109.

Introduction: Emergency service vehicle crashes (ESVCs), including rollovers and collisions with other vehicles and fixed objects, are a leading cause of death among U.S. firefighters. Risk management (RM) is a proactive intervention to identifying and mitigating occupational risks and hazards. The goal of this study was to assess the effect of RM in reducing ESVCs. **Methods:** Three fire departments (A, B and C), representing

urban and suburban geographies, and serving medium to large populations, participated in facilitated RM programs to reduce their ESVCs. Interventions were chosen by each department to address their department-specific circumstances and highest risks. Monthly crash rates per 10,000 calls were calculated for each department an average of 28 months before and 23 months after the start of the RM programs. Interrupted time series analysis was used to assess the effect of the RM programs on monthly crash rates. Poisson regression was used to estimate the number of crashes avoided. Economic data from Department A were analyzed to estimate cost savings. **Results:** Department A had a 15.4% ($P=0.30$) reduction in the overall monthly crash rate immediately post-RM and a 1% ($P=0.18$) decline per month thereafter. The estimated two-year average cost savings due to 167 crashes avoided was \$253,100 (95%CI= \$192,355 – \$313,885). Department B had a 9.7% ($P=0.70$) increase in the overall monthly crash rate immediately post-RM and showed no significant changes in their monthly crash rate. Department C had a 28.4% ($P=0.001$) reduction in overall monthly crash rate immediately post-RM and a 1.2% ($P=0.09$) increase per month thereafter, with an estimated 122 crashes avoided. **Conclusions:** RM programs have the potential to reduce ESVCs in the fire service and their associated costs; results may vary based on the interventions chosen and how they are implemented. **Practical applications:** Risk management may be an effective and broadly implemented intervention to reduce ESVCs in the US fire service.

- **Keywords:** Risk management; Fire service; Safety and health; Time series analysis; Crash prevention

Rahim Dabbagh, Samuel Yousefi. [A hybrid decision-making approach based on FCM and MOORA for occupational health and safety risk analysis](#). Pages 111-123.

Introduction: With the development of industries and increased diversity of their associated hazards, the importance of identifying these hazards and controlling the Occupational Health and Safety (OHS) risks has also dramatically augmented. Currently, there is a serious need for a risk management system to identify and prioritize risks with the aim of providing corrective/preventive measures to minimize the negative consequences of OHS risks. In fact, this system can help the protection of employees' health and reduction of organizational costs. **Method:** The present study proposes a hybrid decision-making approach based on the Failure Mode and Effect Analysis (FMEA), Fuzzy Cognitive Map (FCM), and Multi-Objective Optimization on the basis of Ratio Analysis (MOORA) for assessing and prioritizing OHS risks. After identifying the risks and determining the values of the risk assessment criteria via the FMEA technique, the attempt is made to determine the weights of criteria based on their causal relationships through FCM and the hybrid learning algorithm. Then, the risk prioritization is carried out using the MOORA method based on the decision matrix (the output of the FMEA) and the weights of the criteria (the output of the FCM). **Results:** The results from the implementation of the proposed approach in a manufacturing company reveal that the score at issue can overcome some of the drawbacks of the traditional Risk Priority Number(RPN) in the conventional FMEA, including lack of assignment the different relative importance to the assessment criteria, inability to take into account other important management criteria, lack of consideration of causal relationships among criteria, and high dependence of the prioritization on the experts' opinions, which finally provides a full and distinct risk prioritization.

- **Keywords:** Risk assessment; Occupational health and safety; Failure mode and effect analysis; Fuzzy cognitive map; Multi-objective optimization on the basis of ratio analysis

William J. Saunders, Saleh R. Mousa, Julius Codjoe. [Market basket analysis of safety at active highway-railroad grade crossings](#). Pages 125-137.

Introduction: Data from the Federal Railroad Administration show high numbers of incidents at the approximately 210,446 highway-railroad grade crossings across the United States. One cause for this unsettling trend is the problem of drivers stopping within the dynamic envelope zone (DEZ) of the train while in queue. This research seeks to study DEZ stopping behavior at highway-railroad grade crossings by evaluating regulatory signage and further analyze variables that may affect this behavior. **Method:** A comparative safety analysis is undertaken to evaluate the effectiveness of the standard "Do Not Stop on Tracks" (R8-8) sign by using percentage change calculations and chi-squared tests. The study then conducts a market basket analysis (MBA) to extrapolate on these results and to identify underlying factors associated with observed driver behavior using variables influenced by visibility, perception, and maneuverability. **Results:** Rather low reductions in safety violations resulted from the R8-8 installation, including a 2.2% reduction in DEZ stopping behavior and only a slight 3.7% increase in compliance. The results of the MBA identified associations that affirmed assumptions about driver behavior, while other associations were not as direct but altogether helped broaden the understanding of interactions at grade crossings. **Conclusions:** This study concluded that the R8-8 had a positive but minimal effect on driver behavior at the grade crossings. The MBA successfully demonstrated its value by providing further insight on the safety analysis and by increasing the number of variables that can be analyzed simultaneously. The methodology offers the scientific community an innovative approach to analyzing driver behavior. **Practical Applications:** The results identified important variables for developing preventive measures, which will ultimately help reduce safety violations at grade crossings. The MBA can provide practical insight for railroad safety professionals and transportation engineers when determining problematic intersections and can be used to improve the education on grade crossing interactions.

- **Keywords:** Regulatory signage; Compliance; Naturalistic driving data; Dynamic envelope zone; Association analysis

Stig Winge, Eirik Albrechtsen, Jan Arnesen. [A comparative analysis of safety management and safety performance in twelve construction projects](#). Pages 139-152.

Introduction: Safety management in construction is complicated due to the complex "nature" of the construction industry. The aim of this research was to identify safety management factors (e.g., risk management and site management), contextual factors (e.g., organisational complexity) and combinations of such factors connected to safety performance. **Method:** Twelve construction projects were selected to compare their safety management and safety performance. An analytical framework was developed based on previous research, regulations, and standards where each management factor was defined. We employed qualitative comparative analysis (QCA) to produce case knowledge, compare the cases, and identify connections between the factors and safety performance. The material collected and analyzed included, for example, construction planning documents, reports from OHS-inspections, safety indicators, and interviews with project leaders and OHS experts. **Results and conclusions:** The research showed that: (a) the average score on 12 safety management factors was higher among projects with high safety performance compared to projects with low safety performance; (b) high safety performance can be achieved with both high and low construction complexity and organizational complexity, but these factors complicate coordination of actors and operations; (c) it is possible to achieve high safety performance despite relatively poor performance on many safety management factors; (d) eight safety management factors were found to be "necessary" for high safety performance, namely roles and responsibilities, project management, OHS management and integration, safety climate,

learning, site management, staff management, and operative risk management. Site management, operative risk management, and staff management were the three factors most strongly connected to safety performance. **Practical implications:** Construction stakeholders should understand that the ability to achieve high safety performance in construction projects is connected to key safety management factors, contextual factors, and combinations of such factors.

- **Keywords:** Occupational health and safety management; Safety performance; Construction safety; Construction project; Comparative methods

Shanshan Zhao, Kai Wang, Chenhui Liu, Eric Jackson. [Investigating the effects of monthly weather variations on Connecticut freeway crashes from 2011 to 2015](#). Pages 153-162.

Introduction: The objective of this research is to investigate the effects of monthly weather conditions on traffic crash experience on freeways, considering the interactions between weather, traffic volumes, and roadway conditions. **Methods:** Data from the state of Connecticut from 2011 to 2015 were used. Random parameters negative binomial models with first-order, autoregressive covariance were estimated for representative types of freeway crashes (front-to-rear, sideswipe-same-direction, and fixed-object), most severe crashes (i.e., fatal and injury crashes), and non-injury crashes (i.e., property-damage-only crashes). **Results:** Major findings are that variations in monthly traffic volumes, roadway geometry, and weather conditions explain much of the variations in monthly traffic crashes. Time effects exist in the panel monthly data for all types of crashes. Taking into account this effect improves model prediction results. When the raw weather measures are highly correlated, using dimension reduction techniques helps to extract more interpretable weather factors. By considering the interaction effects between roadway condition variables, additional findings were found. In general, lower temperature, more heavy fog days, decreased precipitation, lower wind speed, higher monthly traffic volumes, and narrower inside shoulder were found to be associated with higher monthly crashes. The effects of area type and outside shoulder width change dramatically as the number of through lanes changes. **Practical applications:** The findings of this research could help researchers and general readers gain a better understanding of the effects of monthly weather conditions and other roadway factors on freeway crashes and give engineers practical guidelines on improving freeway safety.

- **Keywords:** Motor vehicle traffic; Motor vehicle crash; Weather; Crash by type; Crash by severity

Amirarsalan Mehrara Molan, Milhan Moomen, Khaled Ksaibati. [Investigating the effect of geometric dimensions of median traffic barriers on crashes: Crash analysis of interstate roads in Wyoming using actual crash datasets](#). Pages 163-171.

Introduction: Despite the numerous safety studies done on traffic barriers' performance assessment, the effect of variables such as traffic barrier's height has not been identified considering a comprehensive actual crash data analysis. This study seeks to identify the impact of geometric variables (i.e., height, post-spacing, sideslope ratio, and lateral offset) on median traffic barriers' performance in crashes on interstate roads. **Method:** Geometric dimensions of over 110 miles median traffic barriers on interstate Wyoming roads were inventoried in a field survey between 2016 and 2018. Then, the traffic barrier data collected was combined with historical crash records, traffic volume data, road geometric characteristics, and weather condition data to provide a comprehensive dataset for the analysis. Finally, an ordered logit model with random-parameters was developed for the severity of traffic barrier crashes. Based on the results, traffic barrier's height was found to impact crash severity. **Results:** Crashes involving cable barriers with

a height between 30" and 42" were less severe than other traffic barrier types, while concrete barriers with a height shorter than 32" were more likely involved with severe injury crashes. As another important finding, the post-spacing of 6.1–6.3 ft. was identified as the least severe range in W-beam barriers. In terms of variables impacting crash frequency, W-beam and box beam barriers located on frontslopes had higher crash frequency. **Practical applications:** The results show that using flare barriers should reduce the number of crashes compared to parallel barriers.

- **Keywords:** Median traffic barrier; Traffic barrier dimensions; Crash severity; Random parameters ordered logit; Wyoming

Rebecca E. Cash, Remle P. Crowe, Madison K. Rivard, Evan Crowe, Anne C. Knorr, Ashish R. Panchal, Douglas F. Kupas. [Seat belt use in the ambulance patient compartment by emergency medical services professionals is low regardless of patient presence, seating position, or patient acuity.](#) Pages 173-180.

Background: Inconsistent use of seat belts in an ambulance may increase the risk of injury for emergency medical services (EMS) professionals and their patients. Our objectives were to: (1) describe the prevalence of seat belt usage based on patient acuity and seat location, and (2) assess the association between EMS-related characteristics and consistent use of a seat belt. **Methods:** We administered a cross-sectional electronic questionnaire to a random sample of 20,000 nationally-certified EMS professionals, measuring seat belt use in each seating location of an ambulance during transport of stable, critical, or no patients. We included practicing, non-military, emergency medical technicians or higher who reported working in ambulances. We used multivariable logistic regression models to estimate the odds of consistent ($\geq 50\%$ of the time) use of seat belts for the rear-facing jump seat and right-sided crew bench during transport of stable and critical patients. **Results:** A total of 1431 respondents were included in the analysis. Patient compartment seat belt use varied with the highest use in forward-facing seats when no patient was being transported (59.8%) and lowest use in the left-side "CPR" seat with a critical patient (9.4%). Only 40.2% of respondents reported an agency policy regarding seat belt use while riding in the patient compartment. In all multivariable logistic regression models, advanced life support level certification and fewer years of experience were associated with decreased odds of consistent seat belt use. An agency seat belt policy was strongly associated with increased odds of seat belt use in the patient compartment. **Conclusions:** Seat belt use was low and varied by seating location and patient acuity in the patient compartment of an ambulance. **Practical Applications:** EMS organizations should consider primary prevention approaches of provider education, improved ambulance designs, enactment and enforcement of policies to improve seat belt compliance and provider safety.

- **Keywords:** Emergency medical services; Emergency medical technicians; Paramedic; Seat belt; Ambulance

Masoud Ghodrat Abadi, David S. Hurwitz, Kristen L. Macuga. [Towards safer bicyclist responses to the presence of a truck near an urban loading zone: Analysis of bicyclist perceived level of comfort.](#) Pages 181-190.

Introduction: While sophisticated plans have been adopted nationally and globally to increase bicycling's share of daily commutes, safety concerns have negatively impacted targeted bicycling growth. To investigate people's preferences for bicycling in dense urban areas, it is important to recognize how bicycling perceived level of comfort (PLOC) is constructed and how it could relate to safe versus risky behavior while interacting with motorized modes of transportation. **Method:** To examine these issues, we analyzed

results from an online survey with 342 participants. Structural Equation Modeling (SEM) was employed to systematically investigate the construct of bicycling PLOC and simultaneously analyze bicyclists' responses to the presence of a truck in the adjacent lane near an urban loading zone. **Results:** SEM estimation results indicated that participants who said that they engaged in more frequent distracted bicycling reported lower PLOC. On the other hand, those who felt that road users were more lawful and predictable, and who had more bicycling experience, reported higher levels of PLOC. Participants who bicycled for commuting purposes, who made shorter trips, who bicycled more frequently, and who had more exposure to downtown bicycling also reported higher levels of PLOC. Finally, findings showed that higher PLOC was significantly associated with the choice of a safe, rather than a risky response to the presence of a truck, suggesting that a way to improve bicyclist safety would be to build an environment that could increase bicyclists' PLOC.

- **Keywords:** Bicyclist Safety; Bicyclist Behavior; Bicycling Level of Comfort; Structural Equation Modeling

Mark D. Chandler, Terry L. Bunn. [Motor vehicle towing: An analysis of injuries in a high-risk yet understudied industry.](#) Pages 191-200.

Objectives: National fatality rates for commercial tow truck operators exceed those of other first responders who also perform traffic incident management services. The objectives of the current study are to (1) characterize causal factors associated with injuries among commercial tow truck operators engaged in roadside assistance through analysis of coded and free text data obtained from U.S. Occupational Safety and Health Administration (OSHA) investigation files, and (2) utilize supplemental data sources to analyze environmental factors for injuries in which commercial tow truck operators were struck by roadway traffic. **Methods:** Searches of OSHA's online IMIS database were performed to identify investigations of incidents in which tow truck operators were injured while performing roadside assistance duties. Freedom of Information Act (FOIA) requests were submitted to obtain full investigation files for each case. Coded and narrative text analyses were performed to identify causal themes across the identified cases. **Results:** One-hundred and six cases of tow truck operators being killed or severely injured were identified in IMIS; 41 FOIA requests for related investigation documents were fulfilled. Two major event type themes were identified which accounted for 9 in 10 of the cases identified. These were (1) 'struck-by' incidents, which were primarily injuries resulting from contact with roadway traffic, rolling vehicles and equipment or other non-motorized objects; and (2) 'caught-in or -between' incidents, which were primarily injuries resulting from being pinned beneath and between vehicles and being caught in moving parts. **Conclusions:** The towing industry should provide initial and refresher safety training on vehicle loading and unloading, defensive techniques when exposed to traffic on roadways, and proper wheel chocking and braking procedures. States should include tow trucks as a first responder vehicle type in their "Move Over" laws and implement public awareness campaigns to protect all first responders, including tow truck operators.

- **Keywords:** Motor vehicle towing; Tow truck operator; Fatality; Catastrophe; OSHA

John Culhane, Bret Silverglate, Carl Freeman. [Alcohol is a predictor of mortality in motor vehicle collisions.](#) Pages 201-205.

Introduction: It is well recognized that driving while intoxicated increases the probability of a motor-vehicle collision (MVC). The effect of alcohol on the chance of surviving the MVC is less clear. **Method:** Using data from the Fatality Analysis Reporting System (FARS) we conducted analyses for the outcome of mortality using alcohol and other variables as predictors. We also selected alcohol positive (AP) and alcohol negative

(AN) persons from the same MVC and vehicle to control for confounding characteristics. **Results:** The odds ratio (OR) for mortality for alcohol positive drivers was 2.57, ($p < 0.001$ for all the following OR). Other harmful predictive factors were age OR 1.01 per year, vehicle age OR 1.05 per year, male sex OR 1.23, avoidance maneuver OR 1.09, speed related OR 2.89, rollover mechanism OR 2.75, and collision with a fixed object OR 6.70. Protective factors were proper restraint use – OR 0.19 and collision with another moving vehicle, OR 0.21. In the multivariate analysis the OR of mortality for AP vs AN was 1.46. Proper restraint use (OR 0.27) remained protective along with collision with another moving vehicle. When AP and AN persons from the same MVC and the same vehicle were compared, the adjusted OR's for mortality were 1.46 and 2.08, respectively. **Conclusions:** Alcohol is an independent predictor of mortality in an MVC. Proper restraint use is the strongest protective factor. This finding allows a more complete understanding of the risks of driving while intoxicated, not only a higher probability of an MVC, but decreased survival once the MVC occurs. **Practical Applications:** Identification of alcohol as an independent predictor of mortality in an accident may improve risk assessment and influence drivers to avoid driving while intoxicated.

- **Keywords:** Restraint; Driver; Passenger; Risk; Mechanism; Fatality Analysis Reporting System (FARS)

Changquan He, Guangshe Jia, Brenda McCabe, Yuting Chen, Jide Sun.
[Impact of psychological capital on construction worker safety behavior: Communication competence as a mediator.](#) Pages 231-241.

Introduction: Construction workers face a work environment of high risk and mental stress. Psychological capital (PsyCap) could influence employee's mental health and work performance. It would be helpful to determine whether PsyCap affects worker safety behavior. However, few studies empirically examined the impacts of the sub-dimensions of PsyCap on the safety behavior in construction settings, reducing the potential practicability of PsyCap to improve workplace safety performance. Thus, this study tested the relationship between sub-dimensions of PsyCap (self-efficacy, hope, resilience, optimism) and safety behaviors (safety compliance, safety participation), while the mediating role of communication competence was also explored. **Method:** Data were collected from 655 construction workers in China using a psychological capital questionnaire (PCQ). The theoretical model were tested with confirmatory factor analyses (CFA) and structural equation modeling (SEM) techniques. **Results:** Results show that: (a) the self-efficacy dimension of PsyCap positively affected safety compliance and safety participation, while the resilience dimension positively impacted safety participation; (b) the hope dimension was not directly related to safety behaviors, while the optimism dimension negatively associated with safety participation; and (c) communication competence mediated the relationships between the hope and optimism dimensions of PsyCap and safety participation. **Conclusions:** A multidimensional perspective on PsyCap should be taken while examining its effects on safety behavior and the individual communication competence helps to enhance construction safety. Findings of this study shed lights on safety behavior promotion practices based on the multidimensional model. Initiating flexible psychological capital training and intervention, and strengthening communication skills of construction employees are suggested to improve safety performance in the construction industry.

- **Keywords:** Psychological capital; Safety behavior; Communication competence; Construction industry; Structural equation modeling

Sijun Shen, Caitlin N. Pope, Nikiforos Stamatiadis, Motao Zhu. [Validation of not-at-fault driver representativeness assumption for quasi-induced exposure using U.S. national traffic databases.](#) Pages 243-249.

Introduction: The quasi-induced exposure (QIE) method has been widely implemented into traffic safety research. One of the key assumptions of QIE method is that not-at-fault drivers represent the driving population at the time of a crash. Recent studies have validated the QIE representative assumption using not-at-fault drivers from three-or-more vehicle crashes (excluding the first not-at-fault drivers; D3_other) as the reference group in single state crash databases. However, it is unclear if the QIE representativeness assumption is valid on a national scale and is a representative sample of driving population in the United States. The aims of this study were to assess the QIE representativeness assumption on a national scale and to evaluate if D3_other could serve as a representative sample of the U.S. driving population. **Method:** Using the Fatality Analysis Reporting System (FARS) and the National Occupant Protection Use Survey (NOPUS), distributions of driver gender, age, vehicle type, time, and roadway type among the not-at-fault drivers in clean two-vehicle crashes, the first not-at-fault drivers in three-or-more-vehicle crashes, and the remaining not-at-fault drivers in three-or-more vehicle crashes were compared to the driver population observed in NOPUS. **Results:** The results showed that with respect to driver gender, vehicle type, time, and roadway type, drivers among D3_other did not show statistical significant difference from NOPUS observations. The age distribution of D3_other driver was not practically different to NOPUS observations. **Conclusions:** Overall, we conclude that D3_other drivers in FARS represents the driving population at the time of the crash. **Practical applications:** Our study provides a solid foundation for future studies to utilize D3_other as the reference group to validate the QIE representativeness assumption and has potential to increase the generalizability of future FARS studies.

- **Keywords:** Clean multiple vehicle crashes; Quasi-induced exposure; Representativeness assumption; Fatality Analysis Reporting System

Nicole Asa, Alison Newton, Lindsay Sullivan, Junxin Shi, Krista Wheeler, Gary A. Smith, Jingzhen Yang. [Horseback riding-related injuries treated in emergency departments: Risk factors and prevention strategies.](#) Pages 251-257.

Introduction: Despite inherent dangers of horseback riding (HBR), research on HBR-related injuries is sparse. This study used both quantitative and qualitative methods to (1) examine HBR-related injuries treated in emergency departments (EDs) and associated risk factors and (2) explore HBR-related injury experiences and recommendations for prevention strategies from the perspective of riders. **Method:** We retrospectively analyzed data from the Nationwide Emergency Department Sample (NEDS), identifying HBR-related ED visits between 2010 and 2014. Additionally, we conducted 10 phone interviews with active horseback riders to understand their experiences and perspectives regarding HBR-related injuries and recommendations for prevention measures. **Results:** A total of 21,899 ED visits for HBR-related injuries were identified. When weighted, these represented 100,964 ED visits in the United States. Females had a consistently higher proportion of ED visits compared to males across the study period, with the proportion of ED visits being highest in females aged 15–19. Most injuries (85.9%) were treated and released from the ED. Three primary themes were identified as key to the prevention of HBR-related injuries: (1) rider safety (e.g., use of protective equipment), (2) external factors (e.g., awareness of environment), and (3) rider and horse interactions (e.g., matching skill level of the rider to the horse). **Conclusions:** Results indicate that HBR-related injuries treated in EDs are prevalent, with female riders aged 15–19 years having the highest proportion of injuries treated in EDs. **Practical Applications:** There is a critical need for injury prevention programs that

not only promote the use of protective equipment, but that also educate horseback riders on horse behavior, the proper handling of horses, and safe riding practices.

- **Keywords:** Epidemiology; Qualitative research; Recreation/Sports; Risk perception

Yoshinori Nakagawa, Kaechang Park, Hirotada Ueda, Hiroshi Ono, Hiroki Miyake. [Being watched over by a conversation robot may enhance safety in simulated driving.](#)

Introduction: In an aging society that is more and more information-oriented, being able to replace human passengers' protective effects on vehicle drivers with those of social robots is both essential and promising. However, the effects of a social robot's presence on drivers have not yet been fully explored. Thus, using a driving simulator and a conversation robot, this experimental study had two main goals: (a) to find out whether social robots' anthropomorphic qualities (i.e., not the practical information the robot provides drivers) have protective effects by promoting attentive driving and alleviating crash risks; and (b) by what psychological processes such effects emerge.

Method: Participants were recruited from young (n = 38), the middle-aged (n = 39), and the elderly (n = 49) age groups. They were assigned to either the treatment group (simulated driving in a conversation robot's presence) or the control group (simulated driving alone), and their driving performance was measured. Mental states (peaceful, concentrating, and reflective) also were assessed in a post-driving questionnaire using our original scales. **Results:** Although the group of older participants did not experience protective effects (perhaps due to motion sickness), the young participants drove attentively, with the robot enhancing peace of mind. The protective effect was also observed among the middle-aged participants, and the verbal data analysis ascribed this to the robot's role of expressing sympathy, especially when the middle-aged drivers nearly had not-at-fault crashes, which caused them to be stressed. In conclusion, we discuss the practical implications of the results.

- **Keywords:** Passenger effects on drivers; Social robots; Weak AI stance

Travis Kruse, Anthony Veltri, Adam Branscum. [Integrating safety, health and environmental management systems: A conceptual framework for achieving lean enterprise outcomes.](#) Pages 259-271.

Introduction: Expectations from external stakeholders for eco-safe products and production processes and internal stakeholders for transparent, stable, and robust environment, safety, and health operations have driven high technology organizations to adopt multipart management systems. Organizations can protect workers and the environment and simultaneously contribute to lean management principles by implementing integrated management systems. This research adds to the existing discourse and theory pertaining to the integration of environment, safety, and health management systems. **Methods:** The research was exploratory and inductive in nature and used mixed methods. Specifically, qualitative methods included use of an iterated Delphi method to elicit information from a panel of experts and detailed case studies conducted at four high technology performance manufacturing firms, while quantitative analysis of variance of correlated data investigated the within-firm and between-firm variability in motivating factors for adopting integrated systems and methods used for implementing integrated systems. **Results:** The results offer an integrated-lean management system framework and the strategies available and used by a sample of high technology performance organizations to simultaneously protect workers, the environment, and support lean enterprise outcomes. **Practical applications:** Organizations can protect workers, the environment, and simultaneously contribute to lean management principles by implementing integrated management systems requiring joint management that allow for the shared design, evaluation, and continuous

improvement of environmental, safety, and health practices that are compatible with the lean enterprise movement in today's high-performance driven organizations.

- **Keywords:** Management Systems; Environment, Safety & Health Management

Amir Mohammadi, Mehdi Tavakolan. [Modeling the effects of production pressure on safety performance in construction projects using system dynamics.](#) Pages 273-284.

Introduction: Construction incidents occur due to system failures, not due to a single factor such as unsafe behavior or condition. Therefore, construction safety should be investigated using a systematic view capable of illustrating the complex nature of incidents. Construction projects are also often behind their planned schedule and suffer from various pressures caused by contractual deadlines or clients. Previous studies demonstrated that such pressures negatively affect safety performance; however, the process of how production pressure influences safety performance is not fully investigated. **Method:** The present research aimed to understand the feedback mechanism of how production pressure interactively affects safety performance and safety-related managerial components in a construction project. Ground theory method (GTM) is used to create a conceptual causal loop diagram that shows the relationship between incident rate and other variables such as labor hour, actual and planned progress, safety climate, rework, and safety training. Moreover, a power plant construction project was used as a case study to practically investigate the conceptual model; a case study is employed to build a System Dynamics (SD) model. The simulation model was then validated using behavior reproduction and sensitivity analysis. **Results:** The results of the inequality statistics show that the simulation model can be used to forecast trends in the incident rate.

- **Keywords:** Construction management; safety; systems thinking; system dynamics; simulation

Kyra Hamilton, Amy E. Peden, Stephanie Smith, Martin S. Hagger. [Predicting pool safety habits and intentions of Australian parents and carers for their young children.](#) Pages 285-294.

Introduction: Children under five years are most at risk of experiencing fatal and nonfatal drowning. The highest proportion of drowning incidents occur in private swimming pools. Lapses in adult supervision and failures in pool barriers are leading contributory factors for pool drowning in this age group. **Methods:** We investigated the role of the theory of planned behavior social cognitions (attitude, subjective norm, and perceived behavioral control) as well as perceived barriers, planning, role construction, and anticipated regret on parents' and carers' intentions and habits toward two pool safety behaviors: restricting access and supervising children around private swimming pools. The study adopted a cross-sectional correlational design. Participants (N = 509) comprised Australian parents or caregivers with children aged under five years and access to a swimming pool at their residence. Participants completed a battery of self-report measures of social cognitive variables with respect to the swimming pool safety behaviors for their children. **Results:** Path analytic models controlling for past behavior indicated that subjective norm, planning, anticipated regret, and role construction were important predictors of habit, and subjective norm was a consistent predictor of intentions, for both behaviors. Planning predicted intentions in the restricting access sample, while attitudes, barriers, and role construction also predicted intentions in the supervising sample. Both models controlled for past behavior. **Conclusion:** Current findings indicate the importance of psychological factors for restricting access and supervising behaviors, with normative factors prominent for both reasoned (intentions) and non-conscious (habits) behavioral antecedents. It seems factors guiding restricting access, which likely require regular enactment of routine behaviors (e.g., ensuring gate is

not propped open, pool fence meets standards), may be governed by more habitual than intentional processes.

- **Keywords:** Drowning prevention; Child injury; Habit; Intention; Theory of planned behavior

Ruheena Sangrar, Joon Mun, Michael Cammarata, Lauren E. Griffith, Lori Letts, Brenda Vrkljan. [Older driver training programs: A systematic review of evidence aimed at improving behind-the-wheel performance.](#) Pages 295-313.

Introduction: Age- and health-related changes, alongside declines in driving confidence and on-road exposure, have been implicated in crashes involving older drivers. Interventions aimed at improving behind-the-wheel behaviour are diverse and their associated impact remains unclear. This systematic review examined evidence on older driver training with respect to (1) road safety knowledge; (2) self-perceived changes in driving abilities; and (3) behind-the-wheel performance. **Method:** Nine databases were searched for English-language articles describing randomized controlled trials (RCTs) and non-RCTs of driver training interventions aimed at those aged 55+ who did not have medical or other impairments that precluded licensure. Quality appraisals were conducted using Cochrane’s Risk of Bias Tool (RoB) and Risk Of Bias In Non-randomized Studies – of Interventions tool (ROBINS – I). [PROSPERO; registration no. CRD42018087366]. **Results:** Twenty-five RCTs and eight non-RCTs met the inclusion criteria. Interventions varied in their design and delivery where classroom-based education, or a combination of classroom-based education with on-road feedback, improved road safety knowledge. Training tailored to individual participants was found to improve self-perceived and behind-the-wheel outcomes, including crashes. **Conclusions:** Interventions comprised of tailored training can improve knowledge of road safety, changes to self-perception of driving abilities, and improved behind-the-wheel performance of older drivers. Future research should compare modes of training delivery for this driver population to determine the optimal combinations of off- and/or on-road training. **Practical applications:** Training programs aimed at older drivers should be supported by theory and research evidence. By conducting comparative trials with a sufficient sample size alongside well-defined outcomes that are designed in accordance with reporting guidelines, the most effective approaches for training older drivers will be identified.

- **Keywords:** Driver education; Crash rates; Refresher program; Driver training; Older adults