Journal of Safety Research – rok 2020, Volume 76

February 2021

James Freeman, Alexander Parkes, Verity Truelove, Naomi Lewis, Jeremy D. Davey. *Does seeing it make a difference? The self-reported deterrent impact of random breath testing*. Pages 1-8.

Introduction: Random Breath Testing (RBT) remains a primary method to both deter and apprehend drink drivers, yet a large proportion of road fatalities continue to be caused by the offense. Outstanding questions remain regarding how much exposure to RBT operations is needed to influence deterrence-based perceptions and subsequent offending. **Method:** Given this, licensed motorists (N = 961) in Queensland were recruited to complete a questionnaire either in the community (N = 741) or on the side of the road after just being breath tested (N = 243). Survey items measured different types of exposure to RBT operations (e.g. "seen" vs. "being tested") and subsequent perceptions of apprehension as well as self-reported drink driving behaviors. **Results:** The key findings that emerged were: motorists were regularly exposed to RBT operations (both viewing and being tested), such exposure was not significantly correlated with perceptions of apprehension certainty, and a sizable proportion reported engaging in drink driving behaviors (e.g., approx. 25%), although roadside participants naturally reported a lower percentage of offending behaviors. Importantly, it was revealed that current "observations" of RBT was sufficient, but not actual levels of active testing (which needed to be doubled). Nevertheless, higher levels of exposure to RBT operations was found to be predictive of a lack of intention to drink and drive again in the future. **Conclusions:** This paper suggests that mere exposure to enforcement may not create the intended rule compliance, and that the frequency of exposure is also essential for the roadside.

- **Keywords:** Drink driving; Random breath testing; Exposure

Judd H. Michael, Serap Gorucu. *Non-occupational injuries caused by transport packaging: Residential and retail hazards*. Pages 9-15.

Background: Pallets are key components of domestic supply chains, and yet present unique hazards when used by homeowners and retailers for unintended uses. No previous works have investigated non-occupational injuries that occur due to unintentional contact with pallets. This study sought to describe the incidence and epidemiology of non-occupational pallet-related injuries as seen in United States emergency departments (EDs). **Method:** The National Electronic Injury Surveillance System database was used to derive national, weighted estimates of pallet-related injuries by age, sex, injured body part, and location where injury occurred. Data for the

years 2014 to 2018 were analyzed with all relevant narratives reviewed. **Results:** From 2014 to 2018, there were an estimated 30,493 persons who visited an ED for a pallet-related injury. The yearly incidence of pallet injuries rose during this period. The 35–44 age group (n = 5,481) was most likely to be injured, but about 3,000 children and youth under 18 years of age were injured and more than 4,000 persons 65 years of age or older suffered injuries. The elderly were especially likely to suffer injuries from slip, trip and fall incidents. The lower extremities were the most commonly injured body parts. An estimated 3,964 persons, accounting for approximately 14% of all pallet-related injuries, were treated for injuries incurred while at a retail establishment. African Americans, Hispanics, and the elderly appeared to be disproportionately more likely to have pallet-related injuries in retail locations. **Conclusions:** Non-occupational pallet-related injuries affect a wide range of patients and cause a variety of injuries, with the elderly being especially vulnerable to tripping incidents. Retailer prevention strategies should focus on the misuse of pallets for merchandising purposes. Industry should maintain control of pallets so they are not used for unintended purposes. **Practical applications:** Retailers should limit the use of pallets for floor-level merchandising purposes and remove pallets from customer-facing locations where unintentional contact could occur. Owners of pallets should maintain them in a controlled supply chain so that they don't leak out into the hands of homeowners. Policy-makers should educate the public about the dangers of used pallets.

- **Keywords:** Packaging; Pallets; NEISS; Epidemiology; Retail; Household

Zheng Xu, Xin Zou, Taeho Oh, Hai L. Vu. *Studying freeway merging conflicts using virtual reality technology*. Pages 16-29.

Introduction: This research aims to investigate the perceptions and reactions of drivers regarding freeway merging situation, utilizing a new approach with the basis of a multilevel simulation platform which incorporates virtual reality (VR) technology. **Methods:** A VR driving environment integrated with traffic micro-simulation was developed to evaluate driving behaviors and the impact of merging decisions in terms of traffic conflicts. The driving experiments were conducted under a variety of circumstances, including varying traffic flows and the presence of ramp metering. The Surrogate Safety Assessment Model (SSAM) was utilized to extract the number of conflicts from the micro-simulation results. **Results:** The final results indicated that the probability of conflict has a positive correlation with traffic flow, while conflict frequency at freeway merges is affected by the presence of ramp metering due to its potentiality to enhance driver decisions and reduce the drivers' pressure when they make maneuvers. **Practical Applications:** The findings reveal that the proposed VR simulation platform is a useful tool to improve the safety of freeway merging. It has the potential to enhance driver skills and can also be used in the study of human–machine interaction.

- **Keywords:** Merging conflicts; Virtual reality; Traffic micro-simulation; Safety analysis

Emmanuel Kofi Adanu, Abhay Lidbe, Elsa Tedla, Steven Jones. *Injury-severity analysis of lane change crashes involving commercial motor vehicles on interstate highways*. Pages 30-35.

Introduction: One of the challenging tasks for drivers is the ability to change lanes around large commercial motor vehicles. Lane changing is often characterized by speed, and crashes that occur due to unsafe lane changes can have serious consequences. Considering the economic importance of commercial trucks, ensuring the safety, security, and resilience of freight transportation is of paramount concern to the United States Department of Transportation and other stakeholders. **Method:** In this study, a mixed (random parameters) logit model was developed to better understand the relationship between crash factors and associated injury severities of commercial vehicle crashes

involving lane change on interstate highways. The study was based on 2009–2016 crash data from Alabama. **Results:** Preliminary data analysis showed that about 4% of the observed crashes were major injury crashes and drivers of commercial motor vehicles were at-fault in more than half of the crashes. Acknowledging potential crash data limitations, the model estimation results reveal that there is increased probability of major injury when lane change crashes occurred on dark unlit portions of interstates and involve older drivers, at-fault commercial vehicle drivers, and female drivers. The results further show that lane change crashes that occurred on interstates with higher number of travel lanes were less likely to have major injury outcomes. **Practical Applications:** These findings can help policy makers and state transportation agencies increase awareness on the hazards of changing lanes in the immediate vicinity and driving in the blind spots of large commercial motor vehicles. Additionally, law enforcement efforts may be intensified during times and locations of increased unsafe lane changing activities. These findings may also be useful in commercial vehicle driver training and driver licensing programs.

- **Keywords:** lane change; Crash severity; Commercial motor vehicles; interstate crashes

Mette Møller, Kira Hyldekaer Janstrup, Ninette Pilegaard. *Improving knowledge of cyclist crashes based on hospital data including crash descriptions from open text fields*. Pages 36-43.

Introduction: In this study we explore the added value of bicycle crash descriptions from open text fields in hospital records from the Aarhus municipality in Denmark. We also explore how bicycle crash data from the hospital complements crash data registered by the police in the same area and time period. **Method:** The study includes 5,313 Danish bicycle crashes, of which 4,205 were registered at the hospital and 1,078 by the police. All crashes occurred from 2010 to 2015. We performed an in-depth analysis of the open text fields on hospital records to identify factors associated with each crash using four categories: bicyclist, road, bicycle, and the other party. We employed the chi-squared test to compare the distribution of variables between crashes registered at the hospital and by the police. A binary logit model was used to estimate the probability that a crash factor is identified, and that each crash factor is associated with a single-bicycle crash. **Results:** The open-ended text fields in hospital records provide detailed information about crash factors not available in police records, including riding speed, inattention, clothing, specific road conditions, and bicycle defects. The factors alcohol and curb had the highest odds of being identified in relation to a single-bicycle crash. Crash data registered at the hospital included a larger number of bicycle crashes, particularly single-bicycle crashes and crashes with slight injuries only. Conclusion: Crash information registered at the hospital in Aarhus Municipality contributes to a better understanding of bicycle crashes due to detailed information about crash-associated factors as well as information about a larger number of bicycle crashes, particularly single-bicycle crashes. Practical implication: Efforts to improve access to detailed information about bicycle crashes are needed to provide a better basis for bicycle crash prevention.

- **Keywords:** Underreporting; In-depth analysis; Bicycle safety; Crash analysis; Binary logit model

Kai Wang, Tanmoy Bhowmik, Shanshan Zhao, Naveen Eluru, Eric Jackson. *Highway safety assessment and improvement through crash prediction by injury severity and vehicle damage using Multivariate Poisson-Lognormal model and Joint Negative Binomial-Generalized Ordered Probit Fractional Split model*. Pages 44-55.

Introduction: Predicting crash counts by severity plays a dominant role in identifying roadway sites that experience overrepresented crashes, or an increase in the potential for crashes with higher severity levels. Valid and reliable methodologies for predicting highway accidents by severity are necessary in assessing contributing factors to severe highway crashes, and assisting the practitioners in allocating safety improvement resources. **Methods:** This paper uses urban and suburban intersection data in Connecticut, along with two sophisticated modeling approaches, i.e. a Multivariate Poisson-Lognormal (MVPLN) model and a Joint Negative Binomial-Generalized Ordered Probit Fractional Split (NB-GOPFS) model to assess the methodological rationality and accuracy by accommodating for the unobserved factors in predicting crash counts by severity level. Furthermore, crash prediction models based on vehicle damage level are estimated using the same two methodologies to supplement the injury severity in estimating crashes by severity when the sample mean of severe injury crashes (e.g., fatal crashes) is very low. **Results:** The model estimation results highlight the presence of correlations of crash counts among severity levels, as well as the crash counts in total and crash proportions by different severity levels. A comparison of results indicates that injury severity and vehicle damage are highly consistent. **Conclusions:** Crash severity counts are significantly correlated and should be accommodated in crash prediction models. Practical application: The findings of this research could help select sound and reliable methodologies for predicting highway accidents by injury severity. When crash data samples have challenges associated with the low observed sampling rates for severe injury crashes, this research also confirmed that vehicle damage can be appropriate as an alternative to injury severity in crash prediction by severity.

- **Keywords:** Crash prediction by severity; Crash severity surrogate; Unobserved heterogeneity; Multivariate model; Joint fractional split model

Huarong Wang, Casie Morgan, Dongqian Li, Rong Huang, David C. Schwebel. *Children's fear in traffic and its association with pedestrian decisions*. Pages 56-63.

Introduction: Research on risk for child pedestrian injury risk focuses primarily on cognitive risk factors, but emotional states such as fear may also be relevant to injury risk. The current study examined children's perception of fear in various traffic situations and the relationship between fear perception and pedestrian decisions. **Method:** 150 children aged 6–12-years old made pedestrian decisions using a table-top road model. Their perceived fear in the pedestrian context was assessed. **Results:** Children reported greater emotional fear when they faced quicker traffic, shorter distances from approaching traffic, and red rather than green traffic signals. Children who were more fearful made safer pedestrian decisions in more challenging traffic situations. However, when the least risky traffic situation was presented, fear was associated with more errors in children's pedestrian decisions: fearful children failed to cross the street when they could have done so safely. Perception of fear did not vary by child age, although safe pedestrian decisions were more common among the older children. **Conclusions:** Children's emotional fear may predict risk-taking in traffic. When traffic situations are challenging to cross within, fear may appropriately create safer decisions. However, when the traffic situation is less risky, feelings of fear could lead to excessive caution and inefficiency. **Practical applications:** Child pedestrian safety interventions may benefit by incorporating activities that introduce realistic fear of traffic risks into broader safety lessons.

- **Keywords:** Pedestrian; Children; Fear; Traffic situation; Pedestrian decision

Yanchao Song, Siyuan Kou, Chen Wang. *Modeling crash severity by considering risk indicators of driver and roadway: A Bayesian network approach*. Pages 64-72.

Introduction: Traffic crashes could result in severe outcomes such as injuries and deaths. Thus, understanding factors associated with crash severity is of practical importance. Few studies have deeply examined how prior violation and crash experience of drivers and roadways are associated with crash severity. **Method:** In this study, a set of risk indicators of road users and roadways were developed based on their prior violation and crash records (e.g., cumulative crash frequency of a roadway), in order to reflect certain aspect or degree of their driving risk. To explore the impacts of those indicators on crash severity and complex interactions among all contributing factors, a Bayesian network approach was developed, based on citywide crash data collected in Kunshan, China from 2016 to 2018. A variable selection procedure based on Information Value (IV) was developed to identify significant variables, and the Bayesian network was employed to explicitly explore statistical associations between crash severity and significant variables. **Results:** In terms of balanced accuracy and AUCs, the proposed approach performed reasonably well. Bayesian modeling results indicated that the prior crash/violation experiences of road users and roadways were very important risk indicators. For example, migrant workers tend to have high injury risk due to their dangerous violation behaviors, such as retrograding, red-light running, and right-of-way violation. Furthermore, results showed that certain variable combinations had enhanced impacts on severity outcome than single variables. For example, when a migrant worker and a non-motorized vehicle are involved in a crash happening on a local road with high cumulative violation frequency in the previous year, the probability for drivers suffering serious injury or fatality is much higher than that caused by any single factor. **Practical applications:** The proposed methodology and modeling results provide insights for developing effective countermeasures to reduce crash severity and improve traffic system safety performance.

- **Keywords:** Bayesian network; Information value; Crash severity; Risk indicators

Seyed Alireza Samerei, Kayvan Aghabayk, Amin Mohammadi, Nirajan Shiwakoti. *Data mining approach to model bus crash severity in Australia*. Pages 73-82.

Introduction: Buses are different vehicles in terms of dimensions, maneuverability, and driver's vision. Although bus traveling is a safe mode to travel, the number of annual bus crashes cannot be neglected. Moreover, limited studies have been conducted on the bus involved in fatal crashes. Therefore, identification of the contributing factors in the bus involved fatal crashes can reduce the risk of fatality. **Method:** Data set of bus involved crashes in the State of Victoria, Australia was analyzed over the period of 2006–2019. Clustering of crash data was accomplished by dividing them into homogeneous categories, and by implementing association rules discovery on the clusters, the factors affecting fatality in bus involved crashes were extracted. **Results:** Clustering results show bus crashes with all vehicles except motor vehicles and weekend crashes have a high rate of fatality. According to the association rule discovery findings, the factors that increase the risk of bus crashes with non-motor vehicles are: old bus driver, collision with pedestrians at signalized intersections, and the presence of vulnerable road users. Likewise, factors that increase the risk of fatality in bus involved crashes on weekends are: darkness of roads in high-speed zones, pedestrian presence at highways, bus crashes with passenger car by a female bus driver, and the occurrence of multi-vehicle crashes in high-speed zones. **Practical Applications:** The study provides a sequential pattern of factors, named rules that lead to fatality in bus involved crashes. By eliminating or improving one or all of the factors involved in rules, fatal bus crashes may

be prevented. The recommendations to reduce fatality in bus crashes are: observing safe distances with the buses, using road safety campaigns to reduce pedestrians' distracted behavior, improving the lighting conditions, implementing speed bumps and rumble strips in high-speed zones, installing pedestrian detection systems on buses and setting special bus lanes in crowded areas.

- **Keywords:** Bus involved crashes; Crash severity; Public transport; Clustering; Association rule discovery

Jonathan Davis, Cara Hamann, Brandon D. Butcher, Corinne Peek-Asa. *Medical referral and license disposition for drivers in Iowa*. Pages 83-89.

Introduction: Driver retirement and determination of fitness-to-drive are important aspects of reducing the risk of motor-vehicle collision for an older driver. A lack of information about the review process may lead to poor evaluation of drivers or an increased testing burden to referred drivers. **Methods:** This paper evaluates the license review process for the state of Iowa. We evaluated data from January 2014 to January 2018 and described the source of referral, testing process, and ultimate license disposition. Cox proportional hazards for competing risk were used to determine the risk of having a change in restrictions on the license and the risk of license denial. **Results:** 20,742 individuals were followed through the medical referral process. The most common source of referrals was licensing officials (39.7%). Drivers referred by licensing officials were less likely to be denied their license when compared to drivers from other sources (HR = 0.92 95%CI: 0.87–0.98); however, licensing official referrals were more likely to result in license restrictions compared to other sources (HR = 1.91, 95%CI: 1.82–2.00). Drivers referred by either law enforcement or a physician were more likely to ultimately have their license denied. **Conclusions:** Physician and law enforcement referred the drivers most likely to have their license denied. A smaller proportion of drivers were referred by physicians and law enforcement compared to licensing officials. **Practical Applications:** Licensing agencies should work with physicians and law enforcement to identify drivers who may need a review of their license. Comprehensive tracking of all medical referrals for a driver's license review is important for individual states to understand the burden of their driver referral process and for identifying referral sources with a high proportion of referrals with no licensing change for targeted outreach and education.

- **Keywords:** Driver licensing; Fitness to drive; Motor vehicle crash; Older adult; Older driver

Haojie Li, Manman Zhu, Daniel J. Graham, Gang Ren. *Evaluating the speed camera sites selection criteria in the UK*. Pages 90-100.

Introduction: Speed cameras have been implemented to improve road safety over recent decades in the UK. Although the safety impacts of the speed camera have been estimated thoroughly, the criteria for selecting camera sites have rarely been studied. This paper evaluates the current speed camera sites selection criteria in the UK based on safety performance. **Method:** A total of 332 speed cameras and 2,513 control sites with road traffic accident data are observed from 2002 to 2010. Propensity score matching method and empirical Bayes method are employed and compared to estimate the safety effects of speed cameras under different scenarios. **Results:** First, the main characteristics of speed cameras meeting and not meeting the selection criteria are identified. The results indicate that the proximity to school zones and residential neighborhoods, as well as population density, are the main considerations when selecting speed camera sites. Then the official criteria used for selecting camera sites are evaluated, including site length (a stretch of road that has a fixed speed camera or has had one in the past), previous accident history, and risk value (a numerical scale of the risk level). The results suggest that a site length of 500 m should be used to achieve the

optimum safety effects of speed cameras. Furthermore, speed cameras are most effective in reducing crashes when the requirement of minimum number of historical killed and seriously injured collisions (KSIs) is met. In terms of the risk value, it is found that the speed cameras can obtain optimal effectiveness with a risk value greater than or equal to 30, rather than the recommended risk value of 22.

- **Keywords:** Speed Cameras; Selection Criteria; Propensity Score Matching; Empirical Bayes

Zijing Lin, Wei (David) Fan. *Exploring bicyclist injury severity in bicycle-vehicle crashes using latent class clustering analysis and partial proportional odds models*. Pages 101-117.

Introduction: Bicyclists are more vulnerable compared to other road users. Therefore, it is critical to investigate the contributing factors to bicyclist injury severity to help provide better biking environment and improve biking safety. According to the data provided by National Highway Traffic Safety Administration (NHTSA), a total of 8,028 bicyclists were killed in bicycle-vehicle crashes from 2007 to 2017. The number of fatal bicyclists had increased rapidly by approximately 11.70% during the past 10 years (NHTSA, 2019). **Methods:** This paper conducts a latent class clustering analysis based on the police reported bicycle-vehicle crash data collected from 2007 to 2014 in North Carolina to identify the heterogeneity inherent in the crash data. First, the most appropriate number of clusters is determined in which each cluster has been characterized by the distribution of the featured variables. Then, partial proportional odds models are developed for each cluster to further analyze the impacts on bicyclist injury severity for specific crash patterns. **Results:** Marginal effects are calculated and used to evaluate and interpret the effect of each significant explanatory variable. The model results reveal that variables could have different influence on the bicyclist injury severity between clusters, and that some variables only have significant impacts on particular clusters. **Conclusions:** The results clearly indicate that it is essential to conduct latent class clustering analysis to investigate the impact of explanatory variables on bicyclist injury severity considering unobserved or latent features. In addition, the latent class clustering is found to be able to provide more accurate and insightful information on the bicyclist injury severity analysis. **Practical Applications:** In order to improve biking safety, regulations need to be established to prevent drinking and lights need to be provided since alcohol and lighting condition are significant factors in severe injuries according to the modeling results.

- **Keywords:** Bicycle-involved crashes; Injury severity; Latent class analysis; Partial proportional odds models

Craig Lyon, Steve Brown, Ward Vanlaar, Robyn Robertson. *Prevalence and trends of distracted driving in Canada*. Pages 118-126.

Introduction: This study evaluates prevalence and trends in distracted driving in Canada based on multiple indicators collected from the Road Safety Monitor (RSM) and Canada's National Fatality Database maintained by the Traffic Injury Research Foundation (TIRF). **Method:** Data from the RSM on self-reported distracted driving behaviors were analyzed using multivariate techniques including logistic regression analysis in various years spanning from 2004 to 2019. Data from TIRF's National Fatality Database from 2000 to 2016 were also analyzed using piecewise regression analysis to evaluate trends and prevalence of driver distraction. **Results:** Significantly more Canadians reported talking on their phone hands-free or handheld phone while driving in 2019 compared to 2010. There was a 102% increase in the percentage that reported texting while driving in 2019 (9.7%) compared to 2010 (4.8%). For every 10-year increase in age, drivers were 44% less likely to text, 38% less likely to use a handheld phone, and 28% less likely to use a hands-free phone. Males were 62% more likely to

use a handheld phone and 50% more likely to use a hands-free phone than females. Findings related to drivers' perceived danger of distracted driving and attitudes are also presented. Although the number of distraction-related fatalities has not increased substantially from 2000 to 2016, the percentage of all fatalities where distraction was a contributing factor has increased. Unlike drinking drivers, distracted drivers more often kill other road users in crashes than kill themselves. **Conclusions:** In conclusion, while most Canadians appear to understand that one of the high-risk forms of distracted driving (i.e., texting while driving) is indeed dangerous, there is a minority who are unaware of, or resistant to, this fact. **Practical Applications:** Enforcement activities and education initiatives to combat distracted driving ought to be tailored to the target audience based on the patterns uncovered.

- **Keywords:** Safety; Distracted driving; Cell phone; Texting; Fatalities; Survey

Douglas D. Boyd, Mark Scharf, David Cross. *A comparison of general aviation accidents involving airline pilots and instrument-rated private pilots*. Pages 127-134.

Introduction: The extremely low accident rate for U.S air carriers relative to that of general aviation (~1 and ~60/million flight hours respectively) partly reflects advanced airman certification, more demanding recurrency training and stringent operational regulations. However, whether such skillset/training/regulations translate into improved safety for airline pilots operating in the general aviation environment is unknown and the aim of this study. **Methods:** Accidents (1998–2017) involving airline pilots and instrument-rated private pilots (PPL-IFR) operating non-revenue light aircraft were identified from the NTSB accident database. An online survey informed general aviation flight exposure for both pilot cohorts. Statistics used proportion testing and Mann-Whitney U tests. **Results:** In degraded visibility, 0 and 40% ($\chi 2$ $p = 0.043$) of fatal accidents involving airline and PPL-IFR airmen were due to in-flight loss-of-control, respectively. For landing accidents, airline pilots were under-represented for mishaps related to airspeed mismanagement ($p = 0.036$) relative to PPL-IFR but showed a disproportionate count (2X) of ground loss-of-directional control accidents ($p = 0.009$) the latter likely reflecting a preference for tail-wheel aircraft. The proportion of FAA rule violation-related mishaps by airline pilots was >2X (7 vs. 3%) that for PPL-IFR airmen. Moreover, airline pilots showed a disproportionate ($\chi 2$ $p = 0.021$) count of flights below legal minimum altitudes. Not performing an official preflight weather briefing or intentionally operating in instrument conditions without an IFR flight plan represented 43% of airline pilot accidents involving FAA rule infractions. **Conclusions:** These findings inform safety deficiencies for: (a) airline pilots, landing/ground operations in tail-wheel aircraft and lack of 14CFR 91 familiarization regulations regarding minimum operating altitudes and (b) PPL-IFR airmen in-flight loss-of-control and poor landing speed management. **Practical Applications:** For PPL-IFR airmen, training/recurrency should focus on unusual attitude recovery and managing approach speeds. Airline pilots should seek additional instructional time regarding landing tail-wheel aircraft and become familiar with 14CFR 91 rules covering minimum altitudes.

- **Keywords:** General aviation; Light aircraft; Flying accidents; Airline pilots; Aviation safety

Laurie Brown, Andrew Morris, Pete Thomas, Karthikeyan Ekambaram, Dimitris Margaritis, Ragnhild Davidse, Davide Shingo Usami, Massimo Robibaro, Luca Persia, Ilona Buttler, Apostolos Ziakopoulos, Athanasios Theofilatos, George Yannis, Alain Martin, Fallou Wadji. *Investigation of accidents involving powered two wheelers and bicycles – A European in-depth study*. Pages 135-145.

Introduction: The number of road fatalities have been falling throughout the European Union (EU) over the past 20 years and most Member States have achieved an overall reduction. Research has mainly focused on protecting car occupants, with car occupant fatalities reducing significantly. However, recently there has been a plateauing in fatalities amongst 'Vulnerable Road Users' (VRUs), and in 2016 accidents involving VRUs accounted for nearly half of all EU road deaths. **Method:** The SaferWheels study collected in-depth data on 500 accidents involving Powered Two-Wheelers (PTWs) and bicycles across six European countries. A standard in-depth accident investigation methodology was used by each team. The Driver Reliability and Error Analysis Method (DREAM) was used to systematically classify accident causation factors. **Results:** The most common causal factors related to errors in observation by the PTW/bicycle rider or the driver of the other vehicle, typically called 'looked but failed to see' accidents. Common scenarios involved the other vehicle turning or crossing in front of the PTW/bicycle. A quarter of serious or fatal injuries to PTW riders occurred in accidents where the rider lost control with no other vehicle involvement. **Conclusions:** Highly detailed data have been collected for 500 accidents involving PTWs or bicycles in the EU. These data can be further analyzed by researchers on a case-study basis to gain detailed insights on such accidents. Preliminary analysis suggests that 'looked but failed to see' remains a common cause, and in many cases the actions of the other vehicle were the critical factor, though PTW rider speed or inexperience played a role in some cases. **Practical Applications:** The collected data can be analyzed to better understand the characteristics and causes of accidents involving PTWs and bicycles in the EU. The results can be used to develop policies aimed at reducing road deaths and injuries to VRUs.

- **Keywords:** Vulnerable road user; Motorcycle; Collision investigation; Crash causation; DREAM

Peter Tuckel. *Recent trends and demographics of pedestrians injured in collisions with cyclists*. Pages 146-153.

Introduction: Despite extensive media coverage of pedestrians who are injured in collisions with cyclists, little systematic inquiry has been carried out on this topic. This study examines the incidence of pedestrian injuries due to collisions with cyclists in the United States and in New York State and New York City (NYC) from 2005 to 2018. **Method:** The study rests on national data derived from the Nationwide Emergency Department Sample (NEDS) and state and local data gathered by the Statewide Planning and Research Cooperative System (SPARCS). A negative binomial regression analysis was performed on the state and local data to measure the simultaneous effects of demographic variables on the incidence of pedestrian injuries. The study also mapped the incidence of injuries in NYC neighborhoods. **Results:** Pedestrian injuries due to collisions with cyclists declined at both the national and state and local levels from 2005 to 2018. The decline was particularly pronounced among school-aged children. In NYC, the distribution of injuries was concentrated in certain neighborhoods. **Conclusions:** Possible explanations for the decline in injuries include the change in the age composition of NYC's population, the greater level of physical inactivity among school-aged children, stricter enforcement of traffic laws, and, importantly, improvements in the cycling infrastructure. **Practical Applications:** Cycling as a mode of transportation is continuing to grow in popularity, particularly in large cities in the United States and Europe. With this upsurge in popularity, it is important to create a safe environment for all road users.

Improvements in the cycling infrastructure (especially the installation of protected bike lanes) reduce hazards not only to cyclists but to pedestrians as well.

- **Keywords:** Pedestrians; Cyclists; Injuries; Collisions; Epidemiology

Yalong Yuan, Min Yang, Yanyong Guo, Soora Rasouli, Zuoxian Gan, Yifeng Ren. *Risk factors associated with truck-involved fatal crash severity: Analyzing their impact for different groups of truck drivers*. Pages 154-165.

Introduction: Fatal crashes that include at least one fatality of an occupant within 30 days of the crash cause large numbers of injured persons and property losses, especially when a truck is involved. **Method:** To better understand the underlying effects of truck-driver-related characteristics in fatal crashes, a five-year (from 2012 to 2016) dataset from the Fatality Analysis Reporting System (FARS) was used for analysis. Based on demographic attributes, driving violation behavior, crash histories, and conviction records of truck drivers, a latent class clustering analysis was applied to classify truck drivers into three groups, namely, ''middle-aged and elderly drivers with low risk of driving violations and high historical crash records," ''drivers with high risk of driving violations and high historical crash records," and ''middle-aged drivers with no driving violations and conviction records." Next, equivalent fatalities were used to scale fatal crash severities into three levels. Subsequently, a partial proportional odds (PPO) model for each driver group was developed to identify the risk factors associated with the crash severity. Results' **Conclusions:** The model estimation results showed that the risk factors, as well as their impacts on different driver groups, were different. Adverse weather conditions, rural areas, curved alignments, tractor-trailer units, heavier weights and various collision manners were significantly associated with the crash severities in all driver groups, whereas driving violation behaviors such as driving under the influence of alcohol or drugs, fatigue, or carelessness were significantly associated with the high-risk group only, and fewer risk factors and minor marginal effects were identified for the low-risk groups. **Practical Applications:** Corresponding countermeasures for specific truck driver groups are proposed. And drivers with high risk of driving violations and high historical crash records should be more concerned.

- **Keywords:** Truck-involved fatal crash; Risk factors; Crash severity; Latent class clustering; Partial proportional odds model

Jon Berrick, Konstantina Gkritza. *Adolescent noncompliance with age-specific versus universal US motorcycle helmet laws: Systematic review and meta-analysis*. Pages 166-175.

Introduction: The U.S. experience with motorcycle helmets affords an important insight into the responses of adolescents to age-specific laws. Political contention has led to a number of U.S. state law changes back and forth between universal and age-specific laws. Because both kinds of law require adolescent motorcyclists to wear helmets, relatively few studies have focused on how the law type affects their behavior. **Method:** Differential behavior is tested by a systematic review of literature, leading to a meta-analysis, in relation to the experience of various states' motorcycle helmet laws. An electronic search was conducted for before-and-after studies in U.S. states that include data on adolescent helmet usage – both with a universally applicable motorcycle helmet law, and with an age-restricted law (usually, under-21 or under-18) – from observational, injury or fatality records for a certain period (e.g., 12 months) pre and post the state law change. **Results:** The search yielded ten studies, including two that compared a set of age-specific law states with a set of universal law states over the same time period. Heterogeneity analysis of seven single-state studies with raw data revealed an acceptable fit for a random-effects model. Additional noncompliance with age-

restricted laws was indicated by an attributable percentage among exposed of over 65% and odds ratio exceeding 4. **Conclusions:** About two-thirds of adolescent noncompliance with age-restricted motorcycle helmet usage laws disappears with universal applicability. Evidence from numerous international studies of youth reaction to helmet laws suggests that a large part of the greater compliance with universal laws is due to their conveying a more convincing message that helmets afford protection against injury. **Practical Applications:** The meta-analysis provides fresh, young-rider perspective on the continuing debate over motorcycle-helmet laws. Broader insight into adolescent psychology suggests considering alternatives to age-restricted laws more widely in safety and health policy.

- **Keywords:** Adolescent psychology; Age-restricted; Attributable percentage among exposed; Threat of apprehension; Youth control

Zhengwu Wang, Shuai Huang, Jie Wang, Denisa Sulaj, Wei Hao, Aiwu Kuang. *Risk factors affecting crash injury severity for different groups of e-bike riders: A classification tree-based logistic regression model*. Pages 176-183.

Introduction: As a convenient and affordable means of transportation, the e-bike is widely used by different age rider groups and for different travel purposes. The underlying reasons for e-bike riders suffering from severe injury may be different in each case. **Method:** This study aims to examine the underlying risk factors of severe injury for different groups of e-bike riders by using a combined method, integration of a classification tree and a logistic regression model. Three-year of e-bike crashes occurring in Hunan province are extracted, and risk factor including rider's attribute, opponent vehicle and driver's attribute, improper behaviors of riders and drivers, road, and environment characteristics are considered for this analysis. **Results:** E-bike riders are segmented into five groups based on the classification tree analysis, and the group of non-occupational riders aged over 55 in urban regions is associated with the highest likelihood of severe injury among the five groups. The logistics analysis for each group shows that several risk factors such as high-speed roads have commonly significant effects on injury severity for different groups; while major factors only have significant effects for specific groups. **Practical application:** Based on model results, policy implications to alleviate the crash injury for different e-bike riders groups are recommended, which mainly include enhanced education and enforcement for e-bike risky behaviors, and traffic engineering to regulate the use of e-bikes on high speed roads.

- **Keywords:** E-bike crash; Injury severity; Classification tree-based logistic regression; Different riders groups

Li Song, Wei (David) Fan, Yang Li, Peijie Wu. *Exploring pedestrian injury severities at pedestrian-vehicle crash hotspots with an annual upward trend: A spatiotemporal analysis with latent class random parameter approach*. Pages 184-196.

Introduction: With the increasing trend of pedestrian deaths among all traffic fatalities in the past decade, there is an urgent need for identifying and investigating hotspots of pedestrian-vehicle crashes with an upward trend. **Method:** To identify pedestrian-vehicle crash locations with aggregated spatial pattern and upward temporal pattern (i.e., hotspots with an upward trend), this paper first uses the average nearest neighbor and the spatial autocorrelation tests to determine the grid distance and the neighborhood distance for hotspots, respectively. Then, the spatiotemporal analyses with the Getis-Ord Gi* index and the Mann-Kendall trend test are utilized to identify the pedestrian-vehicle crash hotspots with an annual upward trend in North Carolina from 2007 to 2018.

Considering the unobserved heterogeneity of the crash data, a latent class model with random parameters within class is proposed to identify specific contributing factors for each class and explore the heterogeneity within classes. Significant factors of the pedestrian, vehicle, crash type, locality, roadway, environment, time, and traffic control characteristics are detected and analyzed based on the marginal effects. **Results:** The heterogeneous results between classes and the random parameter variables detected within classes further indicate the superiority of latent class random parameter model. **Practical Applications:** This paper provides a framework for researchers and engineers to identify crash hotspots considering spatiotemporal patterns and contribution factors to crashes considering unobserved heterogeneity. Also, the result provides specific guidance to developing countermeasures for mitigating pedestrian-injury at pedestrian-vehicle crash hotspots with an upward trend.

- **Keywords:** Pedestrian; Injury severity; Spatiotemporal analysis; Latent class clustering; Random parameter logit model

Guopeng Zhang, Xinguo Jiang, Xin Qiu, Yingfei Fan, Cen Huang, Mengmeng Wei. *Validating the underlying assumption of quasi-induced exposure technique disaggregated by crash injury severity*. Pages 197-204.

Introduction: Quasi-induced exposure (QIE) technique has been popularly applied in the field of traffic safety research for decades. One of the basic assumptions of QIE theory is that the not-at-fault driving parties (D2s) involved in the crashes are the random selection of overall driving population at the event of crash occurrence. Very few literatures, however, can be identified to validate the assumption for crashes with specific injury severities that may not be satisfied in reality. **Method:** The study aims to check the validity of the assumption categorized by crash injury severity with the use of Michigan crash data. Latent class analysis is employed to generate several latent classes for the crashes with specific injury outcomes. Chi-square test is adopted to identify the significance of the similarity of D2 distributions among the latent classes. **Results:** The results indicate that: (a) for fatal crashes the statistical tests do not identify the significant discrepancies for D2 distributions of driver gender, age, and vehicle type between latent classes; (b) for injury crashes, both D2 driver gender and age have the similar distributions between/among various classes, while the D2 vehicle types show the inconsistent distributions; and (c) with respect to property damage only crashes, the distributions of three vehicle-driver characteristics are significantly different among the latent classes. It implies that the underlying assumption may not entirely hold true for all the injury severities and driver-vehicle characteristics. **Practical Applications:** The findings pinpoint the applicability of the QIE technique under specific scenarios and highlight the importance of validating the underlying assumption of QIE prior to its application.

- **Keywords:** Quasi-induced exposure; Injury severity; Latent class analysis; Chi-square test; Driver-vehicle characteristics

Nabeel Saleem Saad Al-Bdairi, Ali Behnood. *Assessment of temporal stability in risk factors of crashes at horizontal curves on rural two-lane undivided highways*. Pages 205-217.

Introduction: Safety of horizontal curves on rural two-lane, two-way undivided roadways is not fully explored. This study investigates factors that impact injury severity of such crashes. **Method:** To achieve the aim of this paper, issues associated with police-reported crash data such as unobserved heterogeneity and temporal stability need to be accounted for. Hence, a mixed logit model was estimated, while heterogeneity in means and variances is investigated by considering four injury severity outcomes for drivers:

severe injury, moderate injury, possible injury, and no injury. Crash data for the period between 2011 and 2016 for crashes that occurred in the state of Oregon was analyzed. Temporal stability in factors determining the injury severity was investigated by identifying three time periods through splitting crash data into 2011–2012, 2013–2014, and 2015–2016. **Results:** Despite some factors affecting injuries in all specified time periods, the values of the marginal effects showed relative differences. The estimation results revealed that some factors increased the risk of being involved in severe injury crashes, including head-on collisions, drunk drivers, failure to negotiate curves, older drivers, and exceeding the speed limits. **Conclusions:** The hypothesis that attributes of injury severity are temporally stable is rejected. For example, young drivers (30 years old and younger) and middle-aged drivers were found to be temporally instable over time. **Practical applications:** The findings could help transportation authorities and safety professionals to enhance the safety of horizontal curves through appropriate and effective countermeasures.

- **Keywords:** Injury severity; Two-lane undivided highways; Temporal stability; Horizontal curve; Heterogeneity in means and variances

Siying Zhu. *Analysis of the severity of vehicle-bicycle crashes with data mining techniques*. Pages 218-227.

Introduction: Although cycling is increasingly being promoted for transportation, the safety concern of bicyclists is one of the major impediments to their adoption. A thorough investigation on the contributing factors to fatalities and injuries involving bicyclist. **Method:** This paper designs an integrated data mining framework to determine the significant factors that contribute to the severity of vehicle-bicycle crashes based on the crash dataset of Victorian, Australia (2013–2018). The framework integrates imbalanced data resampling, learning-based feature extraction with gradient boosting algorithm and marginal effect analysis. The top 10 significant predictors of the severity of vehicle-bicycle crashes are extracted, which gives an area under ROC curve (AUC) value of 0.8236 and computing time as 37.8 s. **Results:** The findings provide insights for understanding and developing countermeasures or policy initiatives to reduce severe vehicle-bicycle crashes.

- **Keywords:** Safety; Severity; Vehicle-bicycle crashes; Integrated data mining framework; Gradient boosting algorithm

Patricia Alcón Gil, César De Santos-Berbel, Maria Castro. *Driver glare exposure with different vehicle frontlighting systems.* Pages 228-237.

Introduction: Highway safety performance at night has received less attention in research than daytime, despite the higher accident rates occurring under night-time conditions. This study presents a procedure to assess the potential hazard for drivers created by headlight glare and its interaction with the geometric design of highways. **Method:** The proposed procedure consists of a line-of-sight analysis performed by a geoprocessing model in geographic information systems to determine whether the rays of light that connect headlights and oncoming drivers are obstructed by either the roadway or its roadsides. Then, the procedure checks whether the non-obstructed rays of light are enclosed by a given headlight beam. Different hypotheses were set concerning the headlight beam features, including the horizontal spread angle and whether the headlights are fixed or swiveling. A highway section was selected to test and validate the procedure proposed. A 3D recreation of the highway and its environment derived from a LiDAR point cloud was used for this purpose. **Results:** The findings disclose how glare is produced on tangents, horizontal curves, transitions between them and sequences of curves. The effect of visual obstructions conveniently placed is also discussed. **Conclusions:** A greater glare incidence is produced as the horizontal headlights spread angle increases. Swiveling headlights increase glare on highways left curves and reduce

it on right curves. **Practical Applications:** The procedure and conclusions of this study can contribute to develop more effective glare avoidance technologies as well as identify and assess glare-prone sections. The glare evaluation assists in evaluating glare countermeasures such as deciding whether to place a vegetation barrier and where.

- **Keywords:** Road safety; Nighttime driving; Headlights; 3D modeling; Vegetation barrier

Jiwon Park, Seolyoung Lee, Cheol Oh, Byongho Choe. *A data mining approach to deriving safety policy implications for taxi drivers*. Pages 238-247.

Introduction: Traffic safety issues associated with taxis are important because the frequency of taxi crashes is significantly higher than that of other vehicle types. The purpose of this study is to derive safety implications to be used for developing policies to enhance taxi safety based on analyzing intrinsic characteristics underlying the cause of traffic accidents. **Method:** An in-depth questionnaire survey was conducted to collect a set of useful data representing the intrinsic characteristics. A total of 781 corporate taxi drivers participated in the survey in Korea. The proposed analysis methodology consists of two-stage data mining techniques, including a random forest method, with data that represents the working condition and welfare environment of taxi drivers. In the first stage, the drivers' intrinsic characteristics were derived to classify four types of taxi drivers: unspecified normal, work-life balanced, overstressed, and work-oriented. Next, priority was determined for classifying high-risk taxi drivers based on factors derived from the first analysis. **Results:** The derived policies can be categorized into three groups: 'the development of new policies,' 'the improvement of existing policies,' and 'the elimination of negative factors.' Establishing a driving capability evaluation system for elderly drivers, developing mental health management programs for taxi drivers, and inspecting the taxi's internal conditions were proposed as new policies. Improving the driver's wage system, supporting the improvement of rest facilities, and supporting the installation of security devices for protecting taxi drivers are methods for improving existing policies to reinforce the traffic safety of taxi drivers. Last, restricting overtime work for taxi drivers was proposed as a policy to eliminate negative factors for improving taxi traffic safety. **Practical Applications:** It is expected that by devising effective policies using the policy implications suggested in this study, taxi traffic accidents can be prevented and the quality of life of taxi drivers can be improved.

- **Keywords:** Traffic safety; Taxi crashes; Random forest method; Policy implications; Data mining

Xuan Zhang, Huiying Wen, Toshiyuki Yamamoto, Qiang Zeng. *Investigating hazardous factors affecting freeway crash injury severity incorporating real-time weather data: Using a Bayesian multinomial logit model with conditional autoregressive priors*. Pages 248-255.

Introduction: It has been demonstrated that weather conditions have significant impacts on freeway safety. However, when employing an econometric model to examine freeway crash injury severity, most of the existing studies tend to categorize several different adverse weather conditions such as rainy, snowy, and windy conditions into one category, "adverse weather," which might lead to a large amount of information loss and estimation bias. Hence, to overcome this issue, real-time weather data, the value of meteorological elements when crashes occurred, are incorporated into the dataset for freeway crash injury analysis in this study. **Methods:** Due to the possible existence of spatial correlations in freeway crash injury data, this study presents a new method, the spatial multinomial logit (SMNL) model, to consider the spatial effects in the framework of the multinomial logit (MNL) model. In the SMNL model, the Gaussian conditional

autoregressive (CAR) prior is adopted to capture the spatial correlation. In this study, the model results of the SMNL model are compared with the model results of the traditional multinomial logit (MNL) model. In addition, Bayesian inference is adopted to estimate the parameters of these two models. Result: The result of the SMNL model shows the significance of the spatial terms, which demonstrates the existence of spatial correlation. In addition, the SMNL model has a better model fitting ability than the MNL model. Through the parameter estimate results, risk factors such as vertical grade, visibility, emergency medical services (EMS) response time, and vehicle type have significant effects on freeway injury severity. Practical Application: According to the results, corresponding countermeasures for freeway roadway design, traffic management, and vehicle design are proposed to improve freeway safety. For example, steep slopes should be avoided if possible, and in-lane rumble strips should be recommended for steep down-slope segments. Besides, traffic volume proportion of large vehicles should be limited when the wind speed exceeds a certain grade.

- **Keywords:** Freeway safety; Crash injury severity; Real-time weather data; Multinomial logit model; Spatial effect

Jessica B. Cicchino, Paige E. Kulie, Melissa L. McCarthy. *Severity of e-scooter rider injuries associated with trip characteristics*. Pages 256-261.

Introduction: E-scooter rider injuries have been growing, but little is known about how trip and incident characteristics contribute to their severity. **Method:** We enrolled 105 adults injured while riding e-scooters who presented to an emergency department in Washington, DC, during 2019. Enrolled participants completed an interview during the emergency department visit, and their charts were abstracted to document their injuries and treatment. Logistic regression examined the association of incident location and circumstances with the likelihood of sustaining an injury on the Abbreviated Injury Scale (AIS) ≥ 2, while controlling for rider characteristics. **Results:** The most common locations of e-scooter injuries in our study sample occurred on the sidewalk (58%) or road (23%). Accounting for other trip and rider attributes, e-scooter riders injured on the road were about twice as likely as those injured elsewhere to sustain AIS ≥ 2 injuries (RR, 1.96; 95% CI, 1.23–2.36) and those who rode at least weekly more often sustained AIS ≥ 2 injuries compared with less frequent riders (RR, 1.86; 95% CI, 1.11–2.32). **Conclusions:** Greater injury severity for riders injured on the road may reflect higher travel speeds. **Practical applications:** Injury severity associated with riding in the road is one factor that jurisdictions can consider when setting policy on where e-scooters should be encouraged to ride, but the risk of any crash or fall associated with facilities should also be examined. Although injuries are of lower severity on sidewalks, sharing sidewalks with slower moving pedestrians could potentially lead to more conflicts.

- **Keywords:** Micromobility; Non-motorized; Emergency department; Sidewalk; Riding frequency

Sergio Rocha Piedade, Mark R. Hutchinson, Daniel Miranda Ferreira, Alxandre Fogaca Cristante, Nicola Maffulli. *The management of concussion in sport is not standardized. A systematic review*. Pages 262-268.

Introduction: Concussion is traumatic brain injury with associated tissue damage commonly produced by an indirect or direct head or facial trauma that can negatively impact an athletes' career and personal life. In this context, the importance on how to deal with a concussion has received attention from worldwide literature and has become a topic of enormous interest in the sports medicine arena. Objective: This systematic review aimed to investigate how sports-related concussion is being managed regarding

athletic injuries, athletes' age, clinical signs of concussion, adopted questionnaires, as well as decision making in sports medicine. **Methods:** A systematic review of the literature was performed searching 10 electronic databases with no limitations for year of publication up to December 2019. The search terms used were: Brain Concussion, Athletes, Sports Medicine, Athletic Injuries, Clinical Decision-Making, and Decision Making. The articles were considered eligible when the studies related to populations of regular sports practitioners, professional or recreational, of any age; sports injury; articles reporting concussion evaluation in at least 30 athletes; and articles published in English, French, Portuguese, Italian. We excluded systematic review articles, reviews, editorials, sport-unrelated concussion, no questionnaire application, approaching retired athletes, consensus statement letters, author's reply to editorials, synopsis, and abstracts. **Results:** The parameters adopted for decision-making and management were broadly variable and were based on a variety of clinical signs or scoring outcomes from a myriad of questionnaires with little consistency in protocol or management guidelines, which could guide the average clinician. Conclusion: This systematic review provides current evidence that post-concussion management in sports medicine has yet to accomplish a standardized protocol that clinicians could use to optimally care for athletes. The extensive number of manuscripts and studies addressing the topic confirms that sports-related concussion in the pediatric and adolescent population has come to the forefront in the sports medicine field.

- **Keywords:** Brain concussion; Sports medicine; Athletic injuries; Clinical decision-making; Decision making

Salaheddine Bendak, Asayel M. Alnaqbi, Muna Y. Alzarooni, Sara M. Aljanaahi, Shaikha J. Alsuwaidi. *Factors affecting pedestrian behaviors at signalized crosswalks: An empirical study*. Pages 269-275.

Introduction: Safety of pedestrians depends, among other factors, on their behavior while crossing the road. This study aims to assess behaviors of pedestrians at signalized crosswalks. **Method:** Following a literature review and a pilot study, 25 vital pedestrian crossing factors and behaviors were determined. Then data was randomly collected for 708 pedestrians at 10 lighted crossings in Sharjah (UAE), five at road intersections and five mid-block crossings. **Results:** Results indicated that 17.4% of pedestrians observed crossed partly or fully on red and that crossing speed was 1.22 m/s, on the average, which is slightly faster than most speeds recorded in the literature. Moreover, female pedestrians were more likely to cross while chatting with others, less likely to cross on red, and more likely to walk slower than male pedestrians. Results also showed that pedestrians who crossed at road intersections walked slower than those who crossed at mid-block crossings. It was also found that longer red pedestrian times and narrower roads tended to encourage pedestrians to cross on red and that the majority of pedestrians did not look around before crossing. Practical implications: Use of the Health Belief Model for pedestrian safety are discussed.

- **Keywords:** Pedestrian behavior; Road safety; Crosswalks; Pedestrian crashes; Health Belief Model

Nasreen Hussein, Rayya Hassan, Michael T. Fahey. *Effect of pavement condition and geometrics at signalised intersections on casualty crashes*. Pages 276-288.

Introduction: This study investigated the effects of pavement surface condition and other control factors on casualty crashes at signalized intersections. It involved conducting a before and after study for road surface condition and situational factors. It also included assessing the effects of geometric characteristics on safety performance of signalized intersections post resurfacing to control for the effect of pavement surface condition. Pavement surface condition included roughness, rutting, and skid resistance.

The control factors included traffic volume, light and surface moisture condition, and speed limit. The geometric characteristics included approach width, number of lanes, intersection depth, presence of median, presence of shared lane, and presence of bus stop. **Method:** To account for the repeated observations of the effect of light and surface moisture conditions in four occasions (day-dry, day-wet, night-dry and night-wet) Generalized Estimating Equation (GEE) with Negative Binomial (NB) and log link function was applied. For each signalized intersection in the sample, condition data are collected for the year before and after the year of surface treatment. Crash data, however, are collected for a minimum of three and maximum of five years before and after treatment years. **Results:** The results show that before treatment, light condition, road surface moisture condition, and skid resistance interaction with traffic volume are the significant contributors to crash occurrence. For after treatment; light condition, road surface moisture condition, their interaction product, and roughness interaction with light condition, surface moisture condition, and traffic volume are the significant contributors. The geometric variables that were found to have significant effects on crash frequency post resurfacing were approach width interactions with presence of shared lane, bus stop, or median. **Conclusions:** The findings confirm that resurfacing is significant in reducing crash frequency and severity levels. **Practical Applications:** The study findings would help for better understanding of how geometric characteristics can be improved to reduce crash occurrence.

- **Keywords:** Signalised intersections; Casualty crashes; Generalised Estimating Equation; Pavement condition; Geometric characteristics

Wafa Boulagouas, Susana García-Herrero, Rachid Chaib, Sixto Herrera García, Mébarek Djebabra. *On the contribution to the alignment during an organizational change: Measurement of job satisfaction with working conditions*. Pages 289-300.

Introduction: Modern approaches to Occupational Health and Safety have acknowledged the important contribution that continuous improvements to working conditions can make to the motivation of employees, their subsequent performance, and therefore to the competitiveness of the company. Despite this fact, organizational change initiatives represent a path less traveled by employees. Specialized literature has drawn on the fact that employees' satisfaction presents both the foundation and catalyst for effective implementation of improvements to working conditions. **Method:** This paper conceptualizes the alignment of employees through measurement of job satisfaction and uses the Bayesian Network to assess the influence of human factors, particularly the cognitive, emotional, and behavioral aspects. Toward this aim, the Bayesian Network is evaluated through a cross-validation process, and a sensitivity analysis is then conducted for each influential dimension: emotional, cognitive, and behavioral. **Results:** The results reveal that these three dimensions are interrelated and have a direct influence on job satisfaction and employees' alignment during the organization change. Further, they suggest that the best strategy for enhanced alignment and smooth conduct of organizational changes is simultaneous enhancement of the three dimensions. **Practical applications:** This study shows the influence of emotional, cognitive, and behavioral dimensions on job satisfaction and employees' alignment during the organizational change. Furthermore, it elaborates the way to develop efficient and effective strategies for a successful change implementation and sustained alignment.

- **Keywords:** Health and safety; Organizational change; Working conditions; Alignment; Bayesian Networks

Weimin Jin, Mashrur Chowdhury, Sakib Mahmud Khan, Patrick Gerard. *Investigating the impacts of crash prediction models on quantifying safety effectiveness of Adaptive Signal Control Systems*. Pages 301-313.

Introduction: Adaptive Signal Control System (ASCS) can improve both operational and safety benefits at signalized corridors. **Methods:** This paper develops a series of models accounting for model forms and possible predictors and implements these models in Empirical Bayes (EB) and Fully Bayesian (FB) frameworks for ASCS safety evaluation studies. Different models are validated in terms of the ability to reduce the potential bias and variance of prediction and improve the safety effectiveness estimation accuracy using real-world crash data from non-ASCS sites. This paper then develops the safety effectiveness of ASCS at six different corridors with a total of 65 signalized intersections with the same type of ASCS, in South Carolina. **Results:** Validation results show that the FB model that accounts for traffic volume, roadway geometric features, year factor, and spatial effects shows the best performance among all models. The study findings reveal that ASCS reduces crash frequencies in the total crash, fatal and injury crash, and angle crash for most of the intersections. The safety effectiveness of ASCS varies with different intersection features (i.e., AADT at major streets, number of legs at an intersection, the number of through lanes on major streets, the number of access points on minor streets, and the speed limit at major streets). **Conclusions:** ASCS is associated with crash reductions, and its safety effects vary with different intersection features. **Practical Applications:** The findings of this research encourage more ASCS deployments and provide insights into selecting ASCS deployment sites for reducing crashes considering the variation of the safety effectiveness of ASCS.

- **Keywords:** Safety effectiveness; Empirical Bayes; Fully Bayesian; Spatial model; Adaptive signal control

M Sabbir Salek, Weimin Jin, Sakib Mahmud Khan, Mashrur Chowdhury, Patrick Gerard, Saurabh Bikram Basnet, Mohammad Torkjazi, Nathan Huynh. *Assessing the likelihood of secondary crashes on freeways with Adaptive Signal Control System deployed on alternate routes*. Pages 314-326.

Introduction: Reducing the likelihood of freeway secondary crashes will provide significant safety, operational and environmental benefits. This paper presents a method for assessing the likelihood of freeway secondary crashes with Adaptive Signal Control Systems (ASCS) deployed on alternate routes that are typically used by diverted freeway traffic to avoid any delay or congestion due to a freeway primary crash. **Method:** The method includes four steps: (1) identification of secondary crashes, (2) verification of alternate routes, (3) assessment of the likelihood of secondary crashes for freeways with ASCS deployed on alternate routes and non-ASCS (i.e. pre-timed, semi- or fully-actuated) alternate routes, and (4) investigation of unobserved heterogeneity of the likelihood of freeway secondary crashes. Four freeway sections (i.e., two with ASCS deployed on alternate routes and two non-ASCS alternate routes) in South Carolina are considered. Results and **Conclusions:** Findings from the logistic regression modeling reveal significant reduction in the likelihood of secondary crashes for one freeway section (i.e., Charleston I-26 E) with ASCS deployed on alternate route. Other factors such as rear-end crash, dark or limited light, peak period, and annual average daily traffic contribute to the likelihood of freeway secondary crashes. Furthermore, random-parameter logistic regression model results for Charleston I-26 E reveal that unobserved heterogeneity of ASCS effect exists across the observations and ASCS are associated with the reduction of the likelihood of freeway secondary crashes for 84% of the observations (i.e., primary crashes). Location of the primary crash on the freeway is observed to affect the benefit of ASCS toward freeway secondary crash reduction as the primary crash's location determines how many upstream freeway vehicles will be able to

take the alternate route. **Practical Applications:** Based on the findings, it is recommended that the South Carolina Department of Transportation (SCDOT) considers deploying ASCS on alternate routes parallel to freeway sections where high percentages of secondary crashes are found.

- **Keywords:** Secondary crash; Adaptive Signal Control Systems; Crash Likelihood Estimation; Logistic regression model; Unobserved heterogeneity

Daniel C. Ehlman, Tadesse Haileyesus, Robin Lee, Michael F. Ballesteros, Ellen Yard. *Evaluation of the National Electronic Injury Surveillance System – All injury program's self-directed violence data, United States, 2018*. Pages 327-331.

Introduction: National estimates for nonfatal self-directed violence (SDV) presenting at EDs are calculated from the National Electronic Injury Surveillance System – All Injury Program (NEISS–AIP). In 2005, the Centers for Disease Control and Prevention and Consumer Product Safety Commission added several questions on patient characteristics and event circumstances for all intentional, nonfatal SDV captured in NEISS–AIP. In this study, we evaluated these additional questions along with the parent NEISS–AIP, which together is referred to as NEISS–AIP SDV for study purposes. **Methods:** We used a mixed methods design to evaluate the NEISS–AIP SDV as a surveillance system through an assessment of key system attributes. We reviewed data entry forms, the coding manual, and training materials to understand how the system functions. To identify strengths and weaknesses, we interviewed multiple key informants. Finally, we analyzed the NEISS–AIP SDV data from 2018—the most recent data year available—to assess data quality by examining the completeness of variables. **Results:** National estimates of SDV are calculated from NEISS–AIP SDV. Quality control activities suggest more than 99% of the cause and intent variables were coded consistently with the open text field that captures the medical chart narrative. Many SDV variables have open-ended response options, making them difficult to efficiently analyze. **Conclusions:** NEISS–AIP SDV provides the opportunity to describe systematically collected risk factors and characteristics associated with nonfatal SDV that are not regularly available through other data sources. With some modifications to data fields and yearly analysis of the additional SDV questions, NEISS–AIP SDV can be a valuable tool for informing suicide prevention. **Practical Applications:** NEISS-AIP may consider updating the SDV questions and responses and analyzing SDV data on a regular basis. Findings from analyses of the SDV data may lead to improvements in ED care.

- **Keywords:** Suicide; Self-harm; Self-directed violence; Surveillance; NEISS

Yara K. Haddad, Feijun Luo, Gwen Bergen, Jaswinder K. Legha, Adam Atherly. *Special Report from the CDC Antidepressant subclass use and fall risk in community-dwelling older Americans*. Pages 332-340.

Introduction: Falls among older adults are a significant health concern affecting more than a quarter of older adults (age 65+). Certain fall risk factors, such as medication use, increase fall risk among older adults (age 65+). Aim: The aim of this study is to examine the association between antidepressant-medication subclass use and self-reported falls in community-dwelling older adults. **Methods:** This analysis used the 2009–2013 Medicare Current Beneficiary Survey, a nationally representative panel survey. A total of 8,742 community-dwelling older adults, representing 40,639,884 older Medicare beneficiaries, were included. We compared self-reported falls and psychoactive medication use, including antidepressant subclasses. These data are controlled for demographic, functional, and health characteristics associated with increased fall risk. Descriptive analyses and multivariate logistic regression analyses were conducted using SAS 9.4 and Stata 15 software. **Results:** The most commonly used antidepressant subclass were

selective serotonin reuptake inhibitors (SSRI) antidepressants (13.1%). After controlling for characteristics associated with increased fall risk (including depression and concurrent psychoactive medication use), the risk of falling among older adults increased by approximately 30% among those who used a SSRI or a serotonin-norepinephrine reuptake inhibitors (SNRI) compared to non-users. The adjusted risk ratio (aRR) for SSRI was 1.29 (95% CI = 1.13, 1.47) and for SNRI was 1.32 (95% CI = 1.07, 1.62). Conclusion: SSRI and SNRI are associated with increased risk of falling after adjusting for important confounders. Medication use is a modifiable fall risk factor in older adults and can be targeted to reduce risk of falls. **Practical Applications:** Use of selective serotonin reuptake inhibitors and serotonin-norepinephrine reuptake inhibitors increased the risk of falling in older adults by approximately 30%, even after controlling for demographic, functional, and health characteristics, including depression. Health care providers can work towards reducing fall risk among their older patients by minimizing the use of certain medications when potential risks outweigh the benefits.

- **Keywords:** Elderly; Older adults; Falls; Antidepressants; Depression; Psychoactive medications