Ying Wang, Huizhao Tu, N.N. Sze, Hao Li, Xin Ruan. *A novel traffic conflict risk measure considering the effect of vehicle weight*. Pages 1-13.

Introduction: Vehicle weight is deterministic to the impact force in collision, and thus the injury risk of vehicle occupants. In China, involvement of heavy vehicles in overall and fatal crashes are prevalent, even though heavy vehicles only constitute a small proportion of overall registered motor vehicles. However, vehicle weight is rarely considered in the existing traffic conflict risk prediction and assessment models because of the unavailability of required data. **Method:** Novel risk indicators for the diagnosis of traffic conflict risk map, considering the effect of vehicle weight, are proposed, with the advantage of comprehensive traffic flow characteristics and vehicle weight data using Weigh-in-Motion (WIM) technique. Weight-incorporated risk level (WRL) and weight integrated risk level (WIRL) are established to quantify the traffic conflict risk, at an instant and over a specified time period, respectively, by extending the conventional traffic conflict risk measures including time-to-collision (TTC) and modified potential collision energy (PCE). Then, a microscopic traffic simulation model is adopted to estimate the traffic conflict risk map along a highway segment that has partial lane closure. The traffic conflict risk performances, between the risk indicators with and without considering the vehicle weight, are compared. **Results:** The traffic conflict risks estimated using conventional risk indicators without considering the vehicle weight are generally lower than that based on WRL and WIRL. The difference is more profound when the proportion of heavy vehicles in the traffic stream increases. **Conclusions:** The finding is indicative to remedial engineering measures including variable message sign, speed limit, and ramp metering that can mitigate the real-time crash risks on highways, especially in adverse environmental and weather conditions, with due consideration of vehicle composition and crash worthiness of vehicles.

- ▪ **Keywords:** Weigh-in-motion (WIM) technique; Risk indicator; Time-to-collision (TTC); Potential collision energy (PCE); Risk map

Moutushi Tanha, Grant Michelson, Mesbahuddin Chowdhury, Pavel Castka. *Shipbreaking in Bangladesh: Organizational responses, ethics, and varieties of employee safety*. Pages 14-26.

Introduction: The dismantling of large ocean-going ships at the end of their productive use, or shipbreaking, has a poor reputation for employee safety in some developing countries. India and Bangladesh have recently come to dominate the global shipbreaking industry in terms of the tonnage of scrapped and recycled ships and the work is reportedly hazardous, posing significant ethical and practical risks to employee health and safety. This study aims to investigate the veracity of this reputation by identifying how different shipbreaking firms manage workplace safety, and their reasons for doing so. **Methods:** Drawing on in-depth case-based research at three shipbreaking firms in Chittagong, Bangladesh, data were collected from governmental representatives, industry experts, and NGO's through interviews, site observations, and industry reports. Safety performance data (number of injuries and fatalities) were collected between 2014 and 2019 and verified from different sources. **Results:** In contrast to uniformly poor outcomes, the findings show better but uneven practices of workplace safety among the three shipbreaking firms, a phenomenon that we describe as 'varieties of employee safety.' The better performing shipbreaking firms on safety outcomes had higher managerial commitment towards improving safety, provided personal protective equipment (PPE) and training, adopted formal management systems such as external certification, and had more robust management processes concerning workplace safety in place. **Conclusions:** Management agency or choices towards strengthening workplace safety can positively influence safety performance outcomes in Bangladesh shipbreaking firms. We also contend that there is a close relationship between management ethics and occupational risk management in the workplace. This is a relatively novel perspective for health and safety research. **Practical applications:** Our empirical insights challenge common assumptions that safety practices in the shipbreaking industry in developing nations like Bangladesh are homogenous and consistently of low standard. This provides policymakers, the media, and safety practitioners with the opportunity to showcase best practices, whilst also identifying how safety in shipbreaking can be further improved for firms that are poor in their safety performance.

- ▪ **Keywords:** Shipbreaking; Management commitment; Employee safety; Safety performance; Ethics

Xiaohua Zhao, Yang Ding, Ying Yao, Yunlong Zhang, Chaofan Bi, Yuelong Su. *A multinomial logit model: Safety risk analysis of interchange area based on aggregate driving behavior data*. Pages 27-38.

Introduction: Urban expressway interchanges have become accident-prone sites owing to the accelerated increase in motor-vehicle ownership. This study explored the impact of factors, including day of the week, time of day, congestion level, traffic control devices, and road conditions, on road safety risk levels in the interchange area of an urban expressway based on aggregate driving behavior data. **Method:** A large amount of aggregate driving behavior data were obtained from AutoNavi navigation software. The database was built by matching various types of data and observing their characteristics. Day of the week, time of day, congestion level, road conditions (number of lanes, traffic disturbance, and traffic control devices [the type of advance guide sign system, number of warning signs, and the complexity of the diagrammatic guide sign]) were identified as the explanatory variables. The traffic order index (TOI), based on driving behavior and speed variation, was used to evaluate the road safety risk levels, including risky roads, general roads, and safe roads, which served as the response variables. The multinomial logit model (MNL) was developed to explore the impact of various factors, including traffic control devices and road conditions, on road safety risk levels. **Results:** The results showed that the factors that significantly influence risky roads include day of the week, number of lanes, congestion level (slow moving), traffic disturbance (with the

merge or diverge within 500 m), type of advance guide sign system (three-level advance guide sign system), and complexity of diagrammatic guide signs (low or medium complexity). **Practical Applications:** This study could offer plausible suggestions for traffic management departments for the rehabilitation of road conditions and traffic control devices in urban expressway interchange areas.

- **Keywords:** Safety risk analysis; Urban expressway; Interchange; Aggregate driving behavior; Multinomial logit model

Anna-Lena Andersson, Marcus Sokolowski. *Accident or suicide? Improvement in the classification of suicides among road traffic fatalities in Sweden by extended psychosocial investigations, during the years 2010–2019*. Pages 39-45.

Introduction: Suicide is the second leading cause of death in the ages 15–29 worldwide, exceeded only by road injury. However, fatalities in road traffic may be either accidents or suicides. In 2010 Sweden began efforts to separately report deaths in road traffic as either accidents or suicides. **Method:** Three alternative criteria defining what constitutes a fatality by suicide were introduced. After exclusion of natural deaths, fatalities were also classified on a five-level graded scale, which distinguished between accident, undetermined, and suicide. The investigations of fatalities were complemented by extended psychosocial investigations in 2012. The improvement in the classification of suicide deaths was evaluated by an intra-year 2012 comparison, as well as using the 2010–2012 period as a control to evaluate the continued use of extended psychosocial investigations during the 2013–2019 period. **Results:** The 2012 intra-year comparison showed a 63% increase in the number of identified suicides when using extended psychosocial investigations. The additional 14 suicides identified in 2012 were mainly attributed to a resolution of 12 "undetermined" causes of deaths. Suicides of all road fatalities increased from 5.7-6.8% in 2010–2011, to 11.2% in 2012. Over the subsequent period 2013–2019 with extended psychosocial investigations, suicides of all road fatalities averaged 10%, a 60% increase over prior years. An average of ~9 additional suicides was identified each year during 2013–2019, which was accompanied by an annual reduction of ~6 "undetermined" fatalities. **Conclusion:** The use of extended psychosocial investigations is of major importance for our knowledge about the occurrence of suicides in road traffic. **Practical applications:** A standardized and in-depth classification of suicide deaths is a basic prerequisite needed for the cooperation, implementation, and effect-evaluations of suicide intervention and prevention efforts, with potential to include the entire Swedish transportation system.

- **Keywords:** Suicide; Accident; Fatality; Classification; Psychosocial; Cause of death; Road traffic

Leon Straßgütl, Claudia Evers. *Long-term effects of the German zero tolerance law for novice drivers*. Pages 46-53.

Introduction: In 2007, the German legislature introduced a zero tolerance law (ZTL) for novice drivers to reduce the number of alcohol-related crashes. The purpose of our study was to evaluate the long-term effects of this law on current and former novice drivers. **Method:** Our approach was threefold: first, we used individual data of police records from 2003-2018 and conducted a cohort analysis to examine how the first cohort affected by the law responded in the long-term. Second, we analyzed the influence of the ZTL on alcohol-related traffic offenses by current novice drivers. Third, we conducted a survey to examine if the acceptance, knowledge, and behavior regarding the ZTL have changed compared to a decade ago. **Results:** The number of alcohol-related crashes was significantly lower in the first affected cohort than in earlier cohorts. Moreover, current novice drivers had lower levels of alcohol-related crashes and alcohol-related traffic offenses than did novice drivers before the ZTL became effective. The survey showed a

high level of acceptance and knowledge in both current and first cohort and a decreased importance of drinking and driving. **Conclusion:** The ZTL is associated with a long-term increase of traffic safety in Germany. Former novice drivers appear to have retained learned behavior toward drinking and driving. Thus, the ZTL might have an impact on perceived norms resulting in less acceptance of drinking and driving. Changes in society, like lower alcohol consumption and decreased importance of passenger cars among young people, further accelerated these effects. **Practical applications:** ZTL for novice drivers are an effective way to improve traffic safety. It is associated with a positive effect on traffic safety even when drivers were no longer directly affected by the measure. These findings suggest that policies are an effective tool to improve traffic safety and help towards achieving Vision Zero.

- ▪ **Keywords:** Road traffic crashes; Traffic offenses; Alcohol; Cohort analysis; Acceptance

Selman Aslan, Osman Hürol Türkakın. *A construction project scheduling methodology considering COVID-19 pandemic measures*. Pages 54-66.

Introduction: At the beginning of the COVID-19 pandemic, various social measures were taken and various sectors were affected with strict precautions and safety measurements. The construction industry, where numerous employees work together, was affected by these COVID restrictions. The pandemic period typically further delayed the construction contracts. **Methods:** This study addresses the project duration, pandemic risk, and project cost of a construction project case by using both multi-objective genetic algorithm and resource constrained project scheduling techniques, using modeling of COVID-19 infection rate. Finally, the analytic hierarchy process (AHP), a multi-objective technique, is used to obtain an optimal solution using three criteria: project duration, total cost, and pandemic risk value. **Results:** A case study is used for analyzing the outcomes of the pandemic-based modeling, the original schedule of the case study ends in 46 days. Feasible schedules are obtained with durations occurring between 61 to 199 days, the pandemic risks range from 46% to 89%, and the total cost varies from 174,669.8 Turkish Lira (TL) to 186,126.7 TL. Consequently, the most optimal-final solution is obtained Alternative 5 (0.46% pandemic risk, 199 Day (10 workers) with 185,722 TL). **Conclusion:** We conclude that the possible rate of pandemic-related delays can be obtained by using both these techniques and the infection modeling method. Using the COVID-19 infection rate modeling, duration and cost changes are calculated by considering infection risk in construction workers. **Practical Applications:** Using the COVID-19 infection rate modeling, project delays and cost overruns are determined by considering infection risk in construction workers. Optimum worker sizes and delayed construction activities are determined according to the selected solution by using the AHP technique. Expectedly, this study may help determine the construction process while preserving social distances between construction workers during pandemic situations like COVID-19.

- ▪ **Keywords:** OHS; Pandemic; COVID-19; Multi-objective optimization; AHP

Katherine E. Schofield, Andrew D. Ryan, Craig Stroinski. *Risk factors for occupational injuries in schools among educators and support staff*. Pages 67-77.

Introduction: School districts employ a large number of employees who work in educational (e.g., teachers) or other support roles, including educational assistants, custodians, food service, bus drivers, and community and recreation workers. District employees perform a wide array of job tasks and experience a wide spectrum of work-related risks and injuries. **Methods:** Workers' compensation data were coupled with Minnesota Department of Education district employee denominator data to evaluate risk factors for injury and severity. Variables included district location and type, employee job

classification, age, and gender. Rates of injury and rate ratios were calculated to measure comparative injury risk using negative binomial regression and 95% confidence internals. Incidence and frequency of injury cause, nature, and body part we calculated. **Results:** Saint Paul and Minneapolis metropolitan area (versus non-metro) districts had higher risk (RR = 1.35, 95%CI = 1.18–1.54) of employee injuries. All job classifications in support roles had increased risk of injury claims versus educators, however food service (RR = 5.14, 95%CI = 4.61–5.74), custodial (RR = 3.85, 95%CI = 3.41–4.34), and transportation (RR = 4.15, 95%CI = 3.38–5.10) exhibited the highest comparative risk to educators; significant risk of lost-time injury was also present in these workers. Males and females had similar risk of injury for all claims, however males had elevated risk of lost-time injury (RR = 1.46, 95%CI = 1.26–1.69) versus females. All age groups >41-years-old exhibited increased risk of injury as compared to 31–40-year-olds. The magnitude of lost-time injury risk also increased with age. Falls and slips (29.1%), strains/sprains/ruptures (45.2%), and upper extremities (31.3%) most frequent cause, nature, and body part injured, respectively. **Conclusions:** Characteristics of districts, schools, workers, and their jobs tasks and hazards vary. Many categories of support staff in schools have elevated risk of injury, including lost-time injury, as compared to educators. **Practical Applications:** Injury prevention in schools should be approached by targeting job classifications; high risk jobs can be prioritized for prevention.

- **Keywords:** Workers' compensation insurance; Education; Nonfatal injuries; Occupational safety and health; Age and gender

Thomas Wojciechowski. *Understanding mechanisms underlying the relationship between antisocial personality disorder and substance-impaired driving among young adults involved with the justice system as minors.* **Pages 78-86.**

Introduction: Antisocial personality disorder is a risk factor associated with increased risk for substance-impaired driving. While past research has focused on identifying prevalence rates for the disorder among substance-impaired drivers, there is a dearth of research focused on identifying the mechanisms by which the disorder actually functions to increase risk for the behavior among young adults who were formerly adjudicated for a serious offense. There are cognitive, affective, and social mechanisms that may help to explain this relationship. **Method:** Impulse control, hostility, and deviant peer association are examined as mechanisms that explain the relationship in each of these domains, respectively. The Pathways to Desistance data were utilized in analyses, comprising the responses of 1,354 youth who were adjudicated for a serious offense just prior to baseline measurements. Generalized structural equation modeling was used to examine the direct effects of antisocial personality disorder on substance-impaired driving risk and the hypothesized mechanism variables were then included in the model to determine which of them provided significant pathways through which the main relationship operated. **Results:** Results indicated that meeting criteria for a diagnosis of antisocial personality disorder was associated with increased risk of substance-impaired driving at follow-up. This relationship was attenuated to non-significance upon inclusion of the mechanism variables and reduced in magnitude by 20%. This attenuation was due almost entirely to impulse control. **Practical Applications:** This provides indication that intervention for substance-impaired driving offenders with antisocial personality disorder may be most effective when structured around improving impulse control for young adults who were previously involved with the juvenile/criminal justice system.

- **Keywords:** Substance-impaired driving; Antisocial personality disorder; Deviant peer association; Impulse control; Hostility

Digvijay S. Pawar, Ankit Kumar Yadav. *Modelling the pedestrian dilemma zone at uncontrolled midblock sections*. Pages 87-96.

Introduction: Pedestrians at high-speed midblock crossings with the intention to cross the road usually face safety risks due to difficulty in judging the available gaps. The risk to pedestrians is high in developing nations like India since priorities are not respected by road users. Moreover, the non-yielding vehicular traffic puts pedestrians at further risk. While crossing the road, pedestrians are clear about rejecting small gaps and accepting the large gaps, however, they experience a dilemma between the small and large gaps. **Method:** This study attempts to model the dilemma zone for pedestrians intending to cross the high-speed roads (posted speed limit of 60 km/h). The field data were collected using high-definition video cameras at two uncontrolled midblock crossings, each in the cities of Mumbai and Kolhapur, located in the southwestern part of India. The variations in the spatial gap acceptance behavior were analyzed for 1,107 pedestrian observations using binary logit models. **Results:** The findings revealed that the length and the distribution of the dilemma zone were significantly affected by the speed of the approaching vehicle and the distance from it. Moreover, the influence of vehicle type (truck, car, or two-wheeler), pedestrian type (walking alone or in a group), crossing speed, and waiting time also influenced pedestrians' gap acceptance behavior. Interestingly, pedestrians' gender did not play a significant role in their road crossing decisions. **Conclusions:** Overall, the study identified the dilemma zone boundaries that will help pedestrians to judge the safe gaps while crossing, and in turn, reduce the probability of pedestrian-vehicle crashes. **Practical Application:** The proposed dilemma zone intends to protect the pedestrians by assisting in making precise crossing decisions at high-speed midblock crossings.

- **Keywords:** Pedestrian crossing; Approach speed; Gap acceptance; Vehicle type; Binary logit model

Nazmul Arefin Khan, Muhammad Ahsanul Habib. *Exploring the impacts of built environment on pedestrian injury severity involving distracted driving*. Pages 97-108.

Introduction: This study develops an injury severity model that demonstrates level of pedestrians' injury severity during pedestrian-vehicle collisions, specifically those involving distracted driving. **Method:** It uses data from a police-reported collision database that contains pedestrian-vehicle collision information in Nova Scotia, Canada. A latent segmentation-based ordered logit (LSOL) model is developed in this paper that comprehensively examines the influence of built environment characteristics on pedestrian injury severity. It estimates a latent segment allocation model within LSOL modeling framework to capture unobserved heterogeneity across pedestrians. Two latent segments, high- and low-risk segments, are identified probabilistically based on pedestrian characteristics and action, driver action, and collision attributes. **Results:** Results suggest that higher mixed land-use, transit stop density, length of sidewalk in the collision locations, and collisions occurring near schools yield lower pedestrian injury severity. In contrast, pedestrian-vehicle collisions in arterial roads, curved roads, sloped roads, and roundabouts tend to result in severe injuries. Interactions between distracted driving type and built environment characteristics are examined in this study. For example, using a communication device while driving on straight roads increases likelihood of higher pedestrian injury severity. This study also confirms the existence of heterogeneity across latent segments. For instance, higher percentage of people commuting by walking in the collision areas yield severe pedestrian injury in high-risk segments and lower injury severity in low-risk segments. **Practical applications:** The findings of this study will assist transportation planners and road safety stakeholders in developing effective and prioritized policies to reduce pedestrian injury severity involving distracted driving incidents.

Fang Wang, Junzhi Wu, Lin Hu, Chao Yu, Bingyu Wang, Xiaoqun Huang, Karol Miller, Adam Wittek. *Evaluation of the head protection effectiveness of cyclist helmets using full-scale computational biomechanics modelling of cycling accidents*. Pages 109-134.

Introduction: Cycling is a popular choice for urban transportation. Helmets are important and the most popular means of head protection for cyclists. However, a debate about the effectiveness of helmets in protecting a cyclist's head from injury continues. **Method:** We employed computational biomechanics methods to analyze the head protection effectiveness of nine off-the-shelf-helmets for two typical impact scenarios that occur in cycling accidents: cyclist's head impacting a kerb (kerb-impact) and cyclist skidding (skidding impact) on the road surface. We conducted drop tests for all nine analyzed helmets, and used the test data for validation of the corresponding helmet finite element (FE) models created in this study. The validated helmet models were then used in the full-scale computer simulations (FE analysis for the skull, brain and helmet, and multibody dynamics for the remaining segments of the cyclist's body) of the cycling accidents for cyclists wearing a helmet and without a helmet. **Results:** The results indicate that helmets can reduce both the peak linear acceleration of the cyclist head center of gravity (COG) and the risk of cyclist skull fracture. However, higher rotational acceleration of the head COG was predicted for cyclists wearing helmets. The results obtained using the injury criteria that rely on the brain deformations (maximum shear strain MPS and cumulative strain damage measure CSDM) suggest that helmets may offer protection in all the analyzed cyclist impact scenarios. However, the predicted level of protection varies for different helmets and impact scenarios with appreciable variations in the predictions obtained using different injury criteria. Reduction in the maximum principal strain (MPS0.98) for helmeted cyclists was predicted for both impact scenarios. In contrast, wearing the helmet reduced the CSDM only for the skidding impact scenario. For the kerb-impact scenario, no clear influence of the helmet on the predicted CSDM was observed.

Katherine L. Cox, Soumyadeep Bhaumik, Medhavi Gupta, Jagnoor Jagnoor. *Facilitators and barriers of life jacket use for drowning prevention: Qualitative evidence synthesis*. Pages 135-147.

Background: Drowning is a public health problem globally. Despite substantial evidence on the effectiveness of life jackets, their use for drowning prevention has remained low. This study aims to understand the barriers and facilitators of life jacket use. **Methods:** We searched four major electronic databases, contacted experts, hand-searched conference abstracts and screened reference lists to identify primary qualitative studies. We used the Critical Appraisal Skills Programme Checklist for quality appraisal and the PROGRESS Plus framework to understand equity issues. Thematic analysis was conducted. **Results:** We retrieved 1153 records and finally included ten studies that met eligibility criteria. All except two studies were from high-income countries. Four key themes were identified. Firstly, life jacket use was shaped through complex interactions between lived experience and cultural norms which influenced the risk-perception of life jacket utility in preventing deaths. Secondly, the high cost of life jackets was almost always a barrier for its usage. Thirdly, adoption of laws and its subsequent enforcement was perceived to be an important facilitator for life jacket use. Lastly, design issues around comfort, fashion-sense, and shelf life influenced usage. **Conclusion:** The results

of this qualitative evidence synthesis should be considered for health promotion, legal and policy interventions to promote the uptake of life jackets. There is a need for better understanding of perceptions and their role in the uptake of safety behaviours in different countries including the role of equity issues on the use of life jackets.

Mouyid Islam, Parisa Hosseini, Mohammad Jalayer. *An analysis of single-vehicle truck crashes on rural curved segments accounting for unobserved heterogeneity*. Pages 148-159.

Introduction: Medium to large truck crashes, particularly on rural curved roadways, lead to a disproportionately higher number of fatalities and serious injuries relative to other passenger vehicles over time. The intent of this study is to identify and quantify the factors affecting injury severity outcomes for single-vehicle truck crashes on rural curved segments in North Carolina. The crash data were extracted from the Highway Safety Information System (HSIS) from 2010 to 2017. **Method:** This study applied a mixed logit with heterogeneity in means and variances approach to model driver injury severity. The approach accounts for possible unobserved heterogeneity in the data resulting from driver, roadway, vehicle, traffic characteristics and/or environmental conditions. Results' **Conclusion:** The model results indicate that there is a complex interaction of driver characteristics such as demographics (male and female drivers, age below 30 years, and age between 50 to 65 years), driver physical condition (normal driving condition and sleepy while driving), driver actions (unsafe speed, overcorrection, and careless driving), restraint usage (lap-shoulder belt usage and unbelted), roadway and traffic characteristics (undivided road, medium right shoulder width, graded surface, low and medium speed limit, low traffic volume), environmental conditions (rainy condition), vehicle characteristics (tractor-trailer and semi-trailer), and crashes characteristics (fixed object crashes and rollover crashes). In addition, this study compared the contributing factor leading to driver injury severity for curved and straight rural segments. **Practical Applications:** The results clearly indicate the importance of driving behavior, such as, exceeding the speed limit and careless driving along the high-speed curved segments, need to be prioritized for the trucking agency. Similarly, the suggested countermeasures for roadway design and maintenance agency encompass warning signs and advisory speed limit, roadside barrier with chevrons, and edge line rumble strips are important concerning curved segments in rural highways.

Anas Alrejjal, Khaled Ksaibati. *Impact of mountainous interstate alignments and truck configurations on rollover propensity*. Pages 160-174.

Introduction: Combined horizontal and vertical alignments are frequently utilized in mountainous interstates in Wyoming. The roll stability of trucks on these challenging terrain conditions is of great concern for transportation officials. The impact of curve characteristics combined with truck configurations has not been considered in the literature due to data availability issues related to the weight and Center of Gravity (CG) payload height of trucks. **Method:** High-fidelity vehicle dynamics simulation modeling is employed to investigate the rollover propensity of trucks navigating curves of varying geometric design and truck characteristics. A multinomial regression model was then developed to further quantify the impact of these key factors and the effect of their interactions on rollover safety margins. **Results:** It was shown that complying with the assigned speed limits of the curved roadways is not enough to navigate a curve without

experiencing a rollover under some circumstances. The CG payload height and the operating speeds have the highest impact on the safety margins of a truck rollover. Steeper downgrades would amplify the impact of the gross weight of a truck. Tighter curves would also raise the impact of the truck configurations. **Conclusions:** This study assessed the curve speed limits and revealed that the exciting approach to assigning safe speed limits should be modified according to the aforementioned factors. For the first time, findings from this study shed light on the direction and magnitude of the impact of the truck configurations coupled with curve features that contribute to truck rollover safety margins. **Practical Applications:** This study revealed the impact of truck configurations on the roll stability of trucks and pointed out critical cases that should be treated very cautiously by drivers. This assists transportation agencies in assigning more appropriate speed limits of curved roadways according to truck conditions.

- **Keywords:** Vehicle dynamics simulation; Combined horizontal and vertical curves; Rollover margins; Speed limits; Truck configurations

Behram Wali, Numan Ahmad, Asad J. Khattak. *Toward better measurement of traffic injuries – Comparison of anatomical injury measures in predicting the clinical outcomes in motorcycle crashes.* **Pages 175-189.**

Introduction: Little evidence exists in the literature regarding the discrimination power of better anatomical injury measures in differentiating clinical outcomes in motorcycle crashes. Furthermore, multiple injuries to different body parts of the rider are seldom analyzed. This study focuses on comparing anatomical injury measures such as the injury severity score (ISS) and the new injury severity score (NISS) in capturing injuries of multiple injured riders and examining the discriminatory capabilities of the ISS and NISS in predicting clinical outcomes post motorcycle crash. **Methods:** The study harnessed unique and comprehensive injury data on 322 riders from the US DOT Federal Highway Administration's Motorcycle Crash Causation Study (MCCS). Detailed exploratory analysis is performed and discrete/ordered statistical models are estimated for three clinical outcomes: mortality risk, trauma risk, and trauma status. **Results:** Around 9% of the riders died and 45% of the riders had injuries. Around 36% of the riders were hospitalized, disabled, or institutionalized. While a very strong dependence was found between ISS and NISS, ISS underestimated injuries sustained by riders. Statistical models for mortality risk revealed that a unit increase in the ISS and NISS was correlated with a 1.18 and 1.17 times increase in the odds of mortality, respectively. Moreover, a unit increase in ISS and NISS values was correlated with a higher trauma risk by 1.48 and 1.36 times, respectively. Our analysis reveals that the probability of a rider being hospitalized or disabled/institutionalized increases with an increase in the NISS. Conclusions and **practical applications:** The NISS exhibits significantly better calibration and discriminatory ability in differentiating survivors and non-survivors and in predicting trauma status – underscoring the importance of accounting for microscopic body-part-level injury data in motorcycle crashes. We consider that compared with the KABCO scale, the ISS and NISS are more nuanced scores that can better measure the overall injury intensity and can lead to more targeted countermeasures.

- **Keywords:** Motorcycle crash causation; Anatomical injury measures; Injury severity score; New injury severity score; Trauma; Mortality; Trauma status; Discrete and ordered models

Erica Beidler, Abigail C. Bretzin, Ara J. Schmitt, Amy Phelps. *Factors associated with parent and youth athlete concussion knowledge*. Pages 190-197.

Introduction: On-site health care providers are not routinely present at all youth sport events. Therefore, parents and youth athletes are often responsible for identifying and making appropriate immediate care decisions regarding concussions, which may be influenced by their injury health literacy. Previous studies have investigated the level of concussion knowledge of parents and athletes, but few have investigated factors associated with greater awareness at the youth sport level specifically. **Method:** A total of 466 parents and 390 youth contact sport athletes from Pennsylvania and Michigan completed separate surveys of concussion knowledge and personal and family demographic information. **Results:** Parents had a mean concussion knowledge score of 39.3 ± 4.6 out of a possible 47 points. Having a medical occupation ($p = .04$) and being older in age ($p = .03$) were associated with higher concussion knowledge scores in parents ($R2 = 0.018$; 95% $CI = 32.77–38.99$). Youth athletes had a mean concussion knowledge score of 35.0 ± 5.7 out of 47. Having learned about concussion previously ($p < .001$), having a history of diagnosed concussion(s) ($p = .01$), sport type (relative to girls' ice hockey, $p < .001$), older age ($p < .001$), and parent concussion knowledge ($p = .04$) were associated with higher youth athlete concussion knowledge ($R2 = 0.176$; 95% $CI = 19.08–31.72$). **Conclusions:** More evidence-based concussion awareness resources are needed at the youth sport level. While it did not significantly influence concussion knowledge for parents, concussion education is a modifiable factor that may be essential for improving concussion knowledge of youth athletes, thus warranting further study into effective awareness strategies for this population. **Practical Applications:** The factors found to influence concussion knowledge in this study could be considered in future educational concussion initiatives for youth athletes and their parents in order to increase awareness regarding the potential dangers of participating in sport while concussed.

- ▪ **Keywords:** Brain injury; Health literacy; Injury comprehension; Sports; Adolescents

Joshua L. Hunte, Martin Neil, Norman E. Fenton. *A causal Bayesian network approach for consumer product safety and risk assessment*. Pages 198-214.

Introduction: Product risk assessment is the overall process of determining whether a product is judged safe for consumers to use. Among several methods for product risk assessment, RAPEX is the primary one used by regulators in the UK and EU. Despite its widespread use we identify several limitations of RAPEX, including a limited approach to handling uncertainty, especially in the absence of data, and the inability to incorporate causal explanations for using and interpreting the data. **Method:** We develop a Bayesian Network (BN) model to provide an improved systematic method for product risk assessment that resolves the identified limitations with RAPEX. BNs are a rigorous, normative method for modelling uncertainty and causality which are already used for risk assessment in domains such as medicine and finance, as well as critical systems generally. **Results:** We use the BN approach to demonstrate risk assessments for products where relevant test and product instance data are and are not available. Whereas RAPEX can only produce results given relevant data, the BN approach produce results for products with and with no relevant data – replicating RAPEX in the former and providing deeper insights in both cases. **Conclusion:** The BN approach is powerful and flexible for systematic product risk assessment. While it can complement more traditional methods like RAPEX, it is able to provide quantified, auditable assessments in situations where such methods cannot because of lack of data. **Practical Applications:** Safety regulators, manufacturers, and risk professionals can use the BN approach for all types of consumer product risk assessment, including for novel products or products with little or

no historical data. They can also use it to validate the results of existing methods when data becomes available. It informs risk management decisions and helps understand the effect of those decisions on the consumer risk perception.

- ▪ **Keywords:** Bayesian network; Product risk; Risk assessment; RAPEX; Product safety

Md Mahmudul Hasan, Christopher N. Watling, Grégoire S. Larue. *Physiological signal-based drowsiness detection using machine learning: Singular and hybrid signal approaches*. Pages 215-225.

Introduction: Drowsiness is one of the main contributors to road-related crashes and fatalities worldwide. To address this pressing global issue, researchers are continuing to develop driver drowsiness detection systems that use a variety of measures. However, most research on drowsiness detection uses approaches based on a singular metric and, as a result, fail to attain satisfactory reliability and validity to be implemented in vehicles. **Method:** This study examines the utility of drowsiness detection based on singular and a hybrid approach. This approach considered a range of metrics from three physiological signals – electroencephalography (EEG), electrooculography (EOG), and electrocardiography (ECG) – and used subjective sleepiness indices (assessed via the Karolinska Sleepiness Scale) as ground truth. The methodology consisted of signal recording with a psychomotor vigilance test (PVT), pre-processing, extracting, and determining the important features from the physiological signals for drowsiness detection. Finally, four supervised machine learning models were developed based on the subjective sleepiness responses using the extracted physiological features to detect drowsiness levels. **Results:** The results illustrate that the singular physiological measures show a specific performance metric pattern, with higher sensitivity and lower specificity or vice versa. In contrast, the hybrid biosignal-based models provide a better performance profile, reducing the disparity between the two metrics. **Conclusions:** The outcome of the study indicates that the selected features provided higher performance in the hybrid approaches than the singular approaches, which could be useful for future research implications. **Practical Applications:** Use of a hybrid approach seems warranted to improve in-vehicle driver drowsiness detection system. Practical applications will need to consider factors such as intrusiveness, ergonomics, cost-effectiveness, and user-friendliness of any driver drowsiness detection system.

- ▪ **Keywords:** Drowsiness; Features; Machine learning; Physiological signals; Ground truth; Sensitivity; Specificity; Accuracy

Ahmed Al-Kaisy, Kazi Tahsin Huda. *Empirical Bayes application on low-volume roads: Oregon case study*. Pages 226-234.

Introduction: This paper investigates the Empirical Bayes (EB) method and the Highway Safety Manual (HSM) predictive methodology for network screening on low-volume roads in Oregon. **Method:** A study sample of around 870 miles of rural two-lane roadways with extensive crash, traffic and roadway information was used in this investigation. To understand the effect of low traffic exposure in estimating the EB expected number of crashes, the contributions of both the observed and the HSM predicted number of crashes were analyzed. Results and **Conclusions:** The study found that, on low-volume roads, the predicted number of crashes is the major contributor in estimating the EB expected number of crashes. The study also found a large discrepancy between the observed and the predicted number of crashes using the HSM procedures calibrated for the state of Oregon, which could partly be attributed to the unique attributes of low-volume roads that are different from the rest of the network. However, the expected number of crashes for the study sample using the HSM EB method was reasonably close to the observed number of crashes over the 10-year study period. **Practical Applications:** Based on the findings, it can still be very effective to use network

screening methods that rely primarily on risk factors for low-volume road networks. This is especially applicable in situations where accurate and reliable crash data are not available.

Marion Karras, Patricia Delhomme, Antonia Csillik. *French drivers' behavior: Do psychological resources and vulnerabilities matter?* Pages 235-242.

Introduction: Driving is a risky activity, and road users' behavior is one of the many factors that participate in increasing the risk of road-traffic crashes. Drivers must constantly adapt their behavior to the environment and control their vehicles, and must also anticipate the behavior of others, which may pose a threat to their own safety. Interactions between road users can therefore be stressful and elicit strong negative emotions. Psychological resources and vulnerabilities may be important in understanding how drivers perceive and respond to these driving interactions. The aim of this study was to investigate the role of empathy, self-compassion, personal distress, and alexithymia in both dangerous and prosocial driving behaviors. **Method:** Our sample (N = 550) of French drivers was recruited via snowball sampling. The drivers filled in paper-and-pencil questionnaires including the Driver Behavior Questionnaire (DBQ), the French adaptation of the Toronto Empathy Questionnaire (Short-FTEQ), the Interpersonal Reactivity Index (IRI), the Self-Compassion Scale – Short Form (SCS-SF), and the Toronto Alexithymia Scale (TAS-20). **Results:** After controlling for gender and age, regression analyses revealed that road traffic violations were positively predicted by alexithymia and negatively predicted by cognitive empathy; errors were positively predicted by alexithymia and personal distress, and prosocial driving was positively predicted by emotional and cognitive empathy. A two-step cluster analysis identified three groups of drivers: unsafe and psychologically vulnerable (n = 176), self-focused and less prosocial (n = 151), and safe and resourceful (n = 223). **Conclusions:** Empathy seems to promote safe driving behaviors. Moreover, cognitive empathy appears to safeguard drivers against deliberate violations, whereas psychological vulnerabilities seem to increase the probability of engaging in dangerous behaviors. **Practical Applications:** These results could open new research avenues for the prevention of dangerous driving behaviors and the promotion of road safety.

Chenhui Liu. *Exploration of the police response time to motor-vehicle crashes in Pennsylvania, USA*. Pages 243-253.

Introduction: After roadway crashes occur, the quick emergency response is essential for minimizing tolls and economic losses. Many studies have analyzed the post-crash emergency medical services response time, but few ones have explored the post-crash police response time. However, the presence of police is the precondition for other agencies to perform their duties safely and smoothly. **Method:** With Pennsylvania crash data from 2008 to 2017, this study gives an assessment of the post-crash police response time in Pennsylvania. **Results:** First, we demonstrate that police response time is highly correlated to crash consequences: the longer police response time is positively associated with more fatalities at both individual level and county level. Then, for fatal crashes, a negative binomial model with the police agency-level random effects is built to identify the significant factors influencing the police response time. The results indicate that day of week, illumination, weather, area, roadway type, and roadway location could significantly affect the police response time. Police respond much slower to fatal crashes occurring in rural areas, mid-blocks, turnpikes, adverse weather, on weekends, and at

nighttime without streetlights. Police response time shows a decreasing trend since 2016 and varies a lot by police agencies. It is found that many police agencies affiliated to the Pennsylvania State Police, which oversees statewide law enforcement on all interstate and state highways, respond slower than other police agencies. **Practical Applications:** These findings are expected to provide some new insights for Pennsylvania police agencies to improve their response mechanisms to roadway crashes.

- ▪ **Keywords:** Emergency response; Police; Unobserved heterogeneity; Bayesian; Integrated nested Laplace approximation

Kenny Santos, João P. Dias, Conceição Amado. *A literature review of machine learning algorithms for crash injury severity prediction*. Pages 254-269.

Introduction: Road traffic crashes represent a major public health concern, so it is of significant importance to understand the factors associated with the increase of injury severity of its interveners when involved in a road crash. Determining such factors is essential to help decision making in road safety management, improving road safety, and reducing the severity of future crashes. **Method:** This paper presents a recent literature review of the methods that have been applied to road crash injury severity modeling. It includes 56 studies from 2001 to 2021 that consider more than 20 different statistical or machine learning techniques. **Results:** Random Forest was the algorithm with the best results, achieving the best performance in 70% of the times that it was applied and in 29% of all studies. Support Vector Machine and Decision Tree achieved the best performance in 53% and 31% of the times and in 16% and 14% of all studies, respectively. Bayesian Networks and K-Nearest Neighbors achieved the best performance in 67% and 40% of the times that were used but only achieved the best performance in 4% and 7% of all the studies analyzed, respectively. **Conclusions:** At this point, Random Forest revealed to be a good approach for road traffic crash injury severity prediction followed by Support Vector Machine, Decision Tree, and K-Nearest Neighbor. However, there is still a lot of room in this area to explore other techniques that can best suit this purpose as not only the model's performance should be considered but also causality issues, unobserved heterogeneity, and temporal instability. **Practical Applications:** This review enables researchers to understand the recent techniques applied in the analysis of injury severity modeling, and the ones that achieved the best performance results. Based on the reviewed studies, challenges and future research directions are presented.

- ▪ **Keywords:** Road traffic crashes; Injury severity; Prediction models; Machine learning

Yee Mun Lee, Ruth Madigan, Chinebuli Uzondu, Jorge Garcia, Richard Romano, Gustav Markkula, Natasha Merat. *Learning to interpret novel eHMI: The effect of vehicle kinematics and eHMI familiarity on pedestrian' crossing behavior*. Pages 270-280.

Introduction: In current urban traffic, pedestrians attempting to cross the road at un-signalized locations are thought to mostly use implicit communication, such as deceleration cues, to interpret a vehicle's intention to yield. There is less reliance on explicit driver- or vehicle-based messages, such as hand/head movements, or flashing lights/beeping horns. With the impending deployment of Automated Vehicles (AV), especially those at SAE Level 4 and 5, where the driver is no longer in control of the vehicle, there has been a surge in interest in the value of new forms of communication for AVs, for example, via different types of external Human Machine Interfaces (eHMIs). However, there is still much to be understood about how quickly a novel eHMI affects pedestrian crossing decisions, and whether it provides any additional aid, above and beyond implicit/kinematic information from the vehicle. The aim of this between-

participant study, funded by the H2020 interACT project, was to investigate how the combination of kinematic information from a vehicle (e.g., Speed and Deceleration), and eHMI designs, play a role in assisting the crossing decision of pedestrians in a cave-based pedestrian simulator. **Method:** Using an existing, well-recognized, message for yielding (Flashing Headlights - FH) as a benchmark, this study also investigated how quickly a novel eHMI (Slow Pulsing Light Band – SPLB) was learned. To investigate the effect of eHMI visibility on crossing decisions, the distance at which each eHMI was perceivable was also measured. **Results:** Results showed that, compared to SPLB, the FH led to earlier crossings during vehicle deceleration, especially at lower approaching speeds, and smaller time gaps. However, although FH was visible earlier than SPLB, this visibility does not appear to be the only reason for earlier crossings, with message familiarity thought to play a role. Participants were found to learn the meaning conveyed by FH relatively quickly, crossing around 1 second earlier in its presence (compared to the no eHMI condition), across the three blocks of trials. On the other hand, it took participants at least one block of 12 trials for the new SPLB signal to affect crossing, which only accelerated crossing initiations by around 200 ms, compared to the no eHMI condition. The role of comprehension, long-term exposure, and familiarity of novel messages in this context is therefore important, if AVs are to provide safe, trustworthy communication messages, which will enhance traffic flow and efficiency.

- ▪ **Keywords:** Pedestrian; AV; Crossing; User experience; Ehmi; Cave-based pedestrian simulator

Luciano Lalika, Angela E. Kitali, Henrick J. Haule, Emmanuel Kidando, Thobias Sando, Priyanka Alluri. *What are the leading causes of fatal and severe injury crashes involving older pedestrian? Evidence from Bayesian network model*. **Pages 281-292.**

Introduction: Identifying factors contributing to the risk of older pedestrian fatal/severe injuries, along with their possible interdependency, is the first step towards improving safety. Several previous studies focused on identifying the influence of individual factors while ignoring their interdependencies. This study investigated the leading risk factors associated with older pedestrian fatalities/severe injuries by identifying the interdependency relationship among variables. **Method:** A Bayesian Logistic Regression (BLR) model was developed to identify significant factors influencing pedestrian fatalities and severe injuries, followed by a Bayesian Network (BN) model to reveal the interdependency relationship among the statistically significant variables and crash severity. Furthermore, the probabilistic inference was conducted to identify the leading cause of fatal and severe injuries involving older pedestrians. The models were developed with data from 913 pedestrian crashes involving older pedestrians at signalized intersections in Florida from 2016 through 2018. **Results:** Vehicle maneuver, lighting condition, road type, and shoulder type were directly associated with older pedestrian fatality/severe injury. Vehicle maneuver (going straight ahead) was the most significant factor in influencing the severity of crashes involving older pedestrians. The interdependency of vehicle moving straight, nighttime condition, and two-way divided roadway with curbed shoulders was associated with the highest likelihood of fatal and severe-injury crashes involving older pedestrians. **Conclusions:** The Bayesian Network revealed the interdependency between variables associated with fatal and severe injury-crashes involving older pedestrians. The interdependency relationship with the highest likelihood to cause fatalities/severe-injuries comprised factors with the significant individual contribution to the severity of crashes involving older pedestrians. **Practical applications:** The interdependencies among variables identified in this research could help devise targeted engineering, education, and enforcement strategies that could potentially have a greater effect on improving the safety of older pedestrians.

- ▪ **Keywords:** Pedestrian-vehicle crashes; Older pedestrians; Crash severity; Bayesian Logistic Regression; Bayesian Network

Dale W. Russell, Cristel Antonia Russell, Zhike Lei. *Development and testing of a tool to measure the organizational safety climate aboard US Navy ships*. Pages 293-301

Introduction: Safety climate is a critical human factor that can increase safety-related behaviors and reduce accidents. This research reports on a three-phase program of development and validation of a safety climate survey tool initiated by U.S. Naval Surface Forces after numerous accidents and near misses. **Method:** The initial survey was administered to 4,042 sailors aboard 30 warships, and factor analysis supported a three-factor measure of a safety climate composed of operational compliance, positive work environment, and organizational resources. The predictive validity of the newly developed safety climate measure was tested against the number of accidents reported in the 12 months after the safety climate survey. **Results:** This analysis revealed that a positive work environment and operational compliance were linked to fewer accidents; surprisingly, organizational resources were linked to more accidents. Implications for future research on safety climate and occupational safety are discussed.

- **Keywords:** Safety climate; Scale development; Accidents; Naval forces; Validity

Beate Houette, Natascha Mueller-Hirth. *Practices, preferences, and understandings of rewarding to improve safety in high-risk industries*. Pages 302-310.

Introduction: This article examines employers' practices and employees' experiences of incentive programmes that aim to encourage and reward safe behavior in high-risk industries, focusing particularly on the oil and gas sector. Little qualitative research has been carried out that explores how employees would like to be recogniz ed and rewarded within such programs in the oil and gas sector and why, and what their understandings of safety and rewarding are. **Method:** Drawing on 41 semi-structured interviews and observation research across eight sites in three countries, we examine safety incentivization practices, preferences, and understandings. The use of Hazard Identification cards is also being discussed. **Results:** One of our findings is that, contrary to the assumptions of managers and supervisors that material awards are particularly motivational, many employees preferred symbolic recognition, care by the company, the provision of training and professional development, and investment into improving their wellbeing. We also identify a preference for collective recognition over individual rewards and discuss the values of certificates. **Conclusions:** We conclude that rewarding practices of large multinational companies should become more responsive to the individual wishes of employees and their specific socio-economic contexts and highlight the importance of employee involvement in reward programs.

- **Keywords:** Safety; Multicultural workforce; Safety incentive programs; Qualitative research; International reward management; Hazard Identification cards

Ben Benzaman, Nicholas John Ward, William J. Schell. *The influence of inferred traffic safety culture on traffic safety performance in U.S. States (1994–2014)*. Pages 311-319.

Introduction: Traffic safety performance (crash fatalities per billion vehicle miles traveled) is influenced by many factors related to the physical and social environment. The traffic safety culture in the local environment can influence behaviors that influence the risk of a fatal crash. However, if traffic safety culture is defined as "shared beliefs," it is not possible to directly observe the effect of culture on traffic safety performance. **Method:** This study replicated the method proposed by Page (2001) to infer the effect of traffic safety culture on traffic safety performance for U.S. states between 1994 and

2014. This method infers the influence of traffic safety culture from the error between actual and predicted performance based on observable variables that measure the physical and social environment as well as behavioral hazards. **Results:** The results suggest that a positive traffic safety culture can have a protective effect by producing a lower-than-expected fatality rate. Conversely, a negative traffic safety culture can have an exacerbating effect by producing a larger-than-expected fatality rate. **Conclusion:** The derived metric for estimating traffic safety culture had strong concurrent validity by correlating with the ranking of states based only on total crash fatality rate. Practical Implications: Consistent with Page (2001), the analysis also identified common risk factors across states including per capita alcohol consumption and unemployment rate.

- **Keywords:** Traffic safety culture; Traffic safety; Modeling

Sayan Sakhakarmi, JeeWoong Park. *Improved intrusion accident management using haptic signals in roadway work zone*. Pages 320-329.

Introduction: Roadway work zones are known for hazard vulnerability, with many injuries and fatalities each year, due mostly to intrusions. Despite several available measures to improve safety, existing mechanisms are unreliable for workers to perceive alerts, due to the harsh working environment, with loud noise and limited vision. This research attempts to overcome hazard perception difficulties by introducing a new communication mechanism for intrusion hazard perception. **Method:** The presented communication mechanism is based on past tactile sensing research, and is enhanced by signal profile and message modeling investigations. Experimental field trials were conducted for mechanism evaluation with a goal of improved situational awareness through tactile sensing. **Results:** The trial results show that users perceive warning messages well, even when their vision and hearing are limited, and that the signalized messages perceived could augment users' understanding of a potential hazard, allowing immediate precautionary actions. **Practical Applications:** The application of haptic signals in vulnerable work zones has the potential to improve upon limitations in innate sensing (e.g., vision and hearing), thus presenting an opportunity to better protect workers from potential accidents.

- **Keywords:** Safety communication; Perception; Sensing; Intrusion; Work zone

Bingshuo Chen, Xiaohua Zhao, Zhen Ding, Yang Li, Meina Wan, Qing He, Xiaoming Liu. *Why do older drivers self-regulate: Psychological factors influencing self-regulation in a Chinese sample*. Pages 330-340.

Introduction: As China has recently lifted the age limit for getting access to driving licenses, older drivers' safety issues have received wide attention. Driving self-regulation can be regarded as an adjustment strategy for older adults to reduce risks and extend driving lives. Studies abroad mainly stress the three levels and influencing factors of driving self-regulation. China has a long history with a unique cultural background and social reality and relevant research are still in the initial stage. **Method:** This study applied the extended Theory of Planned Behavior (TPB) to explore the psychological factors that affected self-regulation of older drivers. 317 participants mainly from Beijing urban area completed the questionnaires including demographic information and extend TPB items. **Results:** Bivariate correlation analysis showed that self-regulation was negatively correlated with the amount of driving experience (days per week and mileages per month) in a significant way. And so was the number of family-owned motor vehicles. Exploratory factor analysis indicated that the extended TPB questionnaire was reliable and effective for measuring self-regulation. The proposed Structural Equation Model (SEM) explained 73.673% of the variance in self-regulation intention. Attitude (0.50) had the strongest influence among all variables on intention. Subjective norms (0.28), perceived behavior control (0.27), and alternative traffic quality (0.20) significantly influenced intention. Intention (0.34) and physical condition (0.22) imposed significant

effect on self-regulation behavior. **Practical applications:** Feasible suggestions were put forward that contribute to self-regulate reasonably. This study helps to better understand the nature of self-regulation behaviors and provides a theoretical basis for formulating scientific intervention measures. On the transportation side, people from all communities of society should care for and support older drivers.

- **Keywords:** Older drivers; Driving self-regulation; Theory of planned behavior; Structural equation model

Esther K. Choo, Daniel Nishijima, Stacy Trent, Angela Eichelberger, Yu Ye, Ariane Audett, Karen Brasel, Steve Kazmierczak, Cheryl J. Cherpitel. *Cannabis presentations to the emergency department after MVC in the era of legalization for recreational use.* **Pages 341-348.**

Introduction: The objectives of this study were to examine cannabis and alcohol use among injured patients presenting to emergency departments (ED) in cannabis-legal states to capture an expanded profile of cannabis use and evaluate differences in motor-vehicle collision (MVC) characteristics among those using cannabis alone and in combination with alcohol. **Methods:** This was a cross-sectional study of ED visits by drivers in MVC who presented to one of three study sites. Event-related and usual drug and alcohol use information were obtained using a detailed interviewer-administered computerized questionnaire. We also obtained data from blood and breathalyzer tests and the electronic medical record. We examined frequency and types of acute and past-year cannabis and alcohol use and crash mechanisms and characteristics. Our primary method of determining substance use was self-report; we used biosamples secondarily. **Results:** Eight percent of drivers reported cannabis use in the 8 h prior to MVC, alone or in combination with alcohol; however, a higher proportion (18%) were positive by biosample. High-risk crash features were common in MVCs associated with cannabis, as they were for alcohol use and co-use of cannabis and alcohol; however, patients injured seriously enough to require admission were less likely to report cannabis use (7% vs. 9%) and more likely to report alcohol use (16% vs. 10%). **Conclusions:** Cannabis use was common among patients presenting after MVC in this sample of cannabis-legal states. **Practical Applications:** Differences between self-report and biosample data for cannabis and alcohol use were significant and supports the need to use both means of assessing acute use.

- **Keywords:** Motor vehicle collisions; Substance use disorders; Cannabis; Alcohol; Emergency care

Ling Wang, Kang Wang, Wanjing Ma, Mohamed Abdel-Aty, Lin Li. *Real-time safety analysis for expressways considering the heterogeneity of different segment types.* **Pages 349-361.**

Introduction: Studies have proven that the crash possibility and crash type are not the same among different expressway segment types. However, few studies have conducted real-time safety analysis considering different segment types. This study aimed to explore the crash mechanism's heterogeneity for different segment types (i.e., merge, diverge, weaving, and basic segments). **Method:** To enable in-depth exploration, this study used detailed traffic data, which were 0–10 min before crash, at 1-min intervals, and from five detectors of both the upstream and downstream to the target segment. This study analyzed the crash mechanism's heterogeneity from the following aspects: crash characteristics, significant crash contributing variables, and variables' importance. Based on this, a variables selection method was proposed to solve the huge dimension scale in modeling. Then, a nested logit model was built, which could consider the crash mechanism's heterogeneity, to quantitatively analyze the impact of crash contributing factors on the crash risk. **Results:** The results revealed that there are statistically

significant differences in crash characteristics between each segment type. Additionally, the sources of most crash contributing factors were found to be significantly different in the spatial–temporal dimension between each segment type. Moreover, this study found that the weather parameter, indicating pavement's wet condition, had a similar effect on crash risk between different segment types. However, the geometry and traffic parameters had significantly different impacts between different segment types. Moreover, when the number of target segments' upstream ramps increases or when the distance between ramps and the target segment decreases, the crash risk would increase. **Practical Applications:** This study can be applied in the intelligent transportation system to improve traffic safety performance, especially in active traffic management systems.

- **Keywords:** Crash mechanism's heterogeneity; Real-time safety analysis; 1-min interval traffic data; Intelligent transportation system (ITS); Nested logit model; Expressway

Laura Mills, James Freeman, Alexander Parkes, Jeremy Davey. *Do they need to be tested to be deterred? Exploring the impact of exposure to roadside drug testing on drug driving*. Pages 362-370.

Introduction: Maximizing the deterrent effects of Roadside Drug Testing (RDT) operations remains critical for improving road safety. While preliminary research has explored the impact of being tested at RDT sites, there is yet to be an investigation of different types of exposure (e.g., seeing an operation, being tested) and the subsequent relationship(s) with perceptions of certainty of apprehension and future intentions to offend. The overall objective of this research was to explore these relationships with a sample of drug takers. **Method:** A total of 803 Queensland motorists aged between 16 and 75 (M = 27.12, SD = 13.09) completed an online-based survey, and all reported consuming marijuana, MDMA, and/or methamphetamine at least once in the previous 12 months. A convenience sampling method was utilized (via Facebook). **Results:** The drug driving proportion of the sample (58%) reported a total of 30,858 instances of drug driving, or 66 instances on average. Seeing RDT in the previous 12 months (26% of sample) was more common than being tested at RDT (7%). The results indicated that seeing RDT two or more times was related to increased certainty of apprehension (compared to those who had seen it only once or never), although the increase was relatively small. Correlational analyses suggest there were some positive (albeit weak relationships) between exposure to RDT (seen and tested) and past and future offending. However, only three significant predictors of future offending emerged: older age, lower perceptions of apprehension certainty, and greater use of marijuana. **Practical Applications:** The results illuminate the extent of the drug driving problem and the need for greater resourcing to increase the real threat of detection. While the effect of exposure to enforcement was small, it was positive, incremental and supportive of increased roadside police enforcement as well as further research to quantify such deterrent processes.

- **Keywords:** Drug driving; Roadside drug testing; Exposure; Deterrence

Federica Caffaro, Michele Roccato, Giulia de Paolis, Margherita Micheletti Cremasco, Eugenio Cavallo. *Promoting farming sustainability: The effects of age, training, history of accidents and social-psychological variables on the adoption of on-farm safety behaviors*. Pages 371-379.

Introduction: Occupational safety and health (OSH) have a remarkable impact on the sustainability of firms and organizations. However, the sustainability perspective has often focused primarily on environmental and economic concerns, leaving key social and workplace aspects, such as OSH, underemphasized. The link between all these aspects is

particularly relevant in agriculture. **Method:** In the present study we analyzed the paths by which the worker's age, participation in safety training, and previous history of accidents and near misses can influence the adoption of safety behaviors in agriculture through the mediation of attitudes towards safety and perceived behavioral control. Three hundred and ten Italian agricultural operators were administered an ad-hoc questionnaire. **Results:** Having attended safety training courses, having been exposed to previous accidents and near misses, and age showed a positive association with the adoption of on-farm safety behaviors, through the mediation of perceived behavioral control. In more detail, participation in training courses and age showed a positive association with perceived behavioral control, while the previous history of accidents and near misses showed a negative association with behavioral control. In turn, perceived behavioral control was positively associated with the adoption of safety behaviors. **Conclusions:** The present study focused on the chain of events leading to the adoption of on-farm safety behaviors, which can prevent an accidents, pointing out the more critical variables and the level at which they intervene, identifying possible areas of targeted interventions. **Practical applications:** Implications for the development of targeted interventions may deal with: (a) training activities increasing farm operators' sense of control over their safety, (b) older farmers involvement in mentoring initiatives, and (c) systematic recording and use of previous history of accidents and near misses as inputs for training activities to discuss their implications for on-farm safety.

- **Keywords:** Occupational safety; Sustainable agriculture; Theory of Planned Behavior; Safety training; Near misses; Italy

S.M. Sohel Mahmud, Luis Ferreira, Md. Shamsul Hoque, Ahmad Tavassoli. *Overtaking risk modeling in two-lane two-way highway with heterogeneous traffic environment of a low-income country using naturalistic driving dataset*. Pages 380-390.

Introduction: Driver behavior related to overtaking maneuvers, which are considered a major safety risk determinant on two-lane two-way highway in low- and middle-income countries (LMIC), are an important subject of further analysis. This study evaluates safety risk in terms of nature and severity of probable conflicts during overtaking maneuvers on a bi-directional undivided two-lane highway in a heterogeneous traffic environment of a low-income country. Nature and severity of probable conflicts were defined with the application of surrogate safety proximity indicators in real-world naturalistic driving environment. **Method:** A risk severity model for overtaking maneuver was developed to better understand the significant factors associated with the probability of conflict and its severity during overtaking maneuver using discrete choice modeling approaches. The relevance of three alternate discrete outcome frameworks, namely multinomial logit (ML), ordered probit (OP), and mixed logit (MXL) models are addressed. The best fitted model is identified and estimated. The impact of the significant attributes was also evaluated. The study collected data from a section of two-lane highway in Bangladesh using naturalistic driving from both observational and computer vision techniques. A total of 46 explanatory variables related to overtaking maneuver are assessed. **Results:** Speed differential between overtaking and overtaken vehicles have a significant impact on the probability of severe conflicts. Moreover, the presence of a bus as an overtaking vehicle was found to contribute significantly to the severity of conflicts. **Conclusions:** The study makes substantial research contributions related to overtaking behavior and safety risk evaluation during overtaking in mixed traffic environment in low-income countries. The results can be used as a proactive tool for the evaluation of overtaking maneuvers and associated safety risk, and making policy decisions reducing safety risk during overtaking maneuver as well as overall safety, while acknowledging the limited resources and facilities in low-income countries.

- **Keywords:** Overtaking Maneuver; Conflict; Safety risk; Modeling; Mixed logit; Heterogeneous traffic

Anas Alrejjal, Ahmed Farid, Khaled Ksaibati. *Investigating factors influencing rollover crash risk on mountainous interstates*. **Pages 391-398.**

Introduction: The risk of rollover crashes on mountainous roads is a major concern for transportation authorities due to adverse weather conditions and complex topography. Such crashes incur hazardous consequences on road users' lives. Therefore, it is crucial to identify the contributing factors that give rise to these severe crashes in order to identify preventive measures. Furthermore, exploring the potential sources of heterogeneity of rollover crash contributing factors is equally important. **Method:** By having a dataset of single-vehicle crashes that occurred on mountainous curved sections in Wyoming, we applied a random parameters, otherwise known as mixed, logit model to identify the factors contributing to the increased risk of rollovers. Vehicle, driver, roadway, environmental, and crash attributes variables were considered as potential predictors in the model. Then, random parameters were identified to uncover the unobserved effects. **Results:** Weather, road surface conditions, and speeding were found to have a significant impact on rollover crash risk. These factors were also found to exhibit unobserved heterogeneity effects, which could be attributed to the drivers' responses and conditions. Furthermore, it was found that the propensity of rollovers was higher for sports utility vehicles (SUVs) and pick-up trucks among other vehicle types. **Conclusions:** The results indicated that investigating the impact of these factors on the risk of rollovers while taking into account unobserved heterogeneity effects is an essential step for implementing countermeasures to reduce the frequency and severity of rollover crashes. **Practical applications:** This study uncovered insights into the factors that lead vehicles to overturn. This aids in suggesting appropriate safety countermeasures that mitigate the occurrences of rollover crashes to transportation agencies.

- **Keywords:** Rollover crashes; Unobserved heterogeneity effects; Random parameters; Mountainous terrain

Daniel V. McGehee, Cheryl A. Roe, Pranaykumar Kasarla, Chao Wang. *Quantifying and recommending seat belt reminder timing using naturalistic driving video data*. **Pages 399-407.**

Introduction: To better understand the timing of when people buckle their seat belt, an analysis of a naturalistic driving study was used. The study provided a unique perspective inside of the vehicle where the entire seat belt was visible from the time the driver entered the vehicle to one minute of driving forward or 32 kph. **Method:** Seat belt buckling behavior was identified for 30 drivers. An additional 10 drives for 13 of these drivers were identified for a seat belt sequencing, which identified the points when the vehicle was put into ignition, shifted, when vehicle movement began, and when the seat belt was buckled. The speed at belt closure was also identified. The timing from ignition to buckle and to shifting into forward gear were examined to identify the speed and appropriate timing for seat belt reminders. **Results:** The data show that drivers were buckled in over 92% of the 3,102 drives. In addition, in 70% of those total drives, the drivers were buckled before the vehicle began movement. Of greater interest for seat belt reminders/interlocks are those drives when drivers buckle after movement. When considering time from ignition to seat belt closure, the mean was 27.5 s. Because higher speeds are typically reached when traveling forward rather than reverse, it was important to know the time duration from shifting into drive to buckling. With this consideration, the mean to buckle dropped to 16.2 s. The mean speed at buckling when traveling forward was 15.3 kph. From the regression analysis, the input variables 'Age,' 'Sex,' 'Weight,' 'Environment,' and 'Weather' are significant contributors in predicting the log odds of a driver putting on seatbelt. **Conclusions:** With the understanding that higher speeds lead to an increased risk of injury and/or death and with the results of the analysis, a recommendation of a 30 s time from forward shift and a 25 kph (6.9 m/s)

threshold for reminder systems should be implemented. The regression analysis also validates that most of the predicted seat belt buckling times are within 30 s. **Practical Applications:** This would reduce perception of nuisance alerts and protect the driver from higher speed unbuckled crashes. The seat belt buckling time prediction model also demonstrates good potential for developing tailored buckling warning system for different drivers.

- **Keywords:** Seat belt; Nuisance alarm; Safety interlock; Buckle timing

David Wilbanks, Richard Kilpatrick, Yousif Abulhassan. *Key stakeholder perceptions of select forward mobile equipment pedestrian alarms*. Pages 408-415.

Introduction: Workplace interactions between pedestrians and industrial mobile equipment often result in workplace fatalities. Employers are normally required to provide pedestrian warning alarms for reverse travel only, though forward travel accidents may comprise as much as 50% of all related fatalities. **Method:** This study was conducted to compare unique configurations of common pedestrian warning alarms to determine whether worker role or equipment configuration were significant independent variables of worker perception of forward alarm irritation and excellent warning characteristics, and whether forward alarms are perceived to be important. **Results:** While worker role was not found to be a significant variable, select alarm configuration properties were found to be significant. **Practical Applications:** The results of the study suggest that a combination of broadband and light emitting diode devices are preferential to all other configurations studied.

- **Keywords:** Alarms; Worker perception; Mobile equipment; Noise; Pedestrian safety

Junyu Hang, Xuedong Yan, Xiaomeng Li, Ke Duan, Jingsi Yang, Qingwan Xue. *An improved automated braking system for rear-end collisions: A study based on a driving simulator experiment*. Pages 416-427.

Introduction: To assist drivers in avoiding rear-end collisions, many early warning systems have been developed up to date. Autonomous braking technology is also used as the last defense to ensure driver's safety. **Method:** By taking the accuracy and timeliness of automatic system control into account, this paper proposes a rear-end Real-Time Autonomous Emergency Braking (RTAEB) system. The system inserts brake intervention based on drivers' real-time conflict identification and collision avoidance performance. A driving simulator-based experiment under different traffic conditions and deceleration scenarios were conducted to test the different thresholds to trigger intervention and the intervention outcomes. The system effectiveness is verified by four evaluation indexes, including collision avoidance rate, accuracy rate, sensitivity rate, and precision rate. **Results:** The results showed that the system could help avoid all collision events successfully and enlarge the final headway distance, and a TTC threshold of 1.5 s and a maximum deceleration threshold of -7.5 m/s2 could achieve the best collision avoidance effect. The paper demonstrates the situations that are more inclined to trigger the RTAEB (i.e., a sudden brake of the leading vehicle and a small car-following distance). Moreover, the study shows that driver characteristics (i.e., gender and profession) have no significant association with system trigger. **Practical Applications:** The study suggests that development of collision avoidance systems design should pay attention to both the real-time traffic situation and drivers' collision avoidance capability under the present situation.

- **Keywords:** Rear-end collision; AEB; Driving simulator; Collision avoidance

Jesús P. Barrero, Susana García-Herrero, Miguel A. Mariscal. *Influence of noise level and seniority in the workplace on the SAL, ELI and percentage of hearing loss indices in the diagnosis and prevention of hearing loss in the working population*. Pages 428-440.

Introduction: This research relates the most important work-related factors affecting the development of hearing loss to the main methods used as medical assessment criteria in the diagnosis of occupational deafness. These criteria are the Speech Average Loss Index (SAL), the Early Loss Index (ELI) and the Percentage of Hearing Loss, and are applied to data obtained from audiograms performed on workers in occupational medical examinations. **Method:** Depending on the assessment method selected, these often return different results in grading an individual's hearing status and predicting how it will evolve. To address this problem, medical examinations (including audiograms) were carried out on a heterogeneous sample of 1,418 workers in Spain, from which demographic or personal data (gender, age, etc.), occupational data (noise level to which each individual is exposed, etc.) and other non-work-related factors (exposure to noise outside work, family history, etc.) were also gathered. Using Bayesian Networks, the conditional probability of an individual developing hearing loss was obtained taking into account all these factors and, specifically, noise level and length of service in the workplace. Sensitivity analyses were also carried out using the three scales (SAL, ELI and Percentage Hearing Loss Index), proving their suitability as tools the diagnosis and prediction of deafness. These networks were validated under the Receiver Operating Characteristic curve (ROC) criterion and in particular by the Area Under the Curve (AUC). **Results:** The results show that all three methods are deficient in so far as detecting preventive hearing problems related to noise in most workplaces. **Conclusions:** The most restrictive methods for detecting possible cases of deafness are the SAL index and the Percentage Loss Index. The ELI index is the least restrictive of the three methods, but it is not able to discriminate the causes of hearing problems in an individual caused by exposure to noise, either by its intensity level or by the time of exposure to noise. **Practical Applications:** The use of the three methods in the field of occupational risk prevention is extremely limited and it seems reasonable to think that there is a need for the construction of new scales to correct or improve the existing ones.

▪ **Keywords:** Hearing loss; Bayesian network; SAL; ELI; Percentage; Noise level

David M. Goldberg. *Characterizing accident narratives with word embeddings: Improving accuracy, richness, and generalizability*. Pages 441-455.

Introduction: Ensuring occupational health and safety is an enormous concern for organizations, as accidents not only harm workers but also result in financial losses. Analysis of accident data has the potential to reveal insights that may improve capabilities to mitigate future accidents. However, because accident data are often transcribed textually, analyzing these narratives proves difficult. This study contributes to a recent stream of literature utilizing machine learning to automatically label accident narratives, converting them into more easily analyzable fields. **Method:** First, a large dataset of accident narratives in which workers were injured is collected from the U.S. Occupational Safety and Health Administration (OSHA). Word embeddings-based text mining is implemented; compared to past works, this methodology offers excellent performance. Second, to improve the richness of analyses, each record is assessed across five dimensions. The machine learning models provide classifications of body part(s) injured, the source of the injury, the type of event causing the injury, whether a hospitalization occurred, and whether an amputation occurred. Finally, demonstrating generalizability, the trained models are deployed to analyze two additional datasets of accident narratives in the construction industry and the mining and metals industry

(transfer learning). **Practical Applications:** These contributions improve organizations' capacities to rapidly analyze textual accident narratives.

- **Keywords:** Occupational safety; Text mining; Word embeddings; Machine learning; Transfer learning

Brandon Nesbit, Ina Robinson, Shenee Bryan. *A national landscape: Injury and violence prevention health equity scan findings and implications for the field of practice*. Pages 457-462.

Introduction: Many federal and national partners have a renewed commitment to addressing health equity and racial equity as a public health issue of concern. These are especially important issues in addressing many injury and violence prevention (IVP) topic areas. In developing and updating approaches to address injury and violence-related health and racial equity challenges, CDC and Safe States Alliance wanted to better understand how partners in the field are already approaching these issues. An environmental scan was conducted to explore how IVP professionals advance health equity and racial equity in their programmatic work. **Methods:** Data collection occurred from multiple sources including focus groups and surveys. Health equity and racial equity-related questions were added to the Safe States Member Survey: Evaluating the Impact of COVID-19 on the IVP Workforce and Assessing Equity Initiative (COVID Impact and Equity Survey). An analysis of secondary data sources was conducted through ongoing evaluation initiatives at Safe States Alliance (the COVID Impact Evaluation and Connections Lab Evaluation Focus Groups). **Conclusions:** Successes and challenges were identified through the environmental scan that primarily fell into three categories: (1) Injury and Violence Prevention Strategies and Programs, (2) Using IVP Data to Inform Equity Approaches, (3) Equity Approaches in IVP Infrastructure. **Practical Applications:** Practical applications were identified that can be supported at the local, state, and federal/national level and are specific to the areas of IVP strategies and programs, IVP data and surveillance, and IVP organizational infrastructure. A few examples include: (1) Ensuring decision-making power and ownership of programs is shared between community partners and funders; (2) Working with national/federal surveillance system partners to ensure demographic fields/variables are improved to identify disparities and inequities; (3) Development of an "Injury and Violence Prevention Equity Institute" to better prepare IVP professionals to address health and racial equity challenges.

- **Keywords:** Health equity; Racial equity; Social determinants of health; Health disparities; Injury and violence prevention