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Kyle Z. Horvath, Rebecca J. McAdams, Kristin J. Roberts, Motao Zhu, Lara B. McKenzie. *Fun ride or risky transport: Golf cart-related injuries treated in U.S. emergency departments from 2007 through 2017*. Pages 1-7.

Introduction: Golf cart-related injuries constitute a substantial source of morbidity, most notably in pediatric populations. Despite the high rate of injuries, there have been no meaningful changes in golf cart design or legislation to reduce the overall burden of these injuries. This study sought to characterize the epidemiology of golf cart-related injuries treated in United States hospital emergency departments. **Method:** A retrospective analysis was conducted by using data from the National Electronic Injury Surveillance System for patients of all ages who were treated in emergency departments (EDs) (2007–2017) for a golf cart-related injury. **Results:** From 2007 through 2017, an estimated 156,040 (95% CI = 102,402–209,679) patients were treated in U.S. EDs for golf cart-related injuries. The average rate of traumatic brain injuries (TBIs) in children (1.62 per 100,000 children) was more than three times that of TBIs in adults (0.52 per 100,000 adults; rate ratio = 2.38; 95% CI = 2.36–2.41) and nearly twice that of TBIs in seniors (1.11 per 100,000 seniors; rate ratio = 1.21; 95% CI = 1.19–1.22). The rate of injuries in seniors increased significantly by 67.6% from 4.81 per 100,000 seniors in 2007 to 8.06 per 100,000 seniors in 2017 (slope = 0.096; p = 0.041). **Conclusions:** Golf cart use remains an important source of injury for people of all ages, especially in children. As use continues to increase, it is unlikely that golf cart-related injuries will decrease without substantial changes to product design, regulation, and/or legislation. **Practical Applications:** Use of golf carts pose a considerable risk of injury and morbidity; safety recommendations should be followed.

- **Keywords:** NEISS; Transportation safety; Golf cart; Injuries; Traumatic brain injury

Andrew Yockey, Rebecca Vidourek, Keith King. *Drugged driving among US adults: Results from the 2016–2018 national survey on drug use and health*. Pages 8-13.

Introduction: Drugged driving, the act of driving while under the influence of one or more illicit substances, remains a critical problem needing to be addressed. The present study sought to analyze risk factors associated with past-year driving under the influence of alcohol and marijuana among a national sample of U.S. adults. **Method:** Pooled data

from the 2016–2018 National Survey on Drug Use and Health were analyzed among 124,466 adults ages 18 years or older. **Results:** Weighted logistic regression analyses revealed that 8.52% of adults drove under the influence of alcohol in the past year and 4.49% of adults drove under the influence of marijuana in the past year. Of concern, compared to heterosexuals, greater than 1 in 10 sexual minorities drove under the influence of alcohol in the past year. Moreover, a sizeable percentage of adults used other drugs while under the influence of alcohol including inhalants (70.3%), cocaine (68.9%), and hallucinogens (63.7%). Moreover, a great percentage of adults (53.4%) reported using methamphetamine while also under the influence of marijuana. **Practical Applications:** We believe our findings can inform harm reduction efforts and prevention messaging surrounding the dangers of drugged driving.

- **Keywords:** Driving; Harm reduction; Substance use

Subasish Das, Sruthi Ashraf, Anandi Dutta, Ly-Na Tran. *Pedestrians under influence (PUI) crashes: Patterns from correspondence regression analysis*. Pages 14-23.

Introduction: Alcohol-related impairment is a key contributing factor in traffic crashes. However, only a few studies have focused on pedestrian impairment as a crash characteristic. In Louisiana, pedestrian fatalities have been increasing. From 2010 to 2016, the number of pedestrian fatalities increased by 62%. A total of 128 pedestrians were killed in traffic crashes in 2016, and 34.4% of those fatalities involved pedestrians under the influence (PUI) of drugs or alcohol. Furthermore, alcohol-PUI fatalities have increased by 120% from 2010 to 2016. There is a vital need to examine the key contributing attributes that are associated with a high number of PUI crashes. **Method:** In this study, the research team analyzed Louisiana's traffic crash data from 2010 to 2016 by applying correspondence regression analysis to identify the key contributing attributes and association patterns based on PUI involved injury levels. **Results:** The findings identified five risk clusters: intersection crashes at business/industrial locations, mid-block crashes on undivided roadways at residential and business/residential locations, segment related crashes associated with a pedestrian standing in the road, open country crashes with no lighting at night, and pedestrian violation related crashes on divided roadways. The association maps identified several critical attributes that are more associated with fatal and severe PUI crashes. These attributes are dark to no lighting, open country roadways, and non-intersection locations. **Practical Applications:** The findings of this study may be used to help design effective mitigation strategies to reduce PUI crashes.

- **Keywords:** Pedestrian crashes; Pedestrian impairment; Pattern recognition; Correspondence regression; Crash typing

Nicholas J. Ward, Kari Finley, Jay Otto, David Kack, Rebecca Gleason, T. Lonsdale. *Traffic safety culture and prosocial driver behavior for safer vehicle-bicyclist interactions*. Pages 24-31.

Introduction: Bicyclist safety is a growing concern as more adults use this form of transportation for recreation, exercise, and mobility. Most bicyclist fatalities result from a crash with a vehicle. Often, the behaviors of the driver are responsible for the crash. **Method:** This survey study of Montana and North Dakota residents (n = 938) examined the influence of traffic safety culture on driver behaviors that affect safe interactions with bicyclists. **Results:** Prosocial driver behavior was most common and appeared to be intentional. Intention was increased by positive attitudes, normative perceptions, and perceived control. However, normative perceptions appear to offer the most opportunity for change. **Practical Application:** Strategies that increase perceptions that prosocial driver behavior is normal may increase prosocial intentions, thereby increasing bicyclist safety.

- **Keywords:** Traffic safety culture; Prosocial; Driver behavior; Bicyclist safety

Bianca Reveruzzi, Lisa Buckley, Mary Sheehan. *First aid training in secondary schools: A comparative study and implementation considerations*. Pages 32-40.

Introduction: School-based first aid training has benefits for adolescents with an opportunity to increase health and safety knowledge relating to injury and cardiac arrest. **Method:** Using a quasi-experimental design we evaluated differences among students (Mage = 13.46 years, 55% female) taught first aid through the Skills for Preventing Injury in Youth (SPIY) program (n = 1942), treatment-as-usual school-based first aid training (n = 675), and students who did not receive first aid training (n = 489). **Results:** Results showed significant differences in self-reported knowledge scores at twelve-month follow-up (controlling for baseline knowledge). Students in the SPIY group and the treatment-as-usual first aid group had higher total scores than the control group. Teachers and students reported positive perceptions to first aid study, in particular the interactive delivery and scenarios for contextualizing information. **Practical Applications:** The study provides support for the retention of first aid knowledge up to 12-months and thus the inclusion and feasibility of first aid training in secondary school curriculum.

- **Keywords:** Injury; CPR; Evaluation; Emergency response; Adolescent

Dibakar Saha, Eric Dumbaugh, Louis A. Merlin. *A conceptual framework to understand the role of built environment on traffic safety*. Pages 41-50.

Introduction: Many U.S. cities have adopted the Vision Zero strategy with the specific goal of eliminating traffic-related deaths and injuries. To achieve this ambitious goal, safety professionals have increasingly called for the development of a safe systems approach to traffic safety. This approach calls for examining the macrolevel risk factors that may lead road users to engage in errors that result in crashes. This study explores the relationship between built environment variables and crash frequency, paying specific attention to the environmental mediating factors, such as traffic exposure, traffic conflicts, and network-level speed characteristics. **Methods:** Three years (2011–2013) of crash data from Mecklenburg County, North Carolina, were used to model crash frequency on surface streets as a function of built environment variables at the census block group level. Separate models were developed for total and KAB crashes (i.e., crashes resulting in fatalities (K), incapacitating injuries (A), or non-incapacitating injuries (B)) using the conditional autoregressive modeling approach to account for unobserved heterogeneity and spatial autocorrelation present in data. **Results:** Built environment variables that are found to have positive associations with both total and KAB crash frequencies include population, vehicle miles traveled, big box stores, intersections, and bus stops. On the other hand, the number of total and KAB crashes tend to be lower in census block groups with a higher proportion of two-lane roads and a higher proportion of roads with posted speed limits of 35 mph or less. **Conclusions:** This study demonstrates the plausible mechanism of how the built environment influences traffic safety. The variables found to be significant are all policy-relevant variables that can be manipulated to improve traffic safety. **Practical Applications:** The study findings will shape transportation planning and policy level decisions in designing the built environment for safer travels.

- **Keywords:** Crash mediator; Macrolevel crash analysis; Conditional autoregressive model; Safety planning; Safe systems

Samantha L. Case, Devin L. Lucas. *Predicting commercial fishing vessel disasters through a novel application of the theory of man-made disasters*. Pages 51-56.

Introduction: Vessel disasters (e.g., sinkings, capsizings) are a leading contributor to fatalities in the U.S. commercial fishing industry. Primary prevention strategies are needed to reduce the occurrence of vessel disasters, which can only be done by developing an understanding of their causes and risk factors. If less serious vessel casualties (e.g., loss of propulsion, fire, flooding) are predictors of future disasters, then reducing vessel casualties should in turn reduce vessel disasters and the accompanying loss of life. **Method:** This case-control study examined the association between vessel casualties and disasters using fishing vessels in Alaska during 2010–2015. **Results:** The findings show that vessels that experienced casualties within a preceding 10-year period were at increased odds of disaster. Other significant predictors included safety decal status and hull material. **Practical Applications:** The results of this analysis emphasize the importance of implementing vessel-specific preventive maintenance plans. At an industry level, specific prevention policies should be developed focusing on high-risk fleets to identify and correct a wide range of safety deficits before they have catastrophic and fatal consequences.

- **Keywords:** Occupational safety; Maritime; Disaster incubation; Drift

Wei Hu, Violet Freudenberg, Hongren Gong, Baoshan Huang. *The "Golden Hour" and field triage pattern for road trauma patients*. Pages 57-66.

Introduction: Although the term "golden hour" is a well-known concept among trauma system and emergency medical service providers, the relationship between time and trauma patient outcome and the process of prehospital care for road trauma patients in rural settings are poorly understood. As the underlying basis for triage decision-making, the estimated transport interval to trauma center is usually absent in the existing studies. **Method:** In this study, the crash data between 2013 and 2017 were obtained from the Fatality Analysis Reporting System, and the estimated intervals were calculated by using a Geographic Information System software. By comparing the estimated intervals with actual emergency medical services records, the field triage patterns for road patients were investigated at the state and county levels. Results and **Conclusions:** With the help of the interval prediction maps, the different triage patterns among counties were identified. Further, the average fatalities per 100,000 population by county from the National Highway Traffic Safety Administration were adopted to clarify the associated outcomes. The linear regression analysis results revealed that, for most states, all intervals except the notification interval had a significant correlation with the mortality. The estimated interval had a more significant relationship with the mortality than the actual transport interval. **Practical applications:** These findings indicated that adhering to the "golden hour" without regarding the destination may not be helpful for the survival of road trauma patients. The regression analyses and the interval maps can be used to identify patterns of inappropriate destination selection so that prospective decision-making can be improved.

- **Keywords:** Trauma system; Geographical information system; Field triage; Road patients

Natalie Watson-Brown, Bridie Scott-Parker, Teresa Senserrick. *Higher-order driving instruction and opportunities for improvement: Exploring differences across learner driver experience*. Pages 67-77.

Introduction: Few studies have investigated what guidance occurs during the Learner phase of driving, particularly during formal lessons. The objective of this research was threefold: (a) investigate functional and higher-order driving instruction (HO-DI) in formal Learner lessons, (b) explore teaching approaches within the context of a theoretical framework, and (c) investigate variation in these three elements of instruction as a function of Learner driving experience. The theoretical framework developed to guide this research integrated the constructivist Goals for Driver Education and self-determination theory. **Method:** Professional instruction was explored through naturalistic observation; 15 instructors provided GoPro recordings of 110 driving lessons with Learners aged 16–19 years (n = 96) at varying levels of experience: Early (<20 logbook hours), Mid (21–70 h), and Late (71–>100 h). **Results:** Employing a previously-developed coding taxonomy, instructor guidance opportunities were identified as 15% HO-DI, 73% functional instruction, and 12% untaken or missed HO-DI. Functional instruction peaked in the Mid Phase, while HO-DI was prominent in the Early phase suggesting missed opportunities in the later phases when use of silence peaked. Some elements of self-determination theory's needs-supportive model were readily identified in teaching approaches, such as feedback. **Conclusions:** An understanding of functional and HO-DI, including teaching strategies, was established within the context of an integrated theoretical framework, with different trajectories across Learner experience identified. Teaching strategies reflected constructivism and self-determination theory providing theoretical support for these frameworks to be applied in future driver training studies. Continued research efforts are needed to understand how best to balance functional and HO-DI to maximize young novice drivers' learning prior to independent driving, particularly during the late Learner period. **Practical Applications:** Naturalistic observation of current HO-DI and teaching approaches supports the feasibility of integrating recommended improvements arising from the theoretical framework within current practice, with practical implications for improvements to industry training.

- **Keywords:** Graduated driver licensing; Teen drivers; Professional instruction; Goals for Driver Education; Self-determination theory

Jiho Yeo, Jooyoung Lee, Junhan Cho, Dong-Kyu Kim, Kitae Jang. *Effects of speed humps on vehicle speed and pedestrian crashes in South Korea*. Pages 78-86.

Introduction: Speeding is a crucial risk factor for pedestrian safety because it shortens reaction time while increasing the impact force in collisions. Various types of traffic calming measures to prevent speeding have been devised. A speed hump—a raised bump installed in the pavement—has been widely used for this purpose. **Method:** To evaluate the effectiveness of speed humps, the speed profiles of vehicles passing speed humps were analyzed along with pedestrian crash records near speed humps. **Results:** The speed profiles showed that vehicles gradually diminished their speeds starting 30 m ahead of speed humps and, immediately after passing the humps, accelerated to regain their original speeds within a distance of 30 m. This speed reduction effect is substantial on both local and major roads: 18.4% and 24.0% reduction in speeds, respectively. The analysis of pedestrian crash records revealed that, inside the zones of speed reduction effect near speed humps (i.e., ±30 m from speed humps), fewer pedestrian crashes per roadway distance occurred and pedestrian injuries were less severe, compared with events outside the effect zones. This safety improvement was greater on major roads than local roads. **Practical Applications:** This work finds that the speed reductions that occurred near speed humps were gradual and influential ±30 m from their locations, suggesting that the hump installations should be close enough to the pedestrian crossings. It is noteworthy that, albeit that speed humps are more prevalent on local

roads, the benefits of speed reduction effects from speed humps were more pronounced on major roads than on local roads. Therefore, speed humps on major roads can be considered a more effective measure for pedestrian safety.

- **Keywords:** Traffic safety; Traffic calming measures; Speed control devices; Speed hump; Crash analysis

Yeşim Üzümcüoğlu, Türker Özkan, Chaozhong Wu, Hui Zhang. *Traffic climate and driver behaviors: The moderating role of driving skills in Turkey and China*. Pages 87-98.

Introduction: While road traffic accidents and fatalities are a worldwide problem, the rates of road traffic accidents and fatalities show differences among countries. Similarly, driver behaviors, traffic climate, and their relationships also show differences among countries. The aim of the current study is to investigate the moderating effect of driving skills on the relationship between traffic climate and driver behaviors by country. (Turkey and China). **Method:** There were 294 Turkish drivers and 292 Chinese drivers, and they completed the Traffic Climate Scale, the Driving Skills Inventory, and the Driver Behavior Questionnaire. The moderated moderation analyses were conducted with Hayes PROCESS tool on SPSS. **Results:** The results showed that safety skills moderated the relationship between internal requirements and violations both in Turkey and China. Safety skills also moderated the relationship between internal requirements and errors only in China and the relationship between functionality and violations in Turkey. Perceptual-motor skills moderated the relationships between external affective demands and errors, and also the relationship between internal requirements and positive driver behaviors in Turkey. It can be inferred that driving skills has different influences on traffic climate-driver behaviors relationship in different cultures and there might be cultural differences in the evaluation of drivers' own driving skills. **Practical Applications:** Among driving skills, safety skills have a more critical role to increase road safety by decreasing number of violations. Interventions to increase safety skills of drivers might be promising for road safety.

- **Keywords:** Traffic climate; Road safety; Driver behaviors; Driving skills

Oliver Wirth, Anne M. Foreman, Jonathan E. Friedel, Michael E. Andrew. *Two discrete choice experiments on laboratory safety decisions and practices*. Pages 99-110.

Introduction: The path toward enhancing laboratory safety requires a thorough understanding of the factors that influence the safety-related decision making of laboratory personnel. **Method:** We developed and administered a web-based survey to assess safety-related decision making of laboratory personnel of a government research organization. The survey included two brief discrete choice experiments (DCEs) that allowed for quantitative analysis of specific factors that potentially influence safety-related decisions and practices associated with two different hypothetical laboratory safety scenarios. One scenario related to reporting a laboratory spill, and the other scenario involved changing protective gloves between laboratory rooms. The survey also included several brief self-report measures of attitude, perception, and behavior related to safety practices. **Results:** Risk perception was the most influential factor in safety-related decision making in both scenarios. Potential negative consequences and effort associated with reporting an incident and the likelihood an incident was detected by others also affected reporting likelihood. Wearing gloves was also affected somewhat by perceived exposure risk, but not by other social or work-related factors included in the scenarios. **Conclusions:** The study demonstrated the promise of DCEs in quantifying the relative impact of several factors on safety-related choices of laboratory workers in two hypothetical but realistic scenarios. Participants were faced with hypothetical choice scenarios with realistic features instead of traditional scaling techniques that ask about

attitudes and perceptions. The methods are suitable for addressing many occupational safety concerns in which workers face tradeoffs in their safety-related decisions and behavior. **Practical Application:** Safety-related decisions regarding laboratory practices such as incident reporting and use of PPE were influenced primarily by workers' perceptions of risk of exposure and severity of risks to health and safety. This finding suggests the importance of providing laboratory workers with adequate and effective education and training on the hazards and risks associated with their work. DCEs are a promising research method for better understanding the relative influences of various personal, social, and organizational factors that shape laboratory safety decisions and practices. The information gained from DCEs may lead to more targeted training materials and interventions.

- **Keywords:** Decision-making; Discrete choice experiment; Laboratory safety

Serap Gorucu, Bryan Weichelt, Emily Redmond, Dennis Murphy. *Coding agricultural injury: Factors affecting coder agreement*. Pages 111-118.

Objectives: To determine coders' agreement level for the Occupational Injury and Illness Classification System (OIICS) source of injury and injury event codes, and the Farm and Agricultural Injury Classification (FAIC) code in the AgInjuryNews.org and to determine the effects of supplemental information and follow-up discussion in final code assignments. **Methods:** Two independent researchers initially coded 1304 injury cases from AgInjurynews.org using the OIICS and the FAIC coding schemes. Code agreement levels for injury source, event, and FAIC and the effect of supplemental information and follow-up discussions on final coding was assessed. **Results:** Coders' agreement levels were almost perfect for OIICS source and event categories at the 3-digit level, with lower agreement at the 4-digit level. By using supplemental information and follow-up discussion, coders improved the coding accuracy by an average 20% for FAIC. Supplemental information and follow-up discussions had helped finalize the disagreed codes 55% of the time for OIICS source coding assignments and 40% of time for OIICS event coding assignments for most detailed 4-digit levels. Five key themes emerged regarding accurate and consistent coding of the agricultural injuries: inclusion/exclusion based on industry classification system; inconsistent/discrepant reports; incomplete/nonspecific reports; effects of supplemental information on coding; and differing interpretations of code selection rules. **Practical applications:** Quantifying the level of agreement for agricultural injuries will lead to a better understanding of coding discrepancies and may uncover areas for improvement to coding scheme itself. High level of initial and final agreement with FAIC and OIICS codes suggest that these coding schemes are user-friendly and amenable to widespread use.

- **Keywords:** Injury; Coder agreement; Injury source; FAIC; Kappa statistics

Haojie Li, Yingheng Zhang, Gang Ren. *A causal analysis of time-varying speed camera safety effects based on the propensity score method*. Pages 119-127.

Introduction: Speed limit enforcement cameras provide an effective approach to reduce vehicle speeds and the number of road accidents. However, it is still unclear whether the safety effects of speed cameras show durability over long periods of time. This paper analyses how the effects of speed cameras on road accidents change over time. A total number of 771 camera sites and 4787 potential control sites are observed for a period of 18 years (1999–2016) across England. **Method:** Covariates such as road class, crash history, speed limit, and annual average daily traffic (AADT) are included in the data set. A difference in difference (DID) based propensity score matching (PSM) method is employed to select proper control sites and estimate the treatment effects. The safety effects of speed cameras are then evaluated from a long-term perspective. The post-treatment period is divided into four equal-length periods: early, medium 1 and 2, and

late. Results and **Conclusions:** The results show that speed cameras have significantly reduced the number of road accidents near the camera sites. However, the effects vary across different time periods. The safety effects of speed cameras experienced a sharp decrease during the medium periods after an initial period of highly reduced accidents (medium 1: −53.1%, medium 2: −40.7%) and recovered slightly during the late period. In addition, to evaluate the criteria for selecting camera sites in the UK, we further investigated whether speed cameras at high risk sites have better safety performance. The results show that while safety effects at high risk camera sites also decreased during the medium periods, the reduction was smaller (medium 1: −20.8%, medium 2: −2.1%). **Practical Applications:** Appropriate road traffic regulations and management, as well as proper camera sites selection criterion, are important to maintain the effectiveness of speed cameras.

- **Keywords:** Road safety; Speed camera; Time-varying effects; Causal analysis; Propensity score matching

James C. Fell, Jennifer Scolese, Tom Achoki, Courtney Burks, Allison Goldberg, William DeJong. *The effectiveness of alternative transportation programs in reducing impaired driving: A literature review and synthesis.* Pages 128-139.

Introduction: Studies have shown that approximately half of arrested intoxicated drivers had their last alcoholic drink at a licensed bar or restaurant. Current efforts to prevent intoxicated patrons from leaving licensed establishments and driving home have been only partially successful. Since a high proportion of drinkers drive to their drinking destination, promoting the use of alternative transportation (AT) – including safe ride shuttles, free or subsidized taxi and ridesharing services, voluntary or paid designated driver programs, and more accessible public transportation – is an important strategy for preventing impaired driving. The primary goal of this study was to review and synthesize the findings of research studies designed to test the effectiveness of AT programs in reducing alcohol-impaired driving. A secondary goal was to report if using AT has led to any unintended consequences, in particular greater alcohol consumption. **Method:** We identified relevant academic articles, new articles, government reports, and other documents (English only) through the University of Chicago library, Google Scholar, and Google Search. We also included published articles recommended by peers. Key search terms included: alternative transportation; safe rides; designated driver; alcohol-impaired driving; alcohol consumption, cost effectiveness; and reduce drunk driving. Initially, we identified 168 potentially relevant sources, of which only 57 were academic articles. After a thorough review, we narrowed down the number of relevant articles to 125 including some background articles and government reports. **Results:** Some AT programs produced reductions in one or more of the following outcomes: (1) impaired driving; (2) impaired driving crashes; (3) driving under the influence (DUI) arrests; and (4) traffic crashes in general, but others were not shown to be effective. A few programs resulted in greater self-reported alcohol use, but there were no significant findings indicating that drinking when using AT led to an increase in alcohol-related harms such as public intoxication, assaults, or other alcohol-related crime. Of the studies that conducted a cost-benefit analysis, most showed that AT programs yielded a positive benefit, but these studies did not include a sufficient number of variables to be considered true cost-benefit analyses. **Conclusions:** There is mixed evidence regarding the effectiveness of AT programs. Evaluations with more rigorous quasi-experimental and experimental designs are needed to identify which types of AT programs work best for different types of communities and target groups. **Practical Applications:** The literature review and synthesis revealed that the most successful AT programs typically have some of these attributes: (1) social acceptance; (2) high level of public awareness; (3) low cost; (4) year-round availability; (5) provide rides to and from drinking venues; (6) several sponsors that provide funding); (7) user convenience; and (8) perceived safety.

- **Keywords:** Alternative transportation; Safe rides; Designated driver; Alcohol-impaired driving; Alcohol consumption

Amit Kramer, Seonghee Cho, Ravi S. Gajendran. *12-Year longitudinal study linking within-person changes in work and family transitions and workplace injury risk*. Pages 140-149.

Introduction: Despite the rich tradition of research on predictors of workplace injury, most studies rely on cross-sectional, between-person designs. Furthermore, prior research has often overlooked the possibility that factors outside the work domain can influence the occurrence of actual injuries at work. To address these limitations, the current study examined the effects of work and family demands on the occurrence of workplace injury. Drawing on the intuition of the work-home resources model (W-HR), we investigated how within-person level changes in demands and resources from both domains influence work injuries over a 12-year period. **Method:** We used 12 years of longitudinal data (N = 7,820) to study the long-term within-person changes in work and family domains and to capture the event of low frequency incidence such as workplace injury. Specifically, we conducted multilevel analyses to study the links between within-person change in time and energy resources both in work and family domains and within-person change in the likelihood of experiencing a workplace injury. Results and **conclusion:** The findings showed that within-person changes in work hours, spousal work hours, income and number of children, were significantly associated with changes in the likelihood of experiencing a workplace injury. We conclude with a discussion of implications for theory and future research of workplace injuries. **Practical application:** The research provided useful insights on the intimate association between work and family domains in the context of safety management.

- **Keywords:** Income; Irregular shift; National Longitudinal Survey of Youth; Occupational injury; Work family demands

Erik Hanson, Michael Boland. *Safety climate at agricultural cooperatives*. Pages 150-154.

Introduction: This study identifies determinants of safety climate at agricultural cooperatives. **Methods:** An extensive survey was designed to build upon past research done in collaboration with DuPont (Risch et al., 2014). In 2014 and 2015, the survey was administered to 1930 employees at 14 different agricultural cooperatives with 154 locations. Injury incidence data were also collected from each location to better understand the overall health and safety environment in this sector. An ordered probit model is used to identify variables that are associated with better safety climates. **Results:** Safety system components such as discipline programs, inspection programs, modified duty programs, off-the-job safety training programs, and recognition programs are positively related to individual safety climate for both managerial employees and nonmanagerial employees. Variables representing an employee's agricultural background, distance between their workplace and childhood home, and formal education are not associated with managerial safety climate. However, agricultural background and childhood home distance are associated with nonmanagerial safety climate. **Conclusions:** Improving occupational health and safety is a priority for many agricultural cooperatives. Lower safety climate emerges as nonmanagerial employees have more experience with production agriculture and work nearer to their home community. **Practical applications:** Employees of agricultural cooperatives face a host of health and safety challenges that are likely to persist into the future. The safety system components associated with safety climate indicate that continuous feedback is important for improving occupational health and safety. Occupational health and safety programming should also acknowledge that many employees have experiences that influence their attitudes and behaviors.

- **Keywords:** Agriculture; Occupational health; Safety climate; Safety culture; Safety outcomes

Amirarsalan Mehrara Molan, Milhan Moomen, Khaled Ksaibati. *The impact of traffic barrier geometric features on crash frequency and injury severity of non-interstate highways*. Pages 155-165.

Introduction: The main objective of this research is to investigate the effect of traffic barrier geometric characteristics on crashes that occurred on non-interstate roads. **Method:** For this purpose, height, side-slope rate, post-spacing, and lateral offset of about 137 miles of traffic barriers were collected on non-interstate (state, federal aid primary, federal aid secondary, and federal aid urban) highways in Wyoming. In addition, crash reports recorded between 2008 and 2017 were added to the traffic barrier dataset. The safety performance of traffic barriers with regards to their geometric features was analyzed in terms of crash frequency and crash severity using random-parameters negative binomial, and random-parameters ordered logit models, respectively. **Results:** From the results, box beam barriers with a height of 27–29 inches were less likely to be associated with injury and fatal injury crashes compared to other barrier types. On the other hand, the likelihood of a severe injury crash was found to be higher for box beam barriers with a height taller than 31 inches. Both W-beam and box beam barriers with a post-spacing between 6.1 and 6.3 inches reduced the probability of severe injury crashes. In terms of the crash frequency, flare traffic barriers had a lower crash frequency compared to parallel traffic barriers. Non-interstate roads without longitudinal rumble strips were associated with a higher rate of traffic barrier crashes.

- **Keywords:** Traffic barrier; Crash severity; Crash frequency; Random-parameters negative binomial; Random-parameters ordered logit

Jessica Wallace, Rachel Affagato, Maxwell Brooke, Jamie McAllister-Deitrick, Ryan N. Moran, Tracey Covassin. *Racial disparities in parent knowledge of concussion and recognition of signs and symptoms*. Pages 166-172.

Introduction: Concussion is a type of traumatic brain injury that can be sustained through participation in different sports. It is important that a parent be able to identify common and uncommon symptoms of a concussion to ensure the safety and good health of their child. The purpose of this study was to compare knowledge of concussion scores among White and African American parents and guardians. Methodology: This cross-sectional study consisted of a single survey of 53 questions that was given to parents/guardians of high school athletes at a preseason parent meeting. Parent and guardian knowledge of concussion was assessed through a series of 45 questions. Participants were asked to correctly identify signs and symptoms of concussion, answer questions regarding the anatomy of a concussion (i.e. a concussion is an injury to the brain), answer true/false questions about general concussion knowledge, select from a list the consequences of multiple concussions and select from a list the consequences of returning to play too soon from a concussion. Knowledge of concussion was calculated by summing correct responses for the 45 knowledge questions. Racial differences were calculated using an ANCOVA, controlling for socioeconomic school type. The statistical significance level was set a priori $p \leq 0.05$ for all analyses. **Results:** Participants of this study consisted of 176 [115 (65.3%) White, 61 (34.7%) African American] parents/guardians of high school athletes. Significant differences in knowledge of concussion scores between White parents/guardians [38.50 ± 4.55 (85.6% correct)], and African American parents/guardians [35.15 ± 4.97, 78.1% correct)] were identified ($F(1,172) = 4.82$, $p = 0.03$). **Conclusion:** Knowledge of concussion disparities exist between African American and White parents/guardians. This disparity could cause complications from concussion to surface among children and adolescents participating in

sport as their parents/guardians may not be able to correctly identify the signs and symptoms in order to seek proper medical care. **Practical Application:** Findings from this study highlight quantitative differences in concussion knowledge of parents from different demographics. These findings underline disparities and inequities in access to concussion-health resources that need to be addressed.

- **Keywords:** Concussion; Traumatic brain injury; Race; Health disparities; Concussion knowledge

Stephen D. Thorp, Julie Le, Nicholas S. Adams, Alan T. Davis, Charles J. Gibson, Gerald P. Wright, Carlos H. Rodriguez, Laura Krech, Gaby A. Iskander, Alistair J. Chapman. *Are motorcycles really "donorcycles"? Examining organ donation rates between unhelmeted and helmeted motorcyclists*. Pages 173-177.

Introduction: Motorcycles are colloquially referred to as "donorcycles" among medical staff. However, the actual impact of helmet laws and helmet use on organ donation is unknown. Michigan's 35-year-old universal helmet law (UHL) was repealed in April 2012 and replaced by a partial-helmet law. We hypothesized that there would be an increase in organ donation rates from unhelmeted motorcyclist fatalities. **Methods:** Michigan's Gift of Life Michigan organ donation database was queried from April 2008 through May 2015 in conjunction with the Michigan Trauma Quality Improvement Program database from the same time period. All in-hospital motorcycle crash fatalities were examined. **Results:** A three-fold increase was found in the rate of organ donation for unhelmeted motorcyclists compared to helmeted motorcyclists ($p = 0.006$). Motorcycle crash fatalities tended to be younger in age after the UHL repeal with an average age of 32.8 years versus 40.8, however, this finding was not statistically significant ($p = 0.071$). Additionally, there was no significant difference in organ donation rates pre-UHL repeal (2008–2012) versus post-repeal (2012–2015). **Conclusions:** This is the first study to demonstrate an increased rate of organ donation among unhelmeted motorcyclist fatalities compared to helmeted rider fatalities. There was no significant increase in the rate of organ donation following the Michigan UHL repeal. However, we identified that some motorcycle crash fatalities were from illegally unhelmeted riders in the past, prior to the repeal. **Practical Application:** Unhelmeted motorcyclists are three times more likely than helmeted riders to become organ donors, possibly due to the well documented increase in severe traumatic brain injuries in this population. From a public health perspective, helmets should be required for all motorcyclists and efforts to advocate in favor of helmet legislation should be supported by trauma systems and health professionals.

- **Keywords:** Organ donation; Helmet law; Motorcycles; Michigan

Blawal Hussain, Hitomi Sato, Tomio Miwa, Takayuki Morikawa. *Influence of personality traits on aberrant driving behaviors: A comparison of Japanese, Chinese, and Vietnamese drivers*. Pages 178-188.

Introduction: This study aims to explore the influence of Big Five personality traits in combination with various socio-demographic factors and experiences of accident involvement on aberrant driving behaviors. The study also compares the effects of the level of development (i.e., developed or developing) of three countries on the personality traits and driving behaviors. **Method:** The four-factor Driver Behavior Questionnaire was used to collect data on aberrant driving behaviors, while a short version of the 10-item Big Five Inventory was used to collect data on personality traits. Responses were collected from Japan (1,250 responses), China (1,250), and Vietnam (1,000). A latent variable model was applied after controlling data in each category (e.g., age). **Results:** This study revealed that respondents who experienced accidents in the past and scored

higher on Agreeableness were less likely to commit aggressive violations in Japan, China, and Vietnam. Further, Japanese and Vietnamese female drivers who scored high on Conscientiousness were found to be less likely to commit ordinary violations. Neuroticism was positively correlated with aggressive violations only in the case of Vietnamese drivers, irrespective of the history of accident involvement. **Conclusions:** Drivers with particular personality types that are linked with aberrant driving behavior may need to receive additional training on behavior management. **Practical Applications:** This study may help road traffic policymakers predict future driving behaviors of Vietnamese and Chinese drivers based on those of Chinese and Japanese drivers, respectively, and act accordingly.

- **Keywords:** Big Five personality traits; Road accident involvement; Driver Behavior Questionnaire; 10-Item Big Five Inventory; Personality characteristics

Todd D. Smith, Charmaine Mullins-Jaime, Mari-Amanda Dyal, David M. DeJoy. *Stress, burnout and diminished safety behaviors: An argument for Total Worker Health® approaches in the fire service*. Pages 189-195.

Introduction: Firefighting is stressful work, which can result in burnout. Burnout is a safety concern as it can negatively impact safety outcomes. These impacts are not fully understood within the fire service. Further, the fire service needs support that safety strategies are needed to protect and promote the health and wellbeing of firefighters. **Methods:** Structural equation modeling was completed to examine a hypothesized model that linked stress and burnout to diminished safety behavior outcomes among a sample of career firefighters. **Results:** Findings support a full mediation model. Firefighter stress perceptions were positively associated with burnout and burnout was negatively associated with safety compliance behavior, personal protective equipment behavior, safe work practices, and safety citizenship behavior. **Conclusions:** These results illustrate the negative impact of health impairment on firefighter safety behaviors. **Practical Applications:** These outcomes suggest that interventions aimed at protecting and promotion firefighter health are needed. Total Worker Health® (TWH) approaches may provide the framework for these interventions.

- **Keywords:** Burnout; Firefighter; Health protection; Safety behavior; Total worker health

Rachel Talbot, Laurie Brown, Andrew Morris. *Why are powered two wheeler riders still fatally injured in road junction crashes? – A causation analysis*. Pages 196-204.

Introduction: Powered Two Wheeler (PTW) crashes continue to be a road safety concern with a plateauing of the number of associated fatalities. **Method:** Forty one UK fatal or serious injury crashes involving a PTW and another vehicle at a junction were examined. Crash causation was analysed using the Driver Reliability and Error Analysis Method (DREAMv3.2). Crashes were split into two groups: Group A, where the other vehicle was travelling in the opposite direction to the PTW and commenced a right turn across the PTW's path; and Group B where the other vehicle turned right out of a side road (or entrance) across the PTW's path. **Results:** Overall, the factor that led directly to the crash (phenotype) was most commonly 'too high speed' or 'too late action' for the motorcyclist and 'too early action' for the other driver. Missed or late observations were contributory factors for both PTW riders and other vehicle drivers. Some differences between groups were observed with the PTW riders in Group B more likely to have 'insufficient skills' and the other vehicle drivers in Group A more likely to have 'attention allocation' as a causation factor. For both groups the crashes occurred because the other vehicle failed to give way to the PTW with causation chains that suggest 'looked but failed to see' is still an issue in this type of crash. The excessive speed of the PTW contributed to some crashes. **Conclusions:** This analysis suggests that drivers failing to

give way to PTW riders at junctions is still a problem. This may relate to the 'looked but did not see' phenomenon. Causation differences were observed between the examined groups. Practical considerations: The DREAM methodology is an effective tool in analysing crash data from police collision investigation reports. Different countermeasures may be necessary to prevent different types of junction crashes.

- **Keywords:** Motorcycle; Accident causation; DREAM; Intersection; Crash investigation

Mikko Nykänen, Vuokko Puro, Maria Tiikkaja, Henriikka Kannisto, Eero Lantto, Frans Simpura, Jose Uusitalo, Kristian Lukander, Tuula Räsänen, Tarja Heikkilä, Anna-Maria Teperi. *Implementing and evaluating novel safety training methods for construction sector workers: Results of a randomized controlled trial*. Pages 205-221.

Introduction: The construction industry is regarded as one of the most unsafe occupational fields worldwide. Despite general agreement that safety training is an important factor in preventing accidents in the construction sector, more studies are needed to identify effective training methods. To address the current research gap, this study evaluated the impact of novel, participatory safety training methods on construction workers' safety competencies. Specifically, we assessed the efficacy of an immersive virtual reality (VR)-based safety training program and a participatory human factors safety training program (HFST) in construction industry workplaces. **Method:** In 2019, 119 construction sector workers from eight workplaces participated in a randomized controlled trial conducted in Finland. All the study participants were assessed using questionnaires at baseline, immediately after the intervention and at one-month follow-up. We applied generalized linear mixed modeling for statistical analysis. **Results:** Compared to lecture-based safety training, VR-based safety training showed a stronger impact on safety motivation, self-efficacy and safety-related outcome expectancies. In addition, the construction sector workers who participated in the VR-based safety training showed a greater increase in self-reported safety performance at one-month follow-up. Contrary to our study hypotheses, we found no significant differences between the study outcomes in terms of study participants in the HFST training condition and the comparison condition without HFST training. **Conclusion:** Our study indicates that VR technology as a safety training tool has potential to increase safety competencies and foster motivational change in terms of the safety performance of construction sector workers. In the future, the efficacy of participatory human factors safety training should be studied further using a version that targets both managerial and employee levels and is implemented in a longer format. Practical implications: Safety training in virtual reality provides a promising alternative to passive learning methods. Its motivating effect complements other safety training activities.

- **Keywords:** Virtual reality; Human factors safety training; Safety self-efficacy; Safety locus of control; Safety motivation

Tiantian Chen, N.N. Sze, Sikai Chen, Samuel Labi. *Urban road space allocation incorporating the safety and construction cost impacts of lane and footpath widths*. Pages 222-232.

Introduction: Walkability continues to attract great attention from urban planners, designers, and engineers as they recognize not only the merits of pedestrian facilities in terms of the health benefits but also their demerits in terms of accident risk to pedestrians. Wide footpaths improve the pedestrian environment and experience, and thereby motivate travelers to walk as much as possible. However, if footpaths are too wide, they may leave a smaller space for the roadway. On the other hand, wide road lanes may lead to higher road vehicle safety but are costly to construct and maintain and

also may leave little space for the footpath. Evidently, for a fixed urban space, what is needed is an optimal balance between the vehicle lane and pedestrian path. This problem is encountered routinely in dense cities including Hong Kong where land availability is severely limited. **Method:** To address the issue, this paper first establishes safety performance functions (SPFs) for the pedestrian space and the road space, using the random-parameter negative binomial regression. The results indicate the extent to which road lane and footpath width changes are associated with changes in in-vehicle occupant and pedestrian casualties. Then the paper uses the SPFs to develop a methodology for optimizing the width allocations to the road lanes and footpaths, duly considering the user (safety) costs and agency (construction) costs associated with each candidate allocation of the widths. Finally, the paper analyzes the sensitivity of the optimal solution to the relative weights of user cost and agency cost. **Results:** When user and agency costs are considered equally important, the optimal lane width is 5.4 m. **Conclusion:** It is observed that the road space allocation ratio used by the Hong Kong road agency suggests that the agency places a higher weight to user cost compared to agency cost. **Practical Application:** The findings can help incorporate design-safety relationships, and the stakeholders (agency and users) perspectives in urban road and footpath design.

- **Keywords:** Road safety; Footpath; Width allocation; Safety cost; Life cycle cost

Wen Hu, Jessica B. Cicchino. *The effects of left-turn traffic-calming treatments on conflicts and speeds in Washington, DC*. Pages 233-240.

Introduction: Left-turning vehicles pose considerable safety risks to pedestrians at intersections. Left-turn traffic-calming treatments are designed to slow left-turn traffic. This study examined the effects of one type of left-turn calming, the hardened-centerline treatment, on the numbers of conflicts between left-turning vehicles and pedestrians and left-turn speeds in Washington, DC. **Method:** Numbers of conflicts between left-turning vehicles and pedestrians, as well as left-turn speeds, were collected at selected intersections in Washington, DC, where the hardened centerline was installed, as well as at control intersections in the city where no treatment was installed, before and after installation. Poisson regression evaluated the change in numbers of conflicts associated with the hardened-centerline treatment. The effect of the treatment on left-turn speeds was estimated by a log-linear regression model, and the effect on the odds of left-turning vehicles exceeding 15 mph was estimated by a logistic regression model. **Results:** The treatment was associated with a 70.5% reduction in conflicts between left-turning vehicles and pedestrians, a 9.8% reduction in mean left-turn speeds, and a 67.1% reduction in the odds of left-turning vehicles exceeding 15 mph. All the reductions were statistically significant. **Conclusions:** The study demonstrates that the hardened-centerline treatment can reduce conflicts between left-turning vehicles and pedestrians, and slow down left-turn traffic at intersections. **Practical applications:** The treatment should be added to the toolbox for communities looking to improve pedestrian safety at intersections.

- **Keywords:** Left turns; Hardened centerline; Pedestrians; Conflicts; Speeds; Intersections

Alex Albert, Bhavana Pandit, Yashwardhan Patil, Joseph Louis. *Does the potential safety risk affect whether particular construction hazards are recognized or not?* Pages 241-250.

Introduction: Evidence from the global construction industry suggests that an unacceptable number of safety hazards remain unrecognized in construction workplaces. Unfortunately, there isn't a sufficient understanding of why particular safety hazards remain unrecognized. Such an understanding is important to address the issue of poor hazard recognition and develop remedial interventions. A recent exploratory effort provided anecdotal evidence that workers often fail to recognize safety hazards that are

expected to impose relatively lower levels of safety risk. In other words, the research demonstrated that the underlying risk imposed by a safety hazard can affect whether a hazard will be recognized or not. **Method:** The presented research focused on empirically testing this preliminary finding. More specifically, the study tested the proposition that Construction workers are more likely to recognize safety hazards that impose higher levels of safety risk than those that impose relatively lower levels of safety risk. The research goals were accomplished through a number of steps. First, a set of 16 construction case images depicting a variety of construction operations that included a number of known safety hazards was presented to a panel of four construction safety experts. The experts were tasked with examining each of the known safety hazards and providing a rating of the relative safety risk that the individual hazards impose. Having obtained an estimate of the underlying safety risk, a hazard recognition activity was administered to 287 workers recruited from 57 construction workplaces in the United States. The hazard recognition activity involved the examination of a random sample of two construction case images that were previously examined by the expert panel and reporting relevant safety hazards. **Results:** The results of the study provided support for the proposition that workers are more likely to recognize hazards that impose relatively higher levels of safety risk. **Practical Applications:** The findings of the study can be leveraged to improve existing hazard recognition methods and develop more robust interventions to address the issue of poor hazard recognition levels.

- **Keywords:** Safety and health; Construction safety, Injury prevention; Hazard recognition; Hazard identification; Safety risk

Tracey Ma, Justin N. Chee, Joshua Hanna, Nadia Al Jenabi, Frances Ilari, Donald A. Redelmeier, Yoassry Elzohairy. *Impact of medical fitness to drive policies in preventing property damage, injury, and death from motor vehicle collisions in Ontario, Canada*. Pages 251-261.

Introduction: Drivers with medical conditions and functional impairments are at increased collision risk. A challenge lies in identifying the point at which such risk becomes unacceptable to society and requires mitigating measures. This study models the road safety impact of medical fitness-to-drive policy in Ontario. **Method:** Using data from 2005 to 2014, we estimated the losses to road safety incurred during the time medically-at-risk drivers were under review, as well as the savings to road safety accrued as a result of licensing decisions made after the review process. **Results:** While under review, drivers with medical conditions had an age- and sex-standardized collision rate no different from the general driver population, suggesting no road safety losses occurred (RR = 1.02; 95% CI: 0.93–1.12). Licensing decisions were estimated to have subsequently prevented 1,211 (95% CI: 780–1,730) collisions, indicating net road safety savings resulting from medical fitness to drive policies. However, more collisions occurred than were prevented for drivers with musculoskeletal disorders, sleep apnea, and diabetes. We theorize on these findings and discuss its multiple implications. **Conclusions:** Minimizing the impact of medical conditions on collision occurrence requires robust policies that balance fairness and safety. It is dependent on efforts by academic researchers (who study fitness to drive); policymakers (who set driver medical standards); licensing authorities (who make licensing decisions under such standards); and clinicians (who counsel patients on their driving risk and liaise with licensing authorities). **Practical Applications:** Further efforts are needed to improve understanding of the effects of medical conditions on collision risk, especially for the identified conditions and combinations of conditions. Results reinforce the value of optimizing the processes by which information is solicited from physicians in order to better assess the functional impact of drivers' medical conditions on driving and to take suitable licensing action.

- **Keywords:** Medical condition; Functional impairment; Motor vehicle collision; Motor vehicle accident; Road traffic injury; Road safety; Driver fitness; Fitness to drive

Zhihong Yao, Rong Hu, Yangsheng Jiang, Taorang Xu. *Stability and safety evaluation of mixed traffic flow with connected automated vehicles on expressways*. Pages 262-274.

Introduction: Connected automated vehicles (CAVs) technology has deeply integrated advanced technologies in various fields, providing an effective way to improve traffic safety. However, it would take time for vehicles on the road to vehicles from human-driven vehicles (HDVs) progress to CAVs. Moreover, the Cooperative Adaptive Cruise Control (CACC) vehicle would degrade into the Adaptive Cruise Control (ACC) vehicle due to communication failure. **Method:** First, the different car-following models are used to capture characteristics of different types of vehicles (e.g., HDVs, CACC, and ACC). Second, the stability of mixed traffic flow is analyzed under different penetration rates of CAVs. Then, multiple safety measures, such as standard deviation of vehicle speed (SD), time exposed rear-end crash risk (TER), time exposed time-to-collision (TET), and time-integrated time-to-collision (TIT) are used to evaluate the safety of mixed traffic flow on expressways. Finally, the sensitivity of traffic demand, the threshold of time-to-collision (TTC), and the parameters of car-following models are analyzed based on a numerical simulation. **Results:** The results show that the ACC vehicle has no significant impact on the SD of mixed traffic flows, but it leads to the deterioration of TET and TIT, making the reduction proportion of TER slower. When the penetration rate exceeds 50%, the increase of CACC vehicles reduces traffic safety risks significantly. Furthermore, the increase in traffic demand and car-following parameters worsens traffic safety on expressways. **Conclusions:** This paper suggests that the CACC vehicles degenerate into ACC vehicles due to communication failure, and the safety risk of mixed traffic flow increases significantly. **Practical Applications:** The application of CAVs can improve the stability and safety of traffic flow.

- **Keywords:** Safety evaluation; Stability analysis; Connected automated vehicles; Time-to-collision; Rear-end crashes

Alexa J. Doerr. *When and how personality predicts workplace safety: Evaluating a moderated mediation model*. Pages 275-283.

Introduction: Though previous research has linked personality and workplace safety, results have been inconsistent. Aims of the present study were to understand when and how personality factors predict safety performance. **Methods:** With 492 working adults, a moderated mediation model was tested whereby the relationship between personality and safety behavior was mediated by safety motivation and moderated by situation strength (i.e., safety climate perceptions). **Results:** Findings indicate that, aside from extraversion, safety motivation mediated all relationships between FFM personality traits and safety behavior. The mediated relationship between conscientiousness and safety motivation was attenuated by safety climate perceptions. However, relationships between all other personality traits and safety motivation, and ultimately safety behavior, remained consistent or, in the case of extraversion, was augmented at higher levels of safety climate perceptions. **Conclusion:** Results demonstrate an empirical basis for how and when personality translates into safety behavior at work. Additionally, findings provide a theoretical explanation for the mixed results among previous studies of personality's relationship with safety outcomes. Implications are discussed for employee selection and training practices in safety-intensive industries.

- **Keywords:** Safety; Situation strength; Safety climate; Personality; Five Factor Model

Jeremías D. Tosi, Rubén D. Ledesma, Carlos M. Díaz Lázaro, Fernando M. Poó. *Implicit attitudes towards risky driving behaviors: Evidence of validity for the implicit association test*. Pages 284-291.

Introduction: Attitudes toward risky driving behaviors are commonly evaluated through direct self-report measures. Nevertheless, these instruments have limitations, such as socially-desirable responding. This study examines the validity of the Implicit Association Test (IAT) as an indirect measure of attitudes towards risky driving. An IAT with "risky" vs. "safe" driving behaviors categories was evaluated. **Method:** A sample of 100 participants (ranging from 18 to 70 years of age) completed the IAT and measures of attitudes, driving styles, personality traits, risk-taking (IOWA Gambling Task), and social desirability (Driver Social Desirability Scale). **Results:** A high level of internal consistency was found for IAT scores. The IAT was correlated with driving styles (risky, dissociative, and careful dimensions), risk-related personality traits (impulsive/sensation seeking and aggression/hostility) and risk-taking measures. IAT scores were also associated with self-reported risky driving behaviors ($r = 0.33$). As expected, a higher level of negative implicit attitudes was found among young drivers. The driver social desirability scale was correlated with most self-report measures, but not with the IAT. **Conclusion:** The present study provides reliability and validity evidence for the IAT as an indirect measure of attitudes towards risky driving. The IAT can serve as an important complement to conventional self-report measures of driving attitudes. **Practical Applications:** Potential use of global measure of implicit attitudes toward risky driving behaviors in the evaluation, education, and training of drivers are discussed.

- **Keywords:** Dual-process model of attitudes; Direct measures; IAT; Implicit attitudes

Feifeng Jiang, Kwok Kit Richard Yuen, Eric Wai Ming Lee. *Analysis of motorcycle accidents using association rule mining-based framework with parameter optimization and GIS technology*. Pages 292-309.

Introduction: Analyzing key factors of motorcycle accidents is an effective method to reduce fatalities and improve road safety. Association Rule Mining (ARM) is an efficient data mining method to identify critical factors associated with injury severity. However, the existing studies have some limitations in applying ARM: (a) Most studies determined parameter thresholds of ARM subjectively, which lacks objectiveness and efficiency; (b) Most studies only listed rules with high parameter thresholds, while lacking in-depth analysis of multiple-item rules. Besides, the existing studies seldom conducted a spatial analysis of motorcycle accidents, which can provide intuitive suggestions for policymakers. **Method:** To address these limitations, this study proposes an ARM-based framework to identify critical factors related to motorcycle injury severity. A method for parameter optimization is proposed to objectively determine parameter thresholds in ARM. A method of factor extraction is proposed to identify individual key factors from 2-item rules and boosting factors from multiple-item rules. Geographic information system (GIS) is adopted to explore the spatial relationship between key factors and motorcycle injury severity. **Results and conclusions:** The framework is applied to a case study of motorcycle accidents in Victoria, Australia. Fifteen attributes are selected after data preprocessing. 0.03 and 0.7 are determined as the best thresholds of support and confidence in ARM. Five individual key factors and four boosting factors are identified to be related to fatal injury. Spatial analysis is conducted by GIS to present hot spots of motorcycle accidents. The proposed framework has been validated to have better performance on parameter optimization and rule analysis in ARM. **Practical applications:** The hot spots of motorcycle accidents related to fatal factors are presented in GIS maps. Policymakers can refer to those maps straightforwardly when decision making. This framework can be applied to various kinds of traffic accidents to improve the performance of severity analysis.

- **Keywords:** Motorcycle Accidents; Association Rule Mining (ARM); threshold determination; Accurate and Efficient Classification Based on Multiple Class-Association Rules (CMAR); Key Factors; Geographic Information System (GIS)

Alexandra S. Mueller, Jessica B. Cicchino, David S. Zuby. *What humanlike errors do autonomous vehicles need to avoid to maximize safety?* Pages 310-318.

Introduction: The final failure in the causal chain of events in 94% of crashes is driver error. It is assumed most crashes will be prevented by autonomous vehicles (AVs), but AVs will still crash if they make the same mistakes as humans. By identifying the distribution of crashes among various contributing factors, this study provides guidance on the roles AVs must perform and errors they must avoid to realize their safety potential. **Method:** Using the NMVCCS database, five categories of driver-related contributing factors were assigned to crashes: (1) sensing/perceiving (i.e., not recognizing hazards); (2) predicting (i.e., misjudging behavior of other vehicles); (3) planning/deciding (i.e., poor decision-making behind traffic law adherence and defensive driving); (4) execution/performance (i.e., inappropriate vehicle control); and (5) incapacitation (i.e., alcohol-impaired or otherwise incapacitated driver). Assuming AVs would have superior perception and be incapable of incapacitation, we determined how many crashes would persist beyond those with incapacitation or exclusively sensing/perceiving factors. **Results:** Thirty-three percent of crashes involved only sensing/perceiving factors (23%) or incapacitation (10%). If they could be prevented by AVs, 67% could remain, many with planning/deciding (41%), execution/performance (23%), and predicting (17%) factors. Crashes with planning/deciding factors often involved speeding (23%) or illegal maneuvers (15%). **Conclusions:** Errors in choosing evasive maneuvers, predicting actions of other road users, and traveling at speeds suitable for conditions will persist if designers program AVs to make errors similar to those of today's human drivers. Planning/deciding factors, such as speeding and disobeying traffic laws, reflect driver preferences, and AV design philosophies will need to be consistent with safety rather than occupant preferences when they conflict. **Practical applications:** This study illustrates the complex roles AVs will have to perform and the risks arising from occupant preferences that AV designers and regulators must address if AVs will realize their potential to eliminate most crashes.

- **Keywords:** Autonomous; Self-driving; Guidance; Design; Recommendations; Crashes