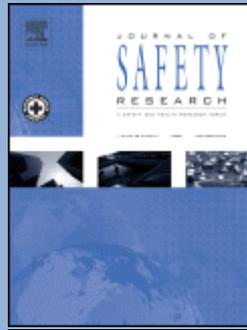


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Johanna Bunner, Roman Prem, Christian Korunka. *Perceived organizational support and perceived safety climate from the perspective of safety professionals: Testing reciprocal causality using a cross-lagged panel design.* Pages 1-8.

Introduction: The objective of this study was to determine the reciprocal relationship between safety professionals perceived organizational support (POS) and perceived safety climate. Safety professionals are most effective when they perceive support from management and employees and they also attribute most of their success to support from the organization. Their work directly improves safety climate, and organizations with a high safety climate show a higher value for the safety professional. The causal direction of this relationship is, however, unclear. **Method:** Using a sample of 162 safety professionals, we conducted a cross-lagged panel study over one year to examine whether safety professionals' POS improves their perceived safety climate and/or whether safety climate also increases POS over time. Data were collected at two points and, after testing for measurement invariance, a cross-lagged SEM was conducted to analyze the reciprocal relationship. **Results:** Our findings show that safety professionals' POS was positively related to perceived safety climate over time. Perceived safety climate, however, did not contribute to safety professionals' POS. **Conclusions:** This study significantly adds to the discussion about the factors influencing safety professionals' successful inclusion in organizations, enabling them to perform their work and, thus, improve occupational safety. **Practical Applications:** Since safety climate increases in organizations in which safety professionals feel supported, this study points out the kind of support that contributes to improved organizational safety. Support for safety professionals may come in classical forms such as approval, pay, job enrichment, and information on or influence over organizational policies.

- **Keywords:** Safety manager; Safety practitioner; Safety culture; Organizational level; Longitudinal

Dwayne Van Eerd, Teresa D'Elia, Era Mae Ferron, Lynda Robson, Benjamin Amick. *Implementation of participatory organizational change in long term care to improve safety.* Pages 9-18.

Introduction: Long Term Care (LTC) facilities are fast-paced, demanding environments placing workers at significant risk for injuries. Health and safety interventions to address hazards in LTC are challenging to implement. The study assessed a participatory

organizational change intervention implementation and impacts. Methods: This was a mixed methods implementation study with a concurrent control, conducted from 2017 to 2019 in four non-profit LTC facilities in Ontario, Canada. Study participants were managers and frontline staff. Intervention sites implemented a participatory organizational change program, control sites distributed one-page health and safety pamphlets. Program impact data were collected via Survey (self-efficacy, control over work, pain and general health) and observation (Quick Exposure Checklist). Interviews/focus groups were used to collect program implementation data. **Results:** Participants described program impacts (hazard controls through equipment purchase/modification, practice changes, and education/training) and positive changes in culture, communication and collaboration. There was a statistically significant difference in manager self-efficacy for musculoskeletal disorder (MSD) hazards between the control and intervention sites over time but no other statistical differences were found. Key program implementation challenges included LTC hazards, staff shortage/turnover, safety culture, staff time to participate, and communication. Facilitators included frontline staff involvement during implementation, management support, focusing on a single unit, training, and involving an external program facilitator. Conclusion: A participatory program can have positive impacts on identifying and reducing MSD hazards. Key to success is involving frontline staff in identifying hazards and creating solutions and management encouragement on a unit working together. High turnover rates, staffing shortages, and time constraints were barriers as they are for all organizational change efforts in LTC. The implementation findings are likely applicable in any jurisdiction. Practical Application: Implementing a participatory organizational change program to reduce MSD hazards is feasible in LTC and can improve communication and aid in identification and control of hazards.

- **Keywords:** Participatory ergonomics; Implementation; Long term care; Hazard reduction

Mahdi Rezapour, Khaled Ksaibati. *Application of machine learning technique for optimizing roadside design to decrease barrier crash costs, a quantile regression model approach.* Pages 19-27.

Introduction: In-transport vehicles often leave the travel lane and encroach onto natural objects on the roadsides. These types of crashes are called run-off the road crashes (ROR). Such crashes accounts for a significant proportion of fatalities and severe crashes. Roadside barrier installation would be warranted if they could reduce the severity of these types of crashes. However, roadside barriers still account for a significant proportion of severe crashes in Wyoming. The impact of the crash severity would be higher if barriers are poorly designed, which could result in override or underride barrier crashes. Several studies have been conducted to identify optimum values of barrier height. However, limited studies have investigated the monetary benefit associated with adjusting the barrier heights to the optimal values. In addition, few studies have been conducted to model barrier crash cost. This is because the crash cost is a heavily skewed distribution, and well-known distributions such as linear or poisson models are incapable of capturing the distribution. A semi-parametric distribution such as asymmetric Laplace distribution can be used to account for this type of sparse distribution. **Method:** Interaction between different predictors were considered in the analysis. Also, to account for exposure effects across various barriers, barrier lengths and traffic volumes were incorporated in the models. This study is conducted by using a novel machine-learning-based cost-benefit optimization to provide an efficient guideline for decision makers. This method was used for predicting barrier crash costs without barrier enhancement. Subsequently the benefit was obtained by optimizing traffic barrier height and recalculating the benefit and cost. The trained model was used for crash cost prediction on barriers with and without crashes. **Results:** The results of optimization clearly demonstrated the benefit of optimizing the heights of road barriers around the state. **Practical Applications:** The findings can be utilized by the Wyoming Department

of Transportation (WYDOT) to determine the heights of which barriers should be optimized first. Other states can follow the procedure described in this paper to upgrade their roadside barriers.

- **Keywords:** Machine learning; Quantile regression model; Traffic barrier crash severity; Optimization; Benefit cost analysis

Yueru Xu, Shan Bao, Anuj K. Pradhan. *Modeling drivers' reaction when being tailgated: A Random Forests Method. Pages 28-35.*

Background: Tailgating is a common aggressive driving behavior that has been identified as one of the leading causes of rear-end crashes. Previous studies have explored the behavior of tailgating drivers and have reported effective solutions to decrease the amount or prevalence of tailgating. This paper tries to fill the research gap by focusing on understanding highway tailgating scenarios and examining the leading vehicles' reaction using existing naturalistic driving data. **Method:** A total of 1,255 tailgating events were identified by using the one-second time headway threshold criterion. Four types of reactions from the leading vehicles were identified, including changing lanes, slowing down, speeding up, and making no response. A Random Forests algorithm was employed in this study to predict the leading vehicle's reaction based on corresponding factors including driver, vehicle, and environmental variables. **Results:** The analysis of the tailgating scenarios and associated factors showed that male drivers were more frequently involved in tailgating events than female drivers and that tailgating was more prevalent under sunny weather and in daytime conditions. Changing lanes was the most prevalent reaction from the leading vehicle during tailgating, which accounted for more than half of the total events. The results of Random Forests showed that mean time headway, duration of tailgating, and minimum time headway were three main factors, which had the greatest impact on the leading vehicle drivers' reaction. It was found that in 95% of the events, leading vehicles would change lanes when being tailgated for two minutes or longer. **Practical Applications:** Results of this study can help to better understand the behavior and decision making of drivers. This understanding can be used in designing countermeasures or assistance systems to reduce tailgating behavior and related negative safety consequences.

- **Keywords:** Road safety; Tailgating; Random Forests; Driving behavior; Naturalistic driving data

Clément Bougard, Damien Davenne, Sébastien Moussay, Stéphane Espié. *Evaluating sleep deprivation and time-of-day influences on crash avoidance maneuvers of young motorcyclists using a dynamic simulator. Pages 36-46.*

Introduction: Motorcyclists are particularly at risk of being injured when involved in a road traffic accident. To avoid such crashes, emergency braking and/or swerving maneuvers are frequently performed. The recent development of dynamic motorcycle simulators may allow to study the influences of various disturbance factors such as sleep deprivation (SD) and time-of-day (TOD) in safe conditions. **Methods:** Twelve young healthy males took part in 8 tests sessions at 06:00 h, 10:00 h, 14:00 h, 18:00 h after a night with or without sleep, in a random order. Participants had to perform an emergency braking and a swerving maneuver, both realized at 20 and 40 kph on a motorcycle dynamic simulator. For each task, the total distance/time necessary to perform the maneuver was recorded. Additional analysis was conducted on reaction and execution distance/time (considered as explanatory variables). **Results:** Both crash avoidance maneuvers (emergency braking and swerving) were affected by increased speed, resulting in longer time and distance at 40 kph than at 20 kph. Emergency braking was mainly influenced by sleep deprivation, which significantly increased the total distance necessary to stop at 40 kph (+1.57 m; + 20%; $p < 0.01$). These impaired performances

can be linked to an increase in reaction time (+21%; $p < 0.01$). Considering the swerving maneuver, TOD and SD influences remained limited. TOD only influenced the reaction time/distance measured at 40 kph with poorer performance in the early morning (+30% at 06:00 h vs 18:00 h; $p < 0.05$). **Discussion:** Our results confirm that crash avoidance capabilities of young motorcyclists were influenced by the lack of sleep, mainly because of increased reaction times. More complex tasks (swerving maneuver) remained mostly unchanged in this paradigm. **Practical Applications:** Prevention campaigns should focus on the dangers of motorcycling while sleepy. Motorcycling simulators can be used to sensitize safely with sleep deprivation and time-of-day influences.

- **Keywords:** Time-of-day; Sleep deprivation; Motorcycle dynamic simulator; Emergency braking; Swerving

María L. de la Hoz-Torres, Antonio J. Aguilar, M^a Dolores Martínez-Aires, Diego P. Ruiz. *A methodology for assessment of long-term exposure to whole-body vibrations in vehicle drivers to propose preventive safety measures. Pages 47-58.*

Introduction: The appearance of musculoskeletal disorders (MDs) in professional drivers due to exposition to whole-body vibration (WBV) makes it relevant to assess this exposure. The European Directive 2002/44/EC has two methods to evaluate exposure to WBV (defined in ISO2631-1:2008). These methods evaluate the exposure associated with an 8-hour working day; however, MDs due to WBV could also be caused by accumulated exposure to vibrations over long term, and hence, the methods defined in the European directive may be limited in their ability to ensure the safety of workers exposed to WBV throughout their years of employment. **Method:** A detailed comparison and discussion of methods defined in the European Directive and the ISO2631-5:2018 was used as a starting point of the main results of this paper. On this basis, a new methodology for the management and organization of preventive measures is proposed to consider the assessment of ISO2631-5:2018 standard and the full working life of workers. Experimental data to assess exposure to WBV in heavy equipment vehicle (HEV) drivers under different road surface conditions and range of velocities were considered to illustrate the process of the proposed methodology. **Results:** The methods defined in the standards provide different assessments leading to a different possible consideration of safe operations when the risks associated with them may actually be high. The proposed methodology can be used with the aim of ensuring safety of workers throughout their working lives and providing an easy implementation of the calculations of ISO2631-5:2018 standard. **Conclusions:** A procedure to assess the health risk probability to which the HEV worker is exposed in terms of the exposure years and a different range of operational vehicle speeds is proposed and exemplified with a study case. **Practical applications:** This study provides a practical tool for the management of WBV exposure related to work-tasks in HEV drivers. Safety managers should consider the global exposition to WBV throughout their working life, and this research provides an easy tool to accomplish it.

- **Keywords:** Whole-body vibrations; ISO2631-5; Vibration assessment; Safety interventions; Heavy equipment vehicles

Kay Fitzpatrick, Eun Sug Park, Michael J. Cynecki, Michael P. Pratt, Michelle Beckley. *Investigation of crashes at pedestrian hybrid beacons: Results of a large-scale study in Arizona. Pages 59-68.*

Introduction: The pedestrian hybrid beacon (PHB) is a traffic control device used at pedestrian crossings. A recent Arizona Department of Transportation research effort investigated changes in crashes for different severity levels and crash types (e.g., rear-end crashes) due to the PHB presence, as well as for crashes involving pedestrians and

bicycles. **Method:** Two types of methodologies were used to evaluate the safety of PHBs: (a) an Empirical Bayes (EB) before-after study, and (b) a long-term cross-sectional observational study. For the EB before-after evaluation, the research team considered three reference groups: unsignalized intersections, signalized intersections, and both unsignalized and signalized intersections combined. **Results:** For the signalized and combined unsignalized and signalized intersection groups, all crash types considered showed statistically significant reductions in crashes (e.g., total crashes, fatal and injury crashes, rear-end crashes, fatal and injury rear-end crashes, angle crashes, fatal and injury angle crashes, pedestrian-related crashes, and fatal and injury pedestrian-related crashes). A cross-sectional study was conducted with a larger number of PHBs (186) to identify relationships between roadway characteristics and crashes at PHBs, especially with respect to the distance to an adjacent traffic control signal. The distance to an adjacent traffic signal was found to be significant only at the $\alpha = 0.1$ level, and only for rear-end and fatal and injury rear-end crashes. **Conclusions:** This analysis represents the largest known study to date on the safety impacts of PHBs, along with a focus on how crossing and geometric characteristics affect crash patterns. The study showed the safety benefits of PHBs for both pedestrians and vehicles. **Practical Applications:** The findings from this study clearly support the installation of PHBs at midblock or intersection crossings, as well as at crossings on higher-speed roads.

- **Keywords:** Pedestrian hybrid beacons; Crashes; Crash modification factors; Pedestrian crossings; Street crossings; HAWK

Nick Turner, Julian Barling, Jeremy F. Dawson, Connie Deng, Sharon K. Parker, Malcolm G. Patterson, Chris B. Stride. *Human resource management practices and organizational injury rates. Pages 69-79.*

Introduction: This study investigated the extent to which five human resource management (HRM) practices—systematic selection, extensive training, performance appraisal, high relative compensation, and empowerment—simultaneously predicted later organizational-level injury rates. **Methods:** Specifically, the association between these HRM practices (assessed via on-site audits by independent observers) with organizational injury rates collected by a national regulatory agency one and two years later were modeled. **Results:** Results from 49 single-site UK organizations indicated that, after controlling for industry-level risk, organization size, and the other four HRM practices, only empowerment predicted lower subsequent organizational-level injury rates. **Practical Applications:** Findings from the current study have important implications for the design of HRM systems and for organizational-level policies and practices associated with better employee safety.

- **Keywords:** Human resource management; Injuries; Occupational safety

Changjian Zhang, Jie He, Xintong Yan, Ziyang Liu, Yikai Chen, Hao Zhang. *Exploring relationships between microscopic kinetic parameters of tires under normal driving conditions, road characteristics and accident types. Pages 80-95.*

Introduction: Freeway accidents are a leading cause of death in China, which also triggers substantial economic loss and an emotional burden to society. However, the internal mechanism of how microscopic kinetic parameters of vehicles influenced by road characteristics determine the occurrence of different types of accidents has not been explicitly studied. This research aimed to explore the “link role” of tire microscopic kinetic parameters in road characteristic variables and traffic accidents to aid in facilitating the traffic design and management, and thus to prevent traffic accident. **Method:** A mountain freeway in Zhejiang Province, China was used as the research object and the data used in this paper were obtained through a real-time vehicle experiment. Multiple

estimation models, including the standard ordered logit (SOL) model, fixed parameters logit (FPL) model, and random parameters logit (RPL) model were established. **Results:** The findings show that road characteristics will affect the longitudinal kinetic characteristics of the vehicle and, consequently, map the level of risk of rear-end accidents. Driving compensation effects were also identified in this paper (i.e., the drivers tend to be more cautious in complicated driving circumstances). Another finding relating to the mountain freeway is that different tunnel characteristics (e.g., tunnel entrance and tunnel exit) have different effects on different types of traffic accidents. **Practical Applications:** The framework proposed in this article can provide new insight for researchers to enlarge the research subjects of both explanatory and outcome variables in accident analysis. Future research could be implemented to consider more driving conditions.

- **Keywords:** Microscopic kinetic parameters of tires; Normal driving conditions; SOL model; FPL model; RPL model; Mechanism of traffic accidents

Jennifer Bonham, Marilyn Johnson, Narelle Haworth. *Cycle Aware: Piloting a module for novice drivers. Pages 96-104.*

Introduction: In low-cycling countries, motor-vehicle traffic and driver behavior are well known barriers to the uptake of bicycles, particularly for utility cycling. Lack of separation between cyclists and faster-moving traffic is one key issue, while attitudes of drivers toward and/or harassment of cyclists is another. Cyclist-related driver education has been recommended as a means to improve driver-cyclist interactions. Methods: The driver licensing process provides an opportunity for such education. The Cycle Aware module was developed to test and enhance novice drivers' knowledge of interacting safely with cyclists. It was piloted across three Australian jurisdictions targeting both novice and experienced drivers. Participants were asked to complete the Cycle Aware module and an accompanying survey. A total of 134 novice and 97 experienced drivers completed the survey with 42 novice and 50 experienced drivers going on to complete the module. **Results:** Both groups of drivers scored equally well in the module but the very youngest and very oldest participants were more likely to have some incorrect responses. We did not find any relationship between correct module scores and attitudes toward cyclists. Survey results showed both novice and experienced drivers had somewhat positive attitudes toward cyclists. The two cohorts differed on several attitude questions. Sixty percent (60%) of novices compared to 30% of experienced drivers reported feeling concerned when sharing the road with cyclists, and novices were less likely to agree that cyclists had a right to use the roads. Conclusions and **practical applications:** The analysis suggests novices need to be better equipped to share roads confidently with cyclists and to recognize cyclists as legitimate traffic participants.

- **Keywords:** Novice driver education; Driver license; Cycling; Cyclist safety; Online learning

Samsiya Khaday, Kai Way Li, Siu Shing Man, Alan Hoi Shou Chan. *Risky scenario identification in a risk perception scale for construction workers in Thailand. Pages 105-114.*

Introduction: Construction sites exhibit unique hazardous characteristics. Hence, investigating the causes of fatal and nonfatal accidents is extremely important to promote safety on construction sites. Literature shows a risk perception (RP) scale for construction workers; to expand the existing research, this study aims to identify risky scenarios for assessing the RP of Thai construction workers, with the goal of reducing workplace incidents. **Method:** The scale development process consists of four phases. Item development was also performed, followed by factor analysis. Reliability and validity assessments were finalized in the process. A survey of 500 construction workers in Thailand was conducted to investigate risky scenarios. Through the process, a total of 17

items remained in the final RP scale, and the reliability and validity of these items were confirmed. **Results:** The RP scale was affirmed to have four dimensions (probability, severity, worry, and unsafe). These dimensions of workers' RP were negatively correlated with the workers' risk-taking behaviors. This study further showed that participants with a high level of affective RP were more likely to have a high level of cognitive RP. Hence, those with a high level of RP tended to be involved in fewer risk-taking behaviors. **Practical Applications:** The final version of the scale was reliable and valid in determining the RP and risk-taking behaviors of construction workers in Thailand.

- **Keywords:** Safety on construction sites; Risk-taking behavior; Risk perception; Demographics

Sharon Levi, Elad Calif, Alexandra Aronin, Anat Gesser-Edelsburg.
Shopping online for children: Is safety a consideration? Pages 115-128.

Introduction: There has been a significant increase in online purchasing and product safety problems have been identified in e-commerce. This study examines consumer behavior and safety perceptions among parents purchasing child products online. **Method:** A mixed methods approach, including focus groups and a survey with parents, identified key characteristics and behaviors. Cluster analysis was used to determine different population segments (including "Informed," "Uninformed," and "Infrequent" consumer groups) based on their frequency of online shopping and search for product information. "Safe" and "Unsafe" behavior groups were identified related to their search for safety information on child products. Logistic regression analysis was used to study the effects of consumer type groups and demographic variables on the chances of being a safer consumer. **Results:** Findings indicate that child product safety considerations are not a priority for parents when shopping online. Only 62% of the survey respondents indicated that they search for information prior to buying a child product online, of which only 13% of the respondents noted that they search for information on product safety. Risky consumer behaviors were identified including the purchase of imitation products (counterfeit or knockoff products) and autonomous checks for product safety in lieu of safety standards. The logistic regression analysis found that being an "Uninformed Consumer" increases the odds of an individual being an "Unsafe Consumer" by 8.4 times ($\chi^2(11) = 97.33, p < .001$). **Practical Applications:** Design of a social marketing campaign that targets these different population segments to change perceptions and promote safe online purchasing is recommended.

- **Keywords:** Child product safety; Social marketing; Online shopping behavior

Colleen M. Peterson, Joseph E. Gaugler.
To speed or not to speed: Thematic analysis of American driving narratives. Pages 129-137.

Introduction: Speeding is a major cause of unintentional roadway death in the United States. Existing data show that U.S. drivers tend to speed less as they age, but reasons for this change remain largely unknown. Limited research has examined why U.S. drivers decide to speed or why U.S. drivers decide not to speed, and none to date has determined why speeding behaviors change over the life course. Research into these issues can provide insight that may be harnessed for more effective anti-speeding interventions that catalyze decisions not to speed. **Methods:** The current study asked a national sample of U.S. drivers (N = 309) about their driving behaviors and how they have changed over time using an open-ended prompt in an online survey. The authors qualitatively coded responses using a narrative analysis lens to identify common themes. **Results:** Results show U.S. drivers often make deliberate choices to speed and some do not consider speeding to be dangerous after achieving perceived mastery of driving skills. Participants tended to report speeding less over time, citing increased concern for family and other roadway users, which may help explain national speeding data trends. Several other themes emerged identifying individual cognitive factors, environmental contexts,

and key persons impacting speeding decisions. **Practical Applications:** Findings show that the most effective means of encouraging U.S. drivers to decide not to speed may be multi-pronged intervention approaches highlighting how speeding reduces roadway driver control, connecting speeding with safety, and encompassing road design and law enforcement strategies.

- **Keywords:** Driver behavior; Driver attitude; Speeding; Decision making; Qualitative research; Roadway safety

Panagiotis Lemonakis, Nikolaos Eliou, Theodoros Karakasidis. *Investigation of speed and trajectory of motorcycle riders at curved road sections of two-lane rural roads under diverse lighting conditions. Pages 138-145.*

Introduction: Vehicular accidents at horizontal curves are over-represented compared to accidents that occur at tangent sections. Investigations have been conducted aimed at identifying the major causes that result in higher accident risk, both in terms of severity and rate, at curved road sections. Excessive or abrupt changes in speeding and improper vertical position are cited as major factors of lane departure, whereas other factors (either human or environmental) have also been documented. However, most research involves 4-wheel vehicles rather than other modes of transport that behave differently. More specifically, while motorcyclist fatalities occur more frequently than passenger vehicles, when accounting for vehicle distance traveled only a limited number of research studies address their behavior at curved road sections. **Method:** This paper presents the findings of field operational tests carried out by motorcyclists along two-lane rural roads with a wide range of horizontal curves using an instrumented motorcycle. Key objectives of the research included the conditions under which the motorcyclists differentiate their trajectory in regards to the direction of the horizontal curves, the correlation between the trajectory and the geometry of the road, and the impact of the lighting conditions on riders' behavior. **Results:** The research showed that motorcyclists tend to ride closer to the centerline of the road, neglect the hazards associated with dim lighting conditions, and maintain constant speed in the left hand and the right-hand horizontal curves.

- **Keywords:** Naturalistic riding; Speed; Trajectory; Deviation; Motorcycle; Horizontal curves

Lynn B. Meuleners, Jonathon Q. Ng, Michelle L. Fraser, Dewi Tjia, Ying Ru Feng, Nigel Morlet. *Changes in driving performance after first and second eye cataract surgery: A driving simulator study. Pages 146-154.*

Introduction: This study investigated the separate impact of first eye and second eye cataract surgery on driving performance, as measured on a driving simulator. **Method:** Forty-four older drivers with bilateral cataract aged 55+ years, awaiting first eye cataract surgery participated in a prospective cohort study. They completed a questionnaire, visual tests and a driving simulator assessment at three time points: before first eye, after first eye, and after second eye cataract surgery. Generalized Estimating Equation Poisson or linear regression models were undertaken to examine the change in four driving outcomes of interest after adjusting for cataract surgery and other potential confounders. **Results:** The rate of crashes/near crashes decreased significantly by 36% (incidence rate ratio (IRR) 0.64, 95% CI 0.47–0.88, $p = 0.01$) after first eye surgery and 47% (IRR 0.53, 95% CI 0.35–0.78, $p < 0.001$) after second eye surgery, compared to before first eye cataract surgery, after accounting for confounders. The rate of crashes/near crashes also decreased with better contrast sensitivity (IRR 0.69, 95% CI 0.48–0.90, $p = 0.041$). A separate model found that time spent speeding 10 kilometers per hour or more over the limit after second eye surgery was significantly less (0.14 min, $p = 0.002$), compared to before first eye surgery, after accounting for confounders. As

contrast sensitivity improved, the duration of speeding also decreased significantly by 0.46 min ($p = 0.038$). There were no statistically significant changes in lane excursions or speed variation. **Practical applications:** The findings highlight the importance of timely first and second eye cataract surgery to ensure driver safety, especially as older drivers wait for second eye cataract surgery. It also provides further evidence that contrast sensitivity is probably a better predictor of driving ability in older drivers with cataract than visual acuity, the measure on which driver licensing requirements are currently based, and should also be used when assessing fitness to drive.

- **Keywords:** Cataract surgery; Driving performance; Driving simulator; Visual measures

Mehdi Hosseinpour, Kirolos Haleem. *Examining crash injury severity and barrier-hit outcomes from cable barriers and strong-post guardrails on Alabama's interstate highways. Pages 155-169.*

Introduction: This study investigates the impact of several risk factors (i.e., roadway, driver, vehicle, environmental, and barrier-specific characteristics) on the injury severity resulting from barrier-related crashes and also on barrier-hit outcomes (i.e., vehicle containment, vehicle redirection, and barrier penetration). A total of 1,685 barrier-related crashes, which occurred on three major interstate highways (I-65, I-85, and I-20) in the state of Alabama, were collected for a seven-year period (2010–2016), and all relevant information from the police reports was reviewed. Features that were rarely explored before (e.g., median width, barrier length, barrier offset or lateral position, left shoulder width, blockout type, and number of cables) were also collected and examined. Two types of longitudinal barriers were analyzed: high-tension cable barriers installed on medians and strong-post guardrails installed on medians and/or roadsides. **Method:** Two separate mixed logit (MXL) models were used to analyze crash injury severity in median and roadside barrier-related crashes. Two additional MXL models were separately adopted for median and roadside barrier-related crashes to estimate the probability of three barrier-hit outcomes (vehicle containment, vehicle redirection, and barrier penetration). **Results:** The results of crash injury severity MXL models showed that, for both median and roadside barrier crashes, barrier penetration, female drivers, and driver fatigue were associated with a higher probability of injury or fatal crashes. The results of barrier-hit MXL models showed that longer barrier length, Brifen cable barrier system, and barrier lateral position were significant predictors of median barrier-hit outcomes, whereas dark lighting condition, driving under the influence (DUI), presence of curved freeway sections, and right shoulder width significantly contributed to roadside barrier-hit outcomes. **Conclusions:** The MXL model succeeded in identifying several contributing factors of crash severity and barrier-hit outcomes along Alabama's interstate highways. **Practical applications:** One study application is to design longer barrier run length (greater than 1230 feet or 0.2 miles) to reduce the barrier penetration likelihood.

- **Keywords:** Safety barrier; Crash injury severity; Barrier-related crashes; Cable barriers; Strong-post guardrails

Tracy Buchman. *Does driver seatbelt use increase usage among front seat passengers? An exploratory analysis. Pages 170-179.*

Introduction and Method: Observational data collected during the Wisconsin 2017, 2018, and 2019 National Occupant Protection Use Survey (NOPUS) were analyzed for this study to explore the influence of drivers' seatbelt use on front seat passengers' usage in the same vehicle. The analyses include comparing seatbelt usage rates for drivers and front passenger(s) based on their gender and based on geographical area as well as analyses of the aggregated data. **Results:** The descriptive analyses strongly suggest that seatbelt usage rates of passengers differ considerably depending on whether the driver uses the seatbelt. When female drivers wear seatbelts, seatbelt usage rates for female

front seat passengers for the three years 2017, 2018, and 2019 are 97.8%, 96.3%, and 97.1% respectively, with corresponding usage rates for male passengers being 95.5%, 93.0%, and 96.0% respectively. When male drivers wear seatbelts, the seatbelt usage rates for male front seat passengers for the three years 2017, 2018, and 2019, are 93.4%, 95.5%, and 94.3%, respectively, with the corresponding usage rates for female passengers being 97.7%, 96.0%, and 97.7%, respectively. The evidence suggests that drivers' use of seatbelts significantly improves the seatbelt usage of front seat passengers. Seatbelt usage rates of male passengers as well as female passengers are higher while traveling with female drivers who use seatbelts than while traveling with male drivers who use seatbelts. Conclusions and **Practical Applications:** Future seatbelt use campaigns should target males.

- **Keywords:** Seatbelt use; Front seat passengers; Traffic safety; Observational survey; Demographic predictors

Mankirat Singh, Wen Cheng, Dean Samuelson, Jerry Kwong, Bengang Li, Menglu Cao, Yihua Li. *Development of pedestrian- and vehicle-related safety performance functions using Bayesian bivariate hierarchical models with mode-specific covariates. Pages 180-188.*

Introduction: Pedestrian safety is a major concern as traffic crashes are the leading cause of fatalities and injuries for commuters. Traffic safety research in the past has developed various strategies to counteract traffic crashes, including the safety performance function (SPF). However, there is still a need for research dedicated to enhancing the SPF for pedestrians from perspectives of methodological framework and data input. To fill this gap, this study aims to add to the current SPF development practice literature by focusing on pedestrian-involved collisions, while considering the typical vehicle ones as well. **Methods:** First, bivariate models are used to account for the common unobserved heterogeneity shared by the pedestrian- and vehicle-related crashes at the same intersections. Second, variable importance ranking technique is used, along with correlation analysis, to determine mode-specific feature input. Third, the exposure information for both modes, annual pedestrian count, and annual daily vehicles traveled are used for model development. Fourth, a recent Bayesian inference approach (integrated nested Laplace approximation (INLA)) was adopted for bivariate setting. Finally, different evaluation criteria are used to facilitate comprehensive model assessment. **Results:** The results reveal different statistically significant factors contributing to each of the modes. The offset intersection provides better safety performance for both pedestrians and drivers as compared to other intersection designs. The model findings also corroborate the sensibility of using the bivariate models, rather than the separate univariate ones. **Practical Applications:** The study shows that pedestrians are more vulnerable to various intersection features such as left-turn channelization, intersection control, urban and rural population group, presence of signal mastarm on the cross-street, and mainline average daily traffic. Greater focus should be directed toward such intersection features to improve pedestrian safety.

- **Keywords:** Pedestrian-Vehicles crashes; Crash frequency Models; Bivariate models; Pedestrian count; Safety Performance Function

Christos Katrakazas, Eva Michelaraki, Marios Sekadakis, Apostolos Ziakopoulos, Armira Kontaxi, George Yannis. *Identifying the impact of the COVID-19 pandemic on driving behavior using naturalistic driving data and time series forecasting. Pages 189-202.*

Introduction: COVID-19 has disrupted daily life and societal flow globally since December 2019; it introduced measures such as lockdown and suspension of all non-essential movements. As a result, driving activity was also significantly affected. Still, to-

date, a quantitative assessment of the effect of COVID-19 on driving behavior during the lockdown is yet to be provided. This gap forms the motivation for this paper, which aims at comparing observed values concerning three indicators (average speed, speeding, and harsh braking), with forecasts based on their corresponding observations before the lockdown in Greece. **Method:** Time series of the three indicators were extracted using a specially developed smartphone application and transmitted to a back-end platform between 01/01/2020 and 09/05/2020, a time period containing normal operations, COVID-19 spreading, and the full lockdown period in Greece. Based on the collected data, XGBoost was employed to identify the most influential COVID-19 indicators, and Seasonal AutoRegressive Integrated Moving Average (SARIMA) models were developed for obtaining forecasts on driving behavior. **Results:** Results revealed the intensity of the impact of COVID-19 on driving, especially on average speed, speeding, and harsh braking per 100 km. More specifically, speeds were found to increase by 2.27 km/h on average compared to the forecasted evolution, while harsh braking/100 km increased to almost 1.51 on average. On the bright side, road crashes in Greece were reduced by 49% during the months of COVID-19 compared to the non-COVID-19 period.

- **Keywords:** COVID-19; Driving behavior; Time-series forecasting; SARIMA; XGBoost

Juliet K. Haarbauer-Krupa, Johna K. Register-Mihalik, Aliza K. Nedimyer, Avinash Chandran, Melissa C. Kay, Paula Gildner, Zachary Y. Kerr. *Factors associated with concussion symptom knowledge and attitudes towards concussion care-seeking among parents of children aged 5–10 years. Pages 203–209.*

Background: Understanding parents' concussion-related knowledge and attitudes will contribute to the development of strategies that aim to improve concussion prevention and sport safety for elementary school children. This study investigated the association between parent- and child-related factors and concussion symptom knowledge and care-seeking attitudes among parents of elementary school children (aged 5–10 years). **Methods:** Four hundred parents of elementary school children completed an online questionnaire capturing parental and child characteristics; concussion symptom knowledge (25 items, range = 0–50; higher = better knowledge); and concussion care-seeking attitudes (five 7-point scale items, range = 5–35; higher = more positive attitudes). Multivariable ordinal logistic regression models identified predictors of higher score levels. Adjusted odds ratios (aOR) with 95% confidence intervals (CI) excluding 1.00 were deemed statistically significant. **Results:** Select parent and child characteristics were associated with higher score levels for both outcomes. For example, odds of better knowledge level in parents were higher with increased age (10-year increase aOR = 1.59; 95% CI = 1.10–2.28), among females (aOR = 3.90; 95% CI = 2.27–6.70), and among white/non-Hispanics (aOR = 1.79; 95% CI = 1.07–2.99). Odds of more positive concussion care-seeking attitude levels were higher among parents with a college degree (aOR = 1.98; 95% CI = 1.09–3.60). Child sports participation was not associated with higher score levels for either outcome. **Conclusions:** Certain elementary school parent characteristics were associated with parents' concussion symptom knowledge and care-seeking attitudes. While the findings suggest providing parents with culturally and demographically relevant concussion education might be helpful, they also emphasize the importance of ensuring education/prevention regardless of their children's sports participation. **Practical Applications:** Pediatric healthcare providers and elementary schools offer an optimal community-centered location to reach parents with this information within various communities.

- **Keywords:** Concussion; Parent education; Elementary school; Injury risk; Young children

Zhongmin Wang, Zhou Jiang, Anna Blackman. *Linking emotional intelligence to safety performance: The roles of situational awareness and safety training.* Pages 210-220.

Introduction: Safety outcomes in the workplace require individual employees to perform (behave) safely in everyday duties. While the literature suggests that emotional management capabilities or traits can be positively related to individual performance in certain conditions, it is not clear how they can influence safety-related performance in high-risk work contexts. Drawing upon trait activation theory, this paper aims to examine when emotional intelligence (EI) benefits employees' safety performance. We propose that when employees receive inadequate safety training, EI is more likely to trigger their situational awareness and consequently promote their safety performance. **Method:** We collected time-lagged data from 133 full-time airplane pilots working in commercial aviation industry. Hierarchical moderated regression analysis was conducted to test the moderating effect of safety training inadequacy on the EI-situational awareness relationship. The moderated mediation model, which involves conditional indirect effects of EI on safety performance via situational awareness across different levels of safety training inadequacy, was tested using the PROCESS-based bootstrap confidence interval. **Results:** Safety training inadequacy negatively moderated the relationship between EI and situational awareness, such that EI was significantly related to situational awareness only when safety training inadequacy was more salient. The more inadequate safety training was, the greater the indirect effect of EI on safety performance via situational awareness was. **Conclusions:** Inadequate safety training, as a negative situational cue, can activate individuals' EI to drive their safety-related cognitions (e.g., situational awareness) and behaviors. Effective safety training may be able to complement employees' low EI in shaping their situational awareness and safety behaviors. **Practical Applications:** Aviation managers should monitor the adequacy and effectiveness of safety training; this could make pilots' situational awareness and safety performance depend less on personal attributes (e.g., EI), which organizations are less able to control. When training capacity is temporarily limited, priority might be given to those with low EI.

- **Keywords:** Emotional intelligence; Situational awareness; Safety; Training

Kelly Sarmiento, Jill Daugherty, Dana Waltzman. *Effectiveness of the CDC HEADS UP online training on healthcare providers' mTBI knowledge and self-efficacy.* Pages 221-228.

Background: Many healthcare providers do not consistently implement recommendations contained in clinical guidelines on mild traumatic brain injury (mTBI). As such, the Centers for Disease Control and Prevention (CDC) created the HEADS UP to Healthcare Providers online training to promote uptake of five key recommendations in the CDC Pediatric mTBI Guideline. **Methods:** Using data from modules in the CDC HEADS UP to Healthcare Providers online training, healthcare providers' self-reported knowledge and self-efficacy prior to and immediately following completion of the training was analyzed. **Results:** Improvements for 8 out of the 10 knowledge questions had a high level of practical significance. The knowledge question with the highest level of practical significance pre- to post-test improvement was for the key guideline recommendation on neuroimaging (pre-test correct: 70.2%; post-test correct: 87.8%; ($p < 0.0001$, Cohen's $g = 0.39$). Four out of the six questions had a self-efficacy level increase of a high level of practical significance ($r > 0.50$) between the pre- and post-tests. The self-efficacy question with pre- to post-test improvement with the highest level of practical significance was "I am confident in my ability to manage the return to sports progression for my patients" ($p < 0.001$; $r = 0.54$). **Conclusions:** The HEADS UP to Healthcare Providers online training led to significant improvements in knowledge and self-efficacy related to mTBI diagnosis and management. Expanded use of this training among healthcare providers who commonly provide care for pediatric patients with mTBI may be

beneficial. **Practical Applications:** This study highlights several factors guideline developers may take into consideration when creating an implementation tool, such as using health behavior theories, working with partners and key stakeholders, and focusing on digital-based tools.

- **Keywords:** Concussion; Guideline; Physician; Nurse; Education; Training

Robert Colonna, Carri L. Hand, Jeffrey D. Holmes, Liliana Alvarez. *Young drivers' determinants of driving under the influence of cannabis: Findings from the Youth Cannabis and Driving Survey (YouCanDS)*. Pages 229-241.

Introduction: Driving under the influence of cannabis (DUIC) is proven to increase the risk of collisions and is most common among young drivers (ages 16 to 24). However, little is known about the specific determinants of DUIC behavior among youth, which limits the capacity to develop evidence-based prevention and intervention efforts. This study developed and evaluated a youth DUIC questionnaire, which was used to establish the DUIC determinants of young drivers. **Method:** The questionnaire was based on the theoretical framework of general deterrence and general prevention. Data obtained included: demographics, past cannabis use and DUIC experiences, DUIC intention, experiences riding as a passenger with someone DUIC, knowledge and credibility of the law, attitudes towards DUIC, and social controls. The resulting questionnaire was validated for a sample of 426 young drivers in the province of Ontario, Canada. An ordinal regression was conducted to examine the relationships between questionnaire items and DUIC intention. **Results:** The questionnaire displayed good construct validity and internal consistency across four out of five domains (KMO and Cronbach α values ≥ 0.70). Of the 426 respondents (52.6% female), 356 (83.6%) reported previous cannabis use, with 296 (69.5%) doing so in the past year, and 142 (33.3%) reporting DUIC. Furthermore, 179 (42%) study participants indicated at least a slight chance of DUIC in the next year. The regression analysis identified six variables predictive of DUIC intention: past DUIC incidence, perceived percent of those convicted that receive the penalty, moral awareness, perceived dangerousness, minor accident risk, and vicarious punishment avoidance. **Conclusions:** Preventive efforts should emphasize these determinants when designing targeted strategies and interventions. **Practical Applications:** These efforts should focus on educating the dangers and risk of a vehicle collision, that law enforcement has the capacity to apprehend and appropriately punish individuals DUIC, and that DUIC is wrong and socially unacceptable.

- **Keywords:** Cannabis; Driving under the influence; Impaired driving; Young drivers

Dhwani Shah, Chris Lee. *Analysis of effects of driver's evasive action time on rear-end collision risk using a driving simulator*. Pages 242-250.

Introduction: Driver's evasive action is closely associated with collision risk in a critical traffic event. To quantify collision risk, surrogate safety measures (SSMs) have been estimated using vehicle trajectories. However, vehicle trajectories cannot clearly capture presence and time of driver's evasive action. Thus, this study determines the driver's evasive action based on his/her use of accelerator and brake pedals, and analyzes the effects of the driver's evasive action time (i.e., duration of evasive action) on rear-end collision risk. **Method:** Fifty drivers' car-following behavior on a freeway was observed using a driving simulator. An SSM called "Deceleration Rate to Avoid Crash (DRAC)" and the evasive action time were determined for each driver using the data from the driving simulator. Each driver tested two traffic scenarios – Cars and Trucks scenarios where conflicting vehicles were cars and trucks, respectively. The factors related to DRAC were identified and their effects on DRAC were analyzed using the Generalized Linear Models and random effects models. **Results:** DRAC decreased with the evasive action time and

DRAC was closely related to drivers' gender and driving experience at the road sections where evasive action to avoid collision was required. DRAC was also significantly different between Cars and Trucks scenarios. The effect of the evasive action time on DRAC varied among different drivers, particularly in the Trucks scenario. **Conclusions:** Longer evasive action time can significantly reduce crash risk. Driver characteristics are more closely related to effective evasive action in complex driving conditions. **Practical Applications:** Based on the findings of this study, driver warning information can be developed to alert drivers to take specific evasive action that reduces collision risk in a critical traffic event. The information is likely to reduce the variability of the driver's evasive action and the speed variations among different drivers.

- **Keywords:** Rear-end collision; Surrogate safety measure; Evasive action; Truck; Driving simulator

Amin Keramati, Pan Lu, Yihao Ren, Denver Tolliver, Chengbo Ai. *Investigating the effectiveness of safety countermeasures at highway-rail at-grade crossings using a competing risk model. Pages 251-261.*

Introduction: Highway-rail at-grade crossings (HRGCs) are critical locations where a railway and a roadway intersect with one another. Crashes at those locations often result in fatalities and economic and social damages due to the impacts on both road and rail users. The main purpose of countermeasures at HRGCs is to permit safe and efficient rail and highway operations. **Method:** Countermeasures at highway-rail grade crossings (HRGCs) considered in this study include all traffic control devices and other warning and barrier devices at or on approaches to crossings. In general, active devices are commonly accepted as more effective countermeasures than passive devices. However, many of the previous effectiveness studies are either at the project level or were conducted without considering the before-improvement condition. This study focuses on the network-level marginal effectiveness of countermeasures on crash rate and severity levels during the 29-year study period from 1990 to 2018 by fully considering before-improvement control levels. A competing risk model (CRM) is able to accommodate the competing nature of crash severities as multiple outcomes from the same event of interest, which is crash occurrence in this study. Subsequently, CRM is used in this study as an integrated one-step estimation approach that investigates both crash frequency and severity likelihood over time. **Results:** The study findings indicate that adding audible devices to crossings already equipped with gates will result in a considerable annual decline in crash occurrence likelihood (0.25%). The same device installed at crossings already controlled by gates and flashing lights results in less reduction in crash occurrence likelihood of 0.14%. Moreover, adding a stop sign to the active crossing controls of gates, standard flashing lights, and audible devices will lead to a decrease in the probability of crash occurrence and severe crashes (injury and fatal). However, adding stop signs to crossings equipped only with crossbucks will increase the crash occurrence.

- **Keywords:** Accident prediction; Railroad grade crossing; Competing risk models; Counter-measure effectiveness

Abdurrasheed Olayinka Sirajudeen, Teik Hua Law, Shaw Voon Wong, Fauzan Mohd Jakarni, Choy Peng Ng. *The sources of the Kuznets relationship between the road deaths to road injuries ratio and economic growth. Pages 262-269.*

Introduction: Past empirical studies indicated that there is a Kuznets or reverse U-shaped relationship between road deaths and per capita income, such that the number of road death increases at a low level of per capita reverse U-shaped relationship was observed between road injuries and per capita income. While these studies explored the

impact of per capita income on road deaths and road injuries, no studies have examined the relationship between per capita income and road death to road injury ratio (DPI). **Method:** Using a fixed effects panel regression analysis from 67 countries spanning over a period of five decades (1960–2013), the present study sought to explore the impact of per capita gross domestic product (per capita GDP) on the DPI ratio and the underlying factors responsible for the relationship. **Results:** Our result suggests that per capita GDP followed a reverse U-shaped relationship with DPI. Moreover, the relative improvements in higher mobility roads as compared to improvements in higher accessibility roads, motorcycle ownership to passenger car ownership ratio, percentage of population living in an urban area, infant mortality rate, and the percentage of population below 15 years of age and above 64 years of age contributed to this relationship. **Practical Applications:** This implies that, at lower level of economic growth where road deaths exceed road injuries, countries should implement low-cost measures to combat road deaths cases. Such measures include mandating wearing of quality helmets and daytime running headlights for motorcycles. On the other hand, at higher level of economic growth where road injuries surpass road deaths, countries are encouraged to devote more resources to improving medical technology and services to treat road injury victims, mandating seatbelt use, as well as enhancing and promoting public transportation service.

- **Keywords:** Road deaths; Road injuries; Motorcycles; Motorcars; Economic growth; Accessibility roads; Mobility roads

Kimberly Vachal, Shantanu Awasthi, Ihsan Ullah Khan, Yun Zhou, Bong-Jin Choi, Seguy Tchakounte-Wakem. *Evaluating 24/7 Sobriety Program participant reoffense risk. Pages 270-275.*

Objective: Our study investigated risk factors in survival among a subpopulation of drivers in North Dakota's 24/7 Sobriety Program. Participants mandated for a second driving-under-the-influence of alcohol (DUI) arrest were studied for a three-year interval that commenced with the start date for a 360-day enrollment. **Method:** A Stratified Cox regression model was developed to compute the hazard ratios for survival. A subsequent DUI-related offense as event of interest. Relation to the explanatory variable array that could be construed from administrative records were investigated. **Results:** Older drivers were 6.31 times more likely to reoffend than the younger driver cohort of 18–35-years. The survival curve slope showed the fastest decline in the 361-day to 730-day interval. Neither gender nor residence region was a significant predictor in DUI reoffense over the three-year monitoring interval. Preliminary work suggests reoffense was more likely if an individual had program history prior to this court mandated 360-day term in the 24/7 Sobriety Program for a second DUI. The program experience finding was unexpected but could not be studied in greater detail due to data and resource limitations. **Conclusions:** Administrative records access created a novel opportunity to explore an evolving impaired driving prevention strategy that has shown early promise. Individual driver survival in and after the 24/7 Sobriety Program was studied for three-years. Findings show age, post-program time interval, and possibly program history as areas to explore to improve survival rates. Driver DUI offense were most common shortly after program completion. Although limited to a single state, findings increase knowledge for refining strategies designed to impact driver subpopulations at higher risk for reoffense.

- **Keywords:** Survival analysis; Alcohol-impaired driving; Stratified Cox regression model

Shaojie Liu, Wei David Fan, Yang Li. *Injury severity analysis of rollover crashes for passenger cars and light trucks considering temporal stability: A random parameters logit approach with heterogeneity in mean and variance.* Pages 276-291.

Problem: The rollover crash is a serious crash type that often causes higher injury severities. Moreover, factors that contribute to the injury severities of rollover crashes may show instabilities in different vehicle types and time periods, which requires further investigations. This study utilizes the rollover crash data in North Carolina from Highway Safety Information System (HSIS) to study the effect instabilities of factors in vehicle type and time periods in rollover crashes. Methods: The injury severities of drivers are estimated using the random parameters logit (RPL) model with heterogeneity in means and variances. Available factors in HSIS have been categorized into three groups, which are drivers, road, and environment, respectively. This study also justifies the segmentations through transferability tests. The effects of identified significant factors are evaluated using marginal effects. **Results:** Factors such as FWP (farm, wood, and pasture areas), unhealthy physical condition, impaired physical condition, road adverse, and so forth have shown instabilities in marginal effects among vehicle types and time periods. **Practical Applications:** The finding of this research could provide important references for policy makers and automobile manufactures to help mitigate the injury severity of rollover crashes.

- **Keywords:** Transferability; Injury severity; Safety; Contributing factors; Vehicle type

Fareed Kaviani, Kristie L. Young, Brady Robards, Sjaan Koppel. *"Like it's wrong, but it's not that wrong:" Exploring the normalization of risk-compensatory strategies among young drivers engaging in illegal smartphone use.* Pages 292-302.

Introduction: Young drivers are the most vulnerable road users and most likely to use a smartphone illegally while driving. Although when compared with drink-driving, attitudes to illegal smartphone risk are nearly identical, smartphone use among young drivers continues to increase. **Method:** Four in-depth focus groups were conducted with 13 young (18–25 years) drivers to gain insight into their perceptions of the risks associated with the behavior. Our aim was to determine how drivers navigate that risk and if their behavior shapes and informs perceptions of norms. **Results:** Three key themes emerged: (a) participants perceived illegal smartphone use as commonplace, easy, and benign; (b) self-regulatory behaviors that compensate for risk are pervasive among illegal smartphone users; and (c) risk-compensation strategies rationalize risks and perceived norms, reducing the seriousness of transgression when compared with drink-driving. Young drivers rationalized their own use by comparing their selfregulatory smartphone and driving skills with those of "bad drivers," not law abiders. **Practical Applications:** These findings suggest that smartphone behaviors shape attitudes to risk, highlighting the importance for any countermeasure aimed at reducing illegal use to acknowledge how a young person's continued engagement in illegal smartphone use is justified by the dynamic composition of use, risk assessment and the perceived norms.

- **Keywords:** Smartphone use while driving; Social norms; Risk compensation; Young drivers; Road safety

Tristan Casey, Nick Turner, Xiaowen Hu, Kym Bancroft. *Making safety training stickier: A richer model of safety training engagement and transfer.* Pages 303-313.

Introduction: Compared to other types of occupational training, safety training suffers from several unique challenges that potentially impair the engagement of learners and their subsequent application or “transfer” of knowledge and skills upon returning to the job. However, existing research on safety training tends to focus on specific factors in isolation, such as design features and social support. The aim of this research is to develop an overarching theoretical framework that integrates factors contributing to training engagement and transfer. **Method:** We conducted a comprehensive qualitative review of safety training research that was published between 2010 and 2020. We searched Web of Science, Scopus, and Google Scholar, yielding 147 articles, and 38 were included. We content analyzed article summaries to arrive at core themes and combined them with contemporary models of general occupational training to develop a rich model of safety training engagement and transfer. **Results:** We propose that training engagement is a combination of pre-training factors such as individual, organizational, and contextual factors, that interact with design and delivery factors. Safety training engagement is conceptualized as a three-component psychological state: affective, cognitive, and behavioral. Organizations should prioritize pre-training readiness modules to address existing attitudes and beliefs, optimize the safety training transfer climate, and critically reflect on their strategy to design and deliver safety training so that engagement is maximized. **Conclusions:** There are practical factors that organizations can use before training (e.g., tailoring training to employees’ characteristics), during training (e.g., ensuring trainer credibility and use of adult learning principles), and after training (e.g., integrating learned concepts into systems). **Practical Applications:** For safety training to ‘stick,’ workers should be affectively, cognitively, and behaviorally engaged in learning, which will result in new knowledge and skills, improvements in attitudes, and new safety behaviors in the workplace. To enable engagement, practitioners must apply adult learning principles, make the training relevant, and tailor the training to the job and individual needs. After training, ensure concepts are embedded and aligned with existing systems and routines to promote transfer.

- **Keywords:** Learning and development; Safety training evaluation; Safety refresher training; Training relapse prevention

Amanda M. Black, Derek W. Meeuwisse, Paul H. Eliason, Brent E. Hagel, Carolyn A. Emery. *Sport participation and injury rates in high school students: A Canadian survey of 2029 adolescents.* Pages 314-321.

Introduction: The objective of this study is to examine sport and recreational (S&R) activity participation and injury rates (IR) in high school students (ages 14–19). **Methods:** High school students (N = 24 schools, n = 2,029; 958 male, 1,048 female, 23 identified ‘other’ or missing; ages 14–19) in Alberta completed a web-based survey during class (October 2018–March 2019). Students identified their top three sports for participation in the past year. Primary outcome measures included IR for (a) any S&R-related injury, (b) most serious S&R-related injury resulting in medical attention, and (c) most serious injury resulting in restriction from S&R for at least one day. **Results:** In total, 1763/2029 (86.89%) respondents [861/958 (89.87%) male, 886/1048 (84.54%) female, 16/23 (69.57%) identifying as ‘other’ or missing] participated in an S&R activity in the past year. Top sports for male participation were basketball (33.08%; 95% CI 27.67–39.00), ice hockey (20.46%; 95% CI 14.87–27.47), and soccer (19.42%; 95% CI 15.67–23.80). Top sports for female participation were dance (22.52%; 95% CI 17.98–27.82), basketball (18.32%; 95% CI 14.32–23.14), and badminton (17.84%; 95% CI 13.35–23.43). Of the 1,971 students completing the S&R injury question, 889 reported at least one injury during the past year [(IR = 45.10 injuries/100 students/year (95% CI 39.72–50.61)]. The medical attention IR was 29.09 injuries/100 students/year (95% CI

24.49–34.17) and time loss IR was 36.00 injuries/100 students/year (95% CI 30.47–41.93). **Conclusions:** High school student S&R IRs are high with 29% of adolescents reporting at least one medical attention injury within the past year. Injury prevention strategies targeting youth are necessary. Practical Application: Participation in S&R activities has multiple physical, psychological, and health benefits for adolescents, but some S&R activities also have greater risks of injury. This study informs the next sports to target for implementation of optimal prospective surveillance and injury prevention strategies among high school aged students.

- **Keywords:** High school; Adolescent; Injury; Youth; Sport; Canada

Bethany A. West, Rose A. Rudd, Erin K. Sauber-Schatz, Michael F. Ballesteros. *Unintentional injury deaths in children and youth, 2010–2019*. Pages 322–330.

Background: Unintentional injuries are the leading cause of death for children and youth aged 1–19 in the United States. The purpose of this report is to describe how unintentional injury death rates among children and youth aged 0–19 years have changed during 2010–2019. **Method:** CDC analyzed 2010–2019 data from the National Vital Statistics System (NVSS) to determine two-year average annual number and rate of unintentional injury deaths for children and youth aged 0–19 years by sex, age group, race/ethnicity, mechanism, county urbanization level, and state. **Results:** From 2010–2011 to 2018–2019, unintentional injury death rates decreased 11% overall—representing over 1,100 fewer annual deaths. However, rates increased among some groups—including an increase in deaths due to suffocation among infants (20%) and increases in motor-vehicle traffic deaths among Black children (9%) and poisoning deaths among Black (37%) and Hispanic (50%) children. In 2018–2019, rates were higher for males than females (11.3 vs. 6.6 per 100,000 population), children aged < 1 and 15–19 years (31.9 and 16.8 per 100,000) than other age groups, among American Indian or Alaska Native (AIAN) and Blacks than Whites (19.4 and 12.4 vs. 9.0 per 100,000), motor-vehicle traffic (MVT) than other causes of injury (4.0 per 100,000), and rates increased as rurality increased (6.8 most urban [large central metro] vs. 17.8 most rural [non-core/non-metro] per 100,000). From 2010–2011 to 2018–2019, 49 states plus DC had stable or decreasing unintentional injury death rates; death rates increased only in California (8%)—driven by poisoning deaths. Conclusion and Practical Application: While the overall injury death rates improved, certain subgroups and their caregivers can benefit from focused prevention strategies, including infants and Black, Hispanic, and AIAN children. Focusing effective strategies to reduce suffocation, MVT, and poisoning deaths among those at disproportionate risk could further reduce unintentional injury deaths among children and youth in the next decade.

- **Keywords:** Child injury; Health equity; Rural/urban; Race/ethnicity