Matthew M. Laske, Philip E. Hinson, Yalcin Acikgoz, Timothy D. Ludwig, Anne M. Foreman, Shawn M. Bergman. *Do employees' work schedules put them at-risk? The role of shift scheduling and holidays in predicting near miss and incident likelihood*. Pages 1-7.

Introduction: Using crew scheduling and injury incident data from a Fortune 500 manufacturing company, this study analyzed the effect of consecutive shifts and shifts near holidays on near misses and incidents. Methods: Logistic regressions were conducted with consecutive workdays, days near holidays, and time of shift as predictors of incident and near miss outcomes. Results: The logistic regression analysis indicated that working consecutive day shifts increases the probability of an incident occurring, with the fourth consecutive shift resulting in the most risk. The consecutive shift pattern did not replicate to employees working the night shift. However, the first and second shifts when transferring to a night schedule appear to have a greater chance of incident. Shifts near holidays did not have a significantly higher risk than other shifts. Practical application: The current research suggests that organizations can use similar analytic techniques to determine if shift scheduling might be related to increased risk and allocate resources to mitigate hazards during those peak probability shifts.

- **Keywords:** Shift-schedule; Consecutive shifts; Holiday schedule; Injury prediction; Near miss prediction

Sanaz Sadeghi, Nazi Soltanmohammadlou, Farnad Nasirzadeh. *Applications of wireless sensor networks to improve occupational safety and health in underground mines*. Pages 8-25.

Introduction: The very complex and hazardous environment of underground mines may significantly contribute to occupational fatalities and injuries. Deploying wireless sensor network (WSN) technology has the potential to improve safety and health monitoring of miners and operators. However, the application of WSN in the industry is not fully understood and current research themes in this area are fragmented. Thus, there is a need for a comprehensive review that directly explores the contribution of WSNs to occupational safety and health (OSH) in underground mines. Method: This study aims to conduct a systematic literature review on the existing applications of WSNs for improving OSH in the underground mining industry to pinpoint innovative research themes and

their main achievements, reveal gaps and shortcomings in the literature, recommend avenues for future scholarly works, and propose potential safety interventions. The major contribution of this review is to provide researchers and practitioners with a holistic understanding of the integration of WSN applications into underground mine safety and health management. Results: The review results have been categorized and discussed under three predominant categories including location monitoring and tracking, physiological and body kinematics monitoring, and environmental monitoring. Finally, seven major directions for future research and practical interventions have been identified based on the existing research gaps including: (1) further applications of WSNs for underground mining OSH management; (2) application of WSNs from research to real-world practice; (3) big data analytics and management; (4) deploying multiple WSNs-based monitoring systems; (5) integration of WSNs with other communication systems; (6) adapting WSNs to the Internet of Things (IoT) infrastructure; and (7) autonomous WSNs.

- **Keywords:** Wireless sensor network (WSN); Wireless underground sensor network (WUSN); Occupational safety and health; Underground mine

Terry Lee Bunn, Madison Liford, Michael Turner, Ashley Bush. *Driver injuries in heavy vs. light and medium truck local crashes, 2010–2019*. Pages 26-34.

Objective: Multiple heavy truck driver injury studies exist, but there is a paucity of research on light and medium truck driver injuries. The objective of this study was to use first report of injury (FROI) data to: (a) compare demographic and injury characteristics; (b) assess workers' compensation (WC) claim disposition and lost work time status; and (c) describe injury scenarios by vehicle type for heavy truck and light/medium truck driver local crashes. Method: Kentucky Department of Workers' Claims FROI quantitative and free text data were analyzed for years 2010–2019. Of 800 total FROIs, 451 involved heavy trucks and 349 involved light or medium trucks. Results: There was a higher light/medium truck driver crash FROI rate compared to the heavy truck driver crash FROI rate. There was a higher proportion of younger light/medium truck driver crash FROIs compared to younger heavy truck driver crash FROIs. The retail trade industry made up the largest percentage of light/medium truck local crash FROIs (47%); the transportation and warehousing industry was most frequently cited in heavy truck FROIs (46%). The heavy truck types most frequently identified in FROIs were semi-trucks (13%) and dump trucks (11%). The most common light/medium truck type identified was delivery trucks (30%). Most commonly, heavy truck crash FROIs involved rollovers, driving off/overcorrecting on narrow roadways, and driving downhill/unable to downshift. Light/medium truck crash FROIs most frequently involved being rear-ended, running red lights, and turning in front of other vehicles. Conclusions: The utilization of WC FROI data highlighted top injury scenarios and specific vehicle types for targeting driver safety training among truck drivers, particularly light/medium truck drivers. Road safety policies regarding driver training, crash reviews, and in-vehicle monitoring systems are needed for truck drivers with previous crash injuries, especially for light and medium truck drivers. Practical applications: Enhanced safety training on speeding on narrow roadways, on nearing intersections, and on downshifting on hills is needed for semi-truck, dump truck, and coal truck drivers with previous crash injuries. Rear-end crash prevention training (e.g., gradual stopping and checking mirrors) is needed for drivers of furniture, automotive parts and accessories, and groceries and soft drink delivery trucks with previous crash injuries.

- **Keywords:** Light truck crash injuries; Medium truck crash injuries; Injury scenarios; Wholesale and retail trade industries; Rear-end crash injuries

Shamsi Soltani, Leilani Schwarcz, Devan Morris, Rebecca Plevin, Rochelle Dicker, Catherine Juillard, Adaobi Nwabuo, Megan Wier. *What is counted counts: An innovative linkage of police, hospital, and spatial data for transportation injury prevention*. **Pages 35-44.**

Introduction: Growing research indicates transportation injury surveillance using police collision reporting alone underrepresents injury to vulnerable groups, including pedestrians, cyclists, and people of color. This reflects differing reporting patterns and non-clinicians' challenge in accurately evaluating injury severity. To our knowledge, San Francisco is the first U.S. city to link and map hospital and police injury data. Analysis of linked data injury patterns informs interventions supporting traffic fatality and injury prevention goals. Methods: Injury and fatality records 2013–2015 were collected from San Francisco Police, Emergency Medical Services (EMS), Medical Examiner, and Zuckerberg San Francisco General Hospital (ZSFG). Probabilistic linkage was conducted using LinkSolv9.0 on match variables collision/admission time, name, birthdate, sex, travel mode, and geographic collision location. Results: From 2013-2015, this study identified 17,000+ transportation-related injuries on public roadways in San Francisco. Twenty-six percent (n = 4,415) appeared in both police and ZSFG sources. Linked injury records represent 39% of police records (N = 11,403) and 43% of hospital records (N = 10,223). Among hospital records, 34% of cyclist, 38% of motor vehicle occupant, 61% of pedestrian, and 54% of motorcyclist records linked with a police record. Linkage rate varied by travel mode even after controlling for injury severity. Transportation-injured ZSFG-treated patients lacking police reports were more often cyclists, male, Hispanic or Black, and less often occupants of motor vehicles compared to those with injuries captured only in police reports. Conclusions: Incorporating hospital and EMS spatial data into injury surveillance systems historically reliant on police reports offers trifold benefits. First, linkage captures injuries absent in police data, adding data on populations empirically vulnerable to injury. Second, it improves injury severity assessment. Finally, linked data better informs and targets interventions serving injury-burdened populations and road users, advancing transportation injury prevention. Practical applications: Linkage closes data gaps, improving ability to quantify injury and develop evidence-based interventions for vulnerable groups.

- ▪ **Keywords:** Probabilistic linkage; Injury surveillance; Traffic collision; Vision Zero; Local health department

Weimin Jin, Mhafuzul Islam, Mashrur Chowdhury. *Risk-based merging decisions for autonomous vehicles*. **Pages 45-56.**

Introduction: The safe freeway merging operation for fully Autonomous Vehicles (AVs) in mixed traffic (i.e., the presence of AVs and non-AVs in a traffic stream) is a challenging task. Under a mixed traffic environment, an AV merging operation could significantly increase conflict risks and reduce operational efficiency. Method: This study quantifies the freeway merging conflict risk and develops a freeway merging decision strategy based on conflict risk assessment for an AV attempting to merge to a traffic stream with non-AVs on the freeway. The performance of the risk-based merging decision strategy is evaluated in uncongested, near-congested, and congested traffic conditions. Results: The analyses show that the risk-based merging strategy causes less abrupt deceleration of an AV's immediate upstream vehicle in the target lane on the freeway compared to the based models (i.e., two models based on gap acceptance concepts and a safe gap model based on a surrogate measure, 'Time-to-Collision (TTC)'). The risk-based merging strategy meets the minimum safe gap between an AV intending to merge and its immediate downstream vehicle in the target lane. The risk-based merging strategy produces lower conflict risk in terms of 'Time Exposed Time-to-Collision (TET)' and 'Time Integrated Time-to-Collision (TIT)' compared to the base models. Moreover, the risk-based merging strategy has a lower impact on the average speed of traffic in the target lane compared to the base models considered in this study. Conclusions: The risk-based

merging strategy shows higher safety benefits for an AV's merging operation compared to base models. Practical Applications: The findings of this research would help design AV controllers for improving the safety of an AV merging operation in a mixed traffic stream.

- **Keywords:** Autonomous vehicle; Merging decision; Risk assessment; Mixed traffic

Paolo Cappellari, Bryan S. Weber. *An analysis of the New York City traffic volume, vehicle collisions, and safety under COVID-19*. Pages 57-65.

Introduction and Method: We use the arguably exogenous intensity of COVID-19 as an instrument in order to study the relationship between traffic volume and vehicle collisions in a large metropolitan area. We correlate data from multiple sources and consider a time interval ranging from about one year before to one year after the pandemic breakout, which allows to account for preexisting seasonal patterns as well as the disruption brought by the pandemic. Results: We identify that increased traffic volume is associated with significantly more collisions with a robust elasticity varying between 1.2 and 1.7. At the same time, higher traffic volumes are associated with a significant reduction in casualties. Conversely, low traffic volumes are associated with high speeds and with particularly dangerous collisions. In terms of social cost, we separately calculated the cost of property damage and casualties. We measured that the reduction in the per-day social cost of collisions during the COVID-19 period is approximately $453,000 in property damage. However, the increase in casualties from collisions at lower traffic volumes are worth approximately $2.6 million in injuries and fatalities, entirely offsetting any benefit from reduced collisions. Practical Applications: This research provides valuable insights that policy makers may take into consideration when shifting traffic volume in relation to social cost and safety, such as congestion taxes.

- **Keywords:** COVID-19; Traffic; Collisions; Smart city

Saeed Esmaeli, Kayvan Aghabayk, Lyndel Bates. *Willingness and intention to run a red light among motorcyclists*. Pages 66-78.

Introduction: An important issue affecting the safety of riders is running a red light. Many factors can affect this risky behavior including demographic, safety, and meteorological factors. Method: Using two models, the Prototype Willingness Model (PWM) and the Theory of Planned Behavior (TPB), this study examines this behavior. In this study, 853 participants completed an online questionnaire. Results: The results indicated that older people and those who were married ran the red light less frequently compared with other riders. Additionally, people who rode motorcycles for more hours in a day had greater intentions and willingness to run the red light. People who had prior risky experiences while riding in the past reported running red lights more frequently. When comparing the two models, the PWM predicted a greater level of variance in the red-light running behavior when compared with the TPB. Among the components of the TPB model, the attitude factor was the strongest predictor. Prototype similarity was the strongest predictor of red-light running among the components of the PWM. Finally, it was observed that using a road safety educational (RSE) solution can effectively reduce the rate of red light traffic running among motorcyclists.

- **Keywords:** Theory of planned behavior; Prototype willingness model; Motorcycle rider; Red-light running; Decision making

Nick Turner, Connie Deng, Steve Granger, Timothy G. Wingate, Rabeel Shafqat, Paul M. Dueck. *Young workers and safety: A critical review and future research agenda*. Pages 79-95.

Introduction: Research on young worker safety often relies on inconsistent definitions of young workers and poorly delineated indicators of occupational safety. This review aims to reconcile these fundamental issues by critically integrating research across disciplines and providing clear directions for future research on young worker safety. Method: We critically review the extant research on young worker safety. Results: We first reconcile the inconsistent definitions of young workers and specify the indicators of occupational safety used in young worker safety research. We next describe the prevalence of workplace injuries and population-level predictors of these injuries among young workers and then outline other factors that increase young workers' susceptibility to workplace injuries. Finally, we discuss the convergence of many of these issues on family farms—a context commonly studied in young worker safety research. Conclusions: Clearer definitions of young workers and indicators of occupational safety can improve the interpretation and comparability of extant research findings. Furthermore, the prevalence of workplace injuries and population-level predictors of injury among young workers are subject to the interactions among age, gender, minority status, and job characteristics. Other factors that increase young workers' susceptibility to injury include young workers' responses to hazardous work, individual differences stemming from young workers' biological and psychological development, managerial attitudes about young workers, and the limited safety training young workers are thus provided, the types of work that young workers typically perform, and the range of social influences on young workers. Practical Applications: Safety campaigns and safety training should consider interactions among young workers' age, gender, minority status, and job characteristics, rather than considering these features independently.

- **Keywords:** Gender; Injuries; Review; Safety; Young workers

Carolyn G. DiGuiseppi, Hailey A. Hyde, Marian E. Betz, Kenneth A. Scott, David W. Eby, Linda L. Hill, Vanya C. Jones, Thelma J. Mielenz, Lisa J. Molnar, David Strogatz, Guohua Li. *Association of falls and fear of falling with objectively-measured driving habits among older drivers: LongROAD study*. Pages 96-104.

Objective: Falls in older adults are associated with increased motor vehicle crash risk, possibly mediated by driving behavior. We examined the relationship of falls and fear of falling (FOF) with subsequent objectively measured driving habits. Methods: This multi-site, prospective cohort study enrolled 2990 active drivers aged 65–79 (53% female). At enrollment, we assessed falls in the past year and FOF (Short Falls Efficacy Scale-International). Driving outcomes included exposure, avoidance of difficult conditions, and unsafe driving during one-year follow-up, using in-vehicle Global Positioning System devices. Results: Past-year falls were associated with more hard braking events (HBE). High FOF was associated with driving fewer days, miles, and trips, driving nearer home and more HBE. Differences were attenuated and not significant after accounting for health, function, medications and sociodemographics. Discussion: Differences in objectively measured driving habits according to past-year fall history and FOF were largely accounted for by differences in health and medications. Rather than directly affecting driving, falls and FOF may serve as markers for crash risk and reduced community mobility due to age-related changes and poor health.

- **Keywords:** Falls; Fear of falling; Traffic safety; Mobility; Aging; Automobile driving

Sharifah N.N. Syed-Yahya, Mohd Awang Idris, Andrew J. Noblet. *The relationship between safety climate and safety performance: A review*. Pages 105-118.

Introduction: Since its inception more than four decades ago, research on safety climate has been conducted in many industries. Subsequently, a plethora of systematic literature reviews on safety climate in various work environments has focused on research trends and measurement scales. Yet, despite these reviews, the overall picture of how safety climate influences performance is still not well understood. The current study reviews existing literature on safety climate, specifically how it affects safety performance. Method: Literature searches were conducted using EBSCOhost and Web of Science databases in March 2021. We included English-language, peer-reviewed studies that reported the results of research done on safety climate and safety performance. We extracted data (contextual, theoretical, methodological and definition of safety performance) from these studies and were deductively analyzed and categorized into common themes. Results: One hundred and sixty-two safety climate studies were identified. We found that studies on safety climate–performance were conducted in 16 types of industries while 23 different theories explained the safety climate–performance relationship. The quantity and quality of variables and methods used varied considerably across the surveys. Safety climate is predominantly used as a predictor while safety-related behavior is the most common definition of safety performance among the articles we reviewed. Few papers from the current review were methodologically strong, suggesting that current evidence on the link between safety climate and safety performance still suffers from common method bias. Conclusions: Although literature has provided evidence for the positive effect on safety performance via a strong safety climate, strong and convincing methods are still lacking and the causality of an improved safety climate still needs to be demonstrated. Practical applications: The findings of the current review offer a better understanding of how employers can improve safety climate in the workplace in various settings.

Ruihong Zhou, Yingfeng Li. *Traffic crash changes following transitions between daylight saving time and standard time in the United States: New evidence for public policy making*. Pages 119-127.

Introduction: This study examined the impact of daylight saving time changes on traffic crashes in the United States. Using a data-driven regression analysis approach, the study analyzed 2014–2016 crash data from six states spanning all four major time zones in the contiguous United States. Method: The researchers developed regression models for a number of analysis scenarios and by days of week separately. Based on the crash data, the team used an eight-week impact period for the spring time change and a four-week impact period for the fall time change. Results: The regression analysis showed that the spring time change was followed by an overall crash reduction of 18% during the eight-week period immediately after the time change, with a considerably higher crash reduction for freeway crashes (24%), rural crashes (24%), or non-intersection crashes (21%). The time change back to SDT in fall was followed by a 6% overall crash increase during the following four weeks, with considerably higher increases for freeway crashes (15%), non-intersection crashes (9%), nighttime crashes (28%), single-vehicle crashes (28%), and crashes in urban areas (12%). This study provides additional insights, including in many cases more comprehensive knowledge on how the changes to and from DST each year affect roadway traffic crashes. Practical Applications: The findings of this project further add to the current understanding on how the time changes affect public health in the form of traffic crashes. They also serve as additional evidence for public policy makers to better weigh the benefits and impacts associated with the time changes in the United States for relevant policy makings.

Ishita Dash, Mark Abkowitz, Craig Philip. *Factors impacting bike crash severity in urban areas*. Pages 128-138.

Introduction: Bicycling plays an important role as a major non-motorized travel mode in many urban areas. While increasingly serving as a key part of an integrated transportation demand management system and a sustainable mobility option, interest in biking as an active transportation mode has been unfortunately accompanied by an increase in the number of bike crashes, many with incapacitating injuries or fatal outcomes. Thus, to improve bicycling safety it is crucial to understand the critical factors that influence severe bicyclist crash outcomes, and to identify and prioritize policies and actions to mitigate these risks. Method: The study reported herein was conducted with this objective in mind. Our approach involves the use of classification models (logistic regression, decision tree and random forest), as well as techniques for treating unbalanced data by under sampling, oversampling, and weighted cost sensitivity (CS) learning, applied to bike crash data from the State of Tennessee's two largest urban areas, Nashville and Memphis. Results: The results indicate that random forest with weighted CS offers the potential for greater explanatory accuracy, an important observation given the paucity of efforts to date in applying random forest to bike safety studies. Inadequate lighting conditions, crashes on roadways, speed limits, average annual daily traffic, number of lanes, and weekends are the critical features identified. Conclusion: Based on these results, a series of specific, suggested policy changes are presented for implementation consideration. Practical Applications: There is existing guidance in FHWA Lighting Handbook and TDOT's Roadway Design Guidelines that spell out some engineering design solutions like lighting provisions, bicycle facility design, and traffic calming measures. These measures may alleviate the identified key features impacting fatal and incapacitating bicycle injuries. Further research should be conducted to gauge the efficacy of the solutions suggested.

Pierluigi Olleja, Jonas Bärgman, Nils Lubbe. *Can non-crash naturalistic driving data be an alternative to crash data for use in virtual assessment of the safety performance of automated emergency braking systems?* Pages 139-151.

Introduction: Developers of in-vehicle safety systems need to have data allowing them to identify traffic safety issues and to estimate the benefit of the systems in the region where it is to be used, before they are deployed on-road. Developers typically want in-depth crash data. However, such data are often not available. There is a need to identify and validate complementary data sources that can complement in-depth crash data, such as Naturalistic Driving Data (NDD). However, few crashes are found in such data. This paper investigates how rear-end crashes that are artificially generated from two different sources of non-crash NDD (highD and SHRP2) compare to rear-end in-depth crash data (GIDAS). Method: Crash characteristics and the performance of two conceptual automated emergency braking (AEB) systems were obtained through virtual simulations – simulating the time-series crash data from each data source. Results: Results show substantial differences in the estimated impact speeds between the artificially generated crashes based on both sources of NDD, and the in-depth crash data; both with and without AEB systems. Scenario types also differed substantially, where the NDD have many fewer scenarios where the following-vehicle is not following the lead vehicle, but instead catches-up at high speed. However, crashes based on NDD near-crashes show similar pre-crash criticality (time-to-collision) to in-depth crash data. Conclusions: If crashes based on near-crashes are to be used in the design and assessment of

preventive safety systems, it has to be done with great care, and crashes created purely from small amounts of everyday driving NDD are not of much use in such assessment. Practical applications: Researchers and developers of in-vehicle safety systems can use the results from this study: (a) when deciding which data to use for virtual safety assessment of such systems, and (b) to understand the limitations of NDD.

Mankirat Singh, Yongping Zhang, Wen Cheng, Yihua Li, Edward Clay. *Effect of transit-oriented design on pedestrian and cyclist safety using bivariate spatial models*. Pages 152-162.

Introduction: Walking and cycling for transportation provide immense benefits (e.g., health, environmental, social). However, pedestrians and bicyclists are the most vulnerable segment of the traveling public due to the lack of protective structure and difference in body mass compared with motorized vehicles. Numerous studies are dedicated to enhancing active transportation modes, but very few studies are devoted to the safety analysis of the transit stops, which serve as the important modal interface for pedestrians and bicyclists. Method: This study bridges the gap by developing joint models based on the multivariate conditional autoregressive (MCAR) priors with distance-oriented neighboring weight matrix. For this purpose, transit-oriented design (TOD) related data in Los Angeles County were used for model development. Feature selection relying on both random forest (RF) and correlation analysis was employed, which leads to different covariates inputs to each of the two joint models, resulting in increased model flexibility. An integrated nested Laplace approximation (INLA) algorithm was adopted due to its fast, yet robust, analysis. For a comprehensive comparison of the predictive accuracy of models, different evaluation criteria were utilized. Results: The results demonstrate that models with correlation effect perform much better than the models without a correlation of pedestrians and bicyclists. The joint models also aid in the identification of the significant covariates contributing to the safety of each of the two active transportation modes. The findings show that population density, employment density, and bus stop density positively influence bicyclist-involved crashes, suggesting that an increase in population, employment, or the number of bus stops leads to more active modes involved collisions. Practical Applications: The findings of this study may prove helpful in the development and implementation of the safety management process to improve the roadway environment for the active modes in the long run.

Elhashemi Ali, Md Nasim Khan, Mohamed M. Ahmed. *Real-time snowy weather detection based on machine vision and vehicle kinematics: A non-parametric data fusion analysis protocol*. Pages 163-180.

Introduction: This study introduces a new analysis protocol for detecting real-time snowy weather conditions on freeways by utilizing trajectory-level data extracted from the Second Strategic Highway Research Program (SHRP2) Naturalistic Driving Study (NDS) dataset. The data include parameters reduced from a real-time image feature extraction technique, time series data collected from external sensors, and CANbus data collected by the NDS ego-vehicles. To provide flexibility in winter maintenance, two segmentation types of one-minute and one-mile segments were used to sample snowy trips and their matched clear weather trips. Method: In this study, four non-parametric models were developed using six data assemblies to detect snowy weather on freeways. The data assemblies are arranged based on three data sources, including image database extracted from an in-vehicle video camera, sensors, and CANbus data, to examine the effectiveness of snow detection models for different data types considering real-time availability of data. Results: Overall, the developed models successfully detected snowy

weather on freeways with an accuracy ranging between 76% to 89%. Results indicated that high accuracy of estimating snowy weather can be accomplished using the data fusion between external sensors data and texture parameters of images, without accessing to CANbus data. Practical Applications: Practical applications can be driven with respect to the time or distance coordinates, using different data fusion assemblies, and data availability. The study proves the importance of employing vehicles as weather sensors in the Connected Vehicles (CV) applications and Variable Speed Limit (VSL) to improve traffic safety on freeways.

- **Keywords:** Snowy weather detection; SHRP2; Naturalistic driving study; Trajectory-level data; Texture feature; Grey level co-occurrence matrix; Unsupervised machine learning; Weather estimation

Aki Jääskeläinen, Sari Tappura, Julius Pirhonen. *The path toward successful safety performance measurement*. Pages 181-194.

Introduction: Safety management is widely seen as a key contributor to occupational health and safety (OHS) performance. Performance measurement is an important tool for management in reaching its goals. Safety performance measurement has gained increasing attention in the literature. However, little is known so far of the path towards successful safety performance measurement resulting in better OHS performance. Methods: This study analyzes the maturity of safety performance measurement in relation to OHS performance and the role of employee commitment and practices of using performance information in facilitating the performance benefits. The empirical data were gathered with a survey that received 270 responses from five industrial organizations. Partial least squares structural equation modeling (PLS-SEM) was used to analyze the data obtained. Results: It is found that commitment to performance measurement is the strongest explaining factor of both supervisor and employee OHS performance, while the maturity of performance measurement has a direct effect on supervisor safety performance only. Practical Applications: The results show how safety performance measurement can be implemented to derive the potential benefits. While managers may benefit directly from advanced performance measures, the wider performance benefits among employees materialize only by using performance measurement properly and committing employees to it.

- **Keywords:** Occupational Health and Safety (OHS); Performance measurement; Performance management; Safety management; Survey study

José Ignacio Nazif-Munoz, Gül Anıl Anakök, Junon Joseph, Santosh Kumar Uprajhiya, Marie Claude Ouimet. *A new alcohol-related traffic law, a further reduction in traffic fatalities? Analyzing the case of Turkey*. Pages 195-203.

Background: In June 2013, an alcohol-related traffic law took effect in Turkey. The law 6487 introduced administrative fines for not respecting blood alcohol concentration limits, health warning messages on alcohol containers (bottles, cans), and prohibited the sale of alcohol beverages in retail facilities between 10 p.m. and 6 a.m.. This article examines how this law is associated with traffic fatality variation. Methods: Data from the Turkish Statistical Institute for the 2008–2019 period were analyzed. Outcomes were traffic fatality rates per 100,000 population and 10,000 motor vehicles. Exposure variable was the presence of law 6487. Alcohol, tobacco, and related beverages' household expenditure, unemployment rate, number of health professionals, number of crashes, and lags of the outcomes represented control variables. A time-series cross-regional fixed effect model was applied. Results: Empirical estimates suggest that the law 6487 was associated with a reduction of 15% (Incidence Rate Ratio (IRR) 0.85, 95% Confidence Interval (CI): 082, 0.94) in the traffic fatality per population rate and with a reduction of 14% (IRR: 0.86 (95% CI: 0.78, 0.92) in the traffic fatality per motor-vehicle

rate. After 6 years of its implementation, this intervention was associated with an absolute reduction of 1519 (95% reduction interval: 1177, 1810) traffic fatalities. Conclusions: Our research emphasizes that legislation with direct and indirect measures targeting driving under the influence of alcohol (DUIA) may be related to traffic fatalities reduction. Practical applications: This finding has important implications for policy and future research in contexts in which alcohol consumption is low such is in Turkey. Future research should seek to identify mechanisms that explain how laws are ultimately associated with DUIA variation.

- **Keywords:** Policy evaluation; Turkey; Fixed effects; Alcohol related laws; Time-series

Marco H. Benedetti, Li Li, Sijun Shen, Neale Kinnear, M. Kit Delgado, Motao Zhu. *Talking on hands-free and handheld cellphones while driving in association with handheld phone bans*. Pages 204-209.

Introduction: Concurrent use of a cellphone while driving impairs driving abilities, and studies of policy effectiveness in reducing distracted driving have yielded mixed results. Furthermore, few studies have considered how hands-free phone use associates with handheld phone bans. It is not clear whether hand-held phone bans dissuade some drivers from using the phone while driving completely, or whether it simply promotes a shift to hands-free use. The present study estimates the association between handheld phone policies and self-reported talking on hands-free and handheld cellphones while driving. Methods: Our data consisted of 16,067 respondents to annual administrations of the Traffic Safety Culture Index from 2012-2017. Our primary exposure variable was handheld phone policy, and our primary outcome variables were self-reported talking on any phone, self-reported talking on a handheld phone, and self-reported talking on a hands-free phone while driving. We estimated adjusted prevalence ratios of the outcomes associated with handheld phone bans via modified Poisson regression. Results: Drivers in states with handheld bans were 13% less likely to self-report talking on any type of cellphone (handheld or hands-free) while driving. When broken down by cellphone type, drivers in states with handheld bans were 38% less likely to self-report talking on a handheld phone and 10% more likely to self-report talking on a hands-free phone while driving. Conclusions: Handheld phone bans were associated with more self-reported talking on hands-free phones and less talking on handheld phones, consistent with a substitution hypothesis. Handheld bans were also associated with less talking on any phone while driving, supporting a net safety benefit. Practical Applications: In the absence of a national ban on handheld phone use while driving, our study supports state handheld phone bans to deter distracted driving and improve traffic safety.

- **Keywords:** Distracted driving; Hands-free phone use while driving; Handheld phone use while driving; Handheld phone policies; Traffic safety; Policy

Billy Chun Lung So, Chunzhuo Hua, Tingting Chen, Qingwen Gao, Siu Shing Man. *Biomechanical assessment of a passive back-support exoskeleton during repetitive lifting and carrying: Muscle activity, kinematics, and physical capacity*. Pages 210-222.

Introduction: Most people have experienced low back pain (LBP) more or less in their lifetime. Heavier load weight could increase the risk of LBP, especially in repetitive lifting and carrying tasks. The risk could also increase with the frequency of lifting. This study aims to investigate the effects of a passive back-support exoskeleton (PBSE) on trunk muscle activation, kinematics, and physical capacity in a repetitive lifting task and a carrying task in consideration of load weights in a laboratory setting. Results: Results showed that using the PBSE, the activities of the thoracic erector spinae and lumbar erector spinae muscles were reduced significantly by nearly 7% MVC and 3% MVC in the

repetitive lifting task and the carrying task, respectively. There was no significant effect of the PBSE on the spine kinematics and physical capacity. Practical Applications: This study supports the use of the PBSE to reduce trunk muscle activity in repetitive lifting and carrying tasks.

- **Keywords:** Muscle activity; Kinematics; Physical capacity; Manual handling operation; Passive back-support exoskeleton

Aimee E. Cox, Jessica B. Cicchino. *Older driver vehicle preferences and perceptions of safety: A survey*. Pages 223-231.

Introduction: Older adults drive older vehicles despite the safety benefits of newer, more crashworthy vehicles. We aimed to build upon previous research and assess vehicle preferences, buying and ownership patterns, and perceptions of safety among older drivers compared with middle-aged drivers. Methods: Mixed-mode telephone and online panel surveys were conducted with a nationally representative sample of drivers ages 35–54 and 70 and older. Participants were interviewed about their primary vehicle and the characteristics they deemed important at purchase, along with general attitudes surrounding vehicle safety. Results: Fifty-eight percent of drivers ages 70–79 and 63% of drivers 80 and older reported keeping a vehicle on average for 7 years or more before replacing it, compared with 32% of drivers 35–54. At purchase, older drivers were less likely than middle-aged drivers to have insisted upon safety technologies and were less likely to consider safety ratings; 10% of drivers 80 and older and 9% of those 70–79 indicated ratings were not at all important, compared with 4% of those ages 35–54. Among drivers 70 and older, driving patterns and income were strongly associated with vehicle age and type of vehicle driven. Conclusions: Older drivers place lower importance on vehicle safety and are less likely to seek safety features at purchase than middle-aged drivers. Compounding this, drivers 70 and older who do not drive frequently or who associate low mileage with vehicle safety are less likely to replace their older, low-mileage vehicles. Practical Application: Increasing older drivers' understanding of the importance of advancements in vehicle safety may result in greater ownership of safer vehicles and fewer road injuries.

- **Keywords:** Older drivers; Vehicle purchase; Motor vehicle safety; Aging; Vehicle age

Johan Fredin-Knutzén, Gergö Hadlaczky, Anna-Lena Andersson, Marcus Sokolowski. *A pilot study evaluating the effectiveness of preventing railway suicides by mid-track fencing, which restrict easy access to high-speed train tracks*. Pages 232-237.

Background: Suicides in the railway system is a serious health, societal, and transportation concern. Restriction of the access to suicide methods in the form of different physical barriers is a promising approach for suicide prevention. Method: Mid-track fencing, which is fencing placed in-between the high-speed and commuter train tracks, was installed at one out of seven stations along a train line outside of Stockholm in the years 2013/2014. The number of suicides at the intervention station was compared to six other stations used as controls, over a total period of 20 years (2002–2021). Results: Suicides at high-speed tracks occurring at stations was the major cause of death on the investigated railway line. Prior to the year 2014, the intervention and control stations displayed similar time trends in the number of suicides. After installation of the mid-track fencing in 2014, there was a 62.5% reduction in the rate of suicides occurring at the intervention station. Compared to the six other control stations, the intervention station displayed a significant reduction in the number of suicides during the years 2014–2021 (OR = 0.14, 95%CI 0.013–0.95). Suicides at the railway lines in-between stations were not increased post-intervention. However, nearby control stations showed a 162% increase in suicides after the intervention, suggesting the induction of

transfer effects. Conclusion: Mid-track fences restricting access to high-speed train tracks may have a large effect on reducing the number of railway suicides at intervention stations, but may also induce an increase in suicides at nearby stations without mid-track fences. Practical applications: Partial physical barriers such as mid-track fencing is deemed to be relatively easy and cheap to install (as compared to full barriers; e.g., full height platform screen doors) and should be considered at all stations on railway lines that have high-speed trains passing by.

Md. Shamsul Arefin, Ishita Roy, Swapna Chowdhury, Md. Shariful Alam. *Employer safety obligations, safety climate, and safety behaviors in the ready-made garment context in Bangladesh*. Pages 238-247.

Purpose: The impact of employer safety obligations on safety climate and safety outcomes has become an important area of research in organizational and safety sciences. Evidence shows that employer safety obligations positively impact safety outcomes, including safety climate and safety behaviors. However, these relationships have not been thoroughly explored within the garment settings. This study is one of the first known studies to examine the relationships between employer safety obligations, safety climate, and safety behavior outcomes in a sample of garment employees. Methods: Two-wave time-lagged data were collected from 347 garment employees and their supervisors in Bangladesh. Hierarchical regression analysis was applied to examine hypothesized relationships using AMOS a SPSS. Results: Employer safety obligations positively influenced safety climate perceptions among garment employees. Safety climate perceptions are positively and significantly associated with safety behaviors, including safety compliance behaviors, prosocial safety behaviors, and proactive safety behaviors. Moreover, the safety climate mediates the influence of employer safety obligations on safety behaviors. Conclusions: These findings provide important evidence of the relationships between employer safety obligations, safety climate, and safety behaviors in the garment industry of Bangladesh. Practical Applications: Ultimately, these findings guide the government, garment manufacturers, and managers to bolster garment employees' safety outcomes.

Miloš Pljakić, Dragan Jovanović, Boško Matović. *The influence of traffic-infrastructure factors on pedestrian accidents at the macro-level: The geographically weighted regression approach*. Pages 248-259.

Introduction: Walking is an active way of moving the population, but in recent years there have been more pedestrian casualties in traffic, especially in developing countries such as Serbia. Macro-level road safety studies enable the identification of influential factors that play an important role in creating pedestrian safety policies. Method: This study analyzes the impact of traffic and infrastructure characteristics on pedestrian accidents at the level of traffic analysis zones. The study applied a geographically weighted regression approach to identify and localize all factors that contribute to the occurrence of pedestrian accidents. Taking into account the spatial correlations between the zones and the frequency distribution of accidents, the geographically Poisson weighted model showed the best predictive performance. Results: This model showed 10 statistically significant factors influencing pedestrian accidents. In addition to exposure measures, a positive relationship with pedestrian accidents was identified in the length of state roads (class I), the length of unclassified streets, as well as the number of bus stops, parking spaces, and object units. However, a negative relationship was recorded with the total length of the street network and the total length of state roads passing through the analyzed area. Conclusion: These results indicate the importance of

determining the categorization and function of roads in places where pedestrian flows are pronounced, as well as the perception of pedestrian safety near bus stops and parking spaces. Practical Applications: The results of this study can help traffic safety engineers and managers plan infrastructure measures for future pedestrian safety planning and management in order to reduce pedestrian casualties and increase their physical activity.

- ▪ **Keywords:** Macro-level modeling; Pedestrian accidents; GWPR; Traffic analysis zones; Transportation planning

Theodore D. Teske, Samantha L. Case, Devin L. Lucas, Christy L. Forrester, Jennifer M. Lincoln. *Have you met Angus? Development and evaluation of a social marketing intervention to improve personal flotation device use in commercial fishing*. Pages 260-268.

Introduction: Drowning is the leading cause of death among commercial fishermen in the United States. Approximately 30% of all commercial fishing fatalities are attributed to falls overboard. One of the simplest and most affordable ways to prevent these fatalities is for crewmembers to wear personal flotation devices (PFDs) while on deck. An examination of over 200 fatal falls overboard in the U.S. fishing industry revealed that none of the victims were wearing PFDs when they died. PFDs are not required to be worn by commercial fishermen in the United States, so this study was designed to encourage behavior change using targeted health communication and social marketing. Methods: This study developed, implemented, and evaluated a multi-media social marketing campaign featuring a fictitious, culturally-relevant spokesman designed to look, talk, and act like the target audience. The messages were crafted to address common barriers to PFD adoption and misconceptions about fleet-specific risks for fatalities from falls overboard. The campaign was evaluated over two seasons of fishing to look at message retention and intent toward action following exposure to the campaign materials. Results: Survey respondents indicated overall positive opinions about the spokesman and the messages. Results also show a reported change in behavior related to using PFDs while working on deck. Discussion: Targeted multi-media messaging can influence behavior of workers in high-risk occupations in remote locations. Safety message development should focus on occupational culture to create valid and authentic communication products for workers in high-risk industries.

- ▪ **Keywords:** Occupational safety; Falls overboard; Behavior change; PFD; Fishermen

Raphaela Pagany. *A spatiotemporal risk prediction of wildlife-vehicle collisions using machine learning for dynamic warnings*. Pages 269-281.

Introduction: The technology in the automotive industry is becoming increasingly safer in the age of automated driving, but the number of accidents is still high, especially in wildlife-vehicle collisions (WVCs). To better avoid these accidents, patterns involved in these accidents must be detected. Method: This paper presents a spatiotemporal risk prediction of WVCs, including various road and environmental characteristics. A process of data preparation using GIS automated by Python scripts was developed to enable a spatiotemporal link of diverse features for the subsequent predictive data analysis. Different machine learning (ML) approaches were applied- random forest (RF), feedforward neural networks (FNN), and support vector machine classifier (SVM) - including automated ML to predict the risk of WVCs. Therefore, a dataset of approximately 731,000 accidents reported to the police in Bavaria over a period of 10 years (2010–2019) was used. In addition, non-accidents were randomly generated in Python over time and space for the supervised ML processes. As the actual risk probability for WVCs and non-WVCs is not entirely known, the impact of different training ratios between accidents and non-accidents was tested on the risk prediction quality (RPQ) (25%, 50%, 75%, 90% WVCs) of the double-weighted sensitivity and single-

weighted specificity rate. Results: The test yielded high mean values of RPQ as an indicator for a suitable WVC prediction. Both RF (86.6%) and FNN (86.7%) were identified as suitable choices for WVC risk prediction in terms of RPQ. The SVM yielded a lower prediction quality, even though acceptable results could be achieved within a shorter runtime. Practical Applications: Spatial transferability was verified since the algorithm was trained on the dataset of Bavaria (excluding Upper Bavaria) and successfully tested in Upper Bavaria. WVC forecasts were also proven through training with datasets from 2010-2017 and in prediction for 2018 and 2019.

- **Keywords:** Wildlife-vehicle collision; Machine learning; Spatiotemporal prediction; Random forest; Neural networks; Support vector machine classifier

Yan Huang, Yun Wang, Xuedong Yan, Xiaomeng Li, Ke Duan, Qingwan Xue. *Using a V2V- and V2I-based collision warning system to improve vehicle interaction at unsignalized intersections*. Pages 282-293.

Introduction: Unsignalized intersections are critical components of the road network where traffic collisions occur frequently. Method: This study aims to design a Vehicle-to-Vehicle (V2V)- and Vehicle-to-Infrastructure (V2I)-based unsignalized intersection collision warning system (UICWS) to improve driver performance and enhance driver safety at unsignalized intersections. A multi-user driving simulator experiment was conducted with 48 participants divided into 24 pairs. The dynamic interaction of each participant pair as they approached the intersection from straight-crossing directions was examined under different warning conditions (i.e., with vs without UICWS) and intersection field of view (IFOV) conditions (i.e., standard vs improved IFOV). Results and conclusions: The experimental results showed that the UICWS could effectively help drivers make appropriate operation decisions and reduce the number of right-angle collisions and near-collisions at unsignalized intersections. In the condition without UICWS, improved IFOV could prompt drivers to make crossing decisions in advance and adjust speed smoothly. Moreover, drivers' crossing maneuvers changed with the relative distance between the subject and conflict vehicles and the intersection. The risks of collisions and near-collisions increased significantly when the two vehicles were at a similar distance to the intersection before they initiated any actions. Practical Applications: The findings show that the proposed UICWS can effectively reduce collisions or near-collisions at unsignalized intersections in a connected vehicle environment. On this basis, some active intervention strategies, such as specific speed guidance depending on the dynamics of the conflict vehicle, can be developed to ensure vehicles passing through unsignalised intersections safely.

- **Keywords:** Unsignalized intersection; Intersection field of view; Collision warning system; Driver interaction; Multi-user driving simulator

Cara J. Hamann, Linder Wendt, Jonathan Davis, Corinne Peek-Asa, Stephanie Jansson, Joseph E. Cavanaugh. *Should we throw the book at 'em? Charge combinations and conviction rates among alcohol-influenced drivers involved in motorcycle crashes.* Pages 294-301.

Introduction: Motorcycle fatality rates are increasing, and impaired driving is a major contributing factor. Impaired driving laws are a main component of state efforts to reduce drunk driving, but motorcycle crash charge and conviction outcomes have yet to be studied. The purpose of this study was to evaluate driver charge and conviction outcomes following alcohol-related motorcycle crashes. Methods: Data for this study were drawn from Iowa crash, charge, and conviction data from 2011 to 2018. The study sample included 480 alcohol-influenced drivers (428 motorcyclists and 52 other vehicle drivers) involved in motorcycle crashes. Driver crash-related charges were categorized by type: Alcohol, Moving Violations, and Administrative/Miscellaneous. Factors associated

with convictions were determined and estimated with multivariable logistic regression models. The main factor of interest was charge combination. Results: Over three-quarters (78.5%) of the 480 alcohol-influenced drivers in crashes received any charge type and 68.1% received an alcohol-related charge. Among drivers with any charge, 88.6% were convicted, and among drivers with alcohol charges, 87.2% were convicted on an alcohol charge. After adjusting for BAC, drivers with a combination of Alcohol, Administrative, and Moving Violation charges had more than three times the odds of conviction of any charge compared to drivers with alcohol only charges (OR = 3.21, 95% CI = 1.00–10.26). However, charge combinations had little impact on alcohol-related convictions. Conclusions: Convictions were more likely when the impaired driver was charged with multiple types of offenses than with a single offense. An increased variety of charges was not associated with greater rates of conviction on alcohol-specific charges, which had high conviction rates overall. Practical Applications: Law enforcement officers should be informed that lesser infractions impact driver conviction outcomes in alcohol-related crashes and procedures for issuing charges should be evaluated to assure equitable enforcement and to hold drivers accountable for unsafe driving behaviors.

- **Keywords:** Citation; Impaired driving; OWI; DUI; Adjudication

Yanqi Lian, Enru Zhou, Jaeyoung Lee, Mohamed Abdel-Aty. *Existence of the safety-in-numbers effect in the aspect of injury severity: A macroscopic analysis for bicyclists and pedestrians*. Pages 302-309.

Objective: Several studies have confirmed the existence of a safety-in-numbers effect in relation to vulnerable road users. The safety-in-numbers effect refers to a phenomenon wherein the number of bicyclists/pedestrians on a road is higher, and consequently, the risk of each bicyclist/pedestrian being involved in a crash is lower. Nevertheless, the existence of the safety-in-numbers effect in the aspect of injury severity in traffic crashes has not yet been investigated. Thus, this study aimed to explore whether traffic injuries are more (less) severe with fewer (more) pedestrians/bicyclists at the county level. Method: Using two fractional split multinomial logit models, the relationships between the number of bicyclists/pedestrians and the proportion of crashes involving bicyclists/pedestrians based on crash severity were investigated at the county level using crash data from Florida. In other words, we explored whether differing number of bicyclists/pedestrians could change the distribution of traffic injury severity levels. Results: The modeling results clearly revealed a lower proportion of severe injuries caused to bicyclists/pedestrians at a higher level of daily bicycle/pedestrian flows, indicating existence of the safety-in-numbers effect. Several variables (e.g., the percentage of people aged 65 years and older, the percentage of commuters using public transportation, and the proportion of recreational land use) were found to have a significant effect on the distribution of traffic injury severity among bicyclists/pedestrians. Conclusion: This study proves that a safety-in-numbers effect exists in the aspect of injury severity among bicyclists and pedestrians. Practical applications: These findings are expected to provide recommendations for promoting the use of active transportation, which will improve the safety of vulnerable road users in future.

- **Keywords:** Safety-in-numbers; Injury severity; Bicyclists; Pedestrians; Fractional split multinomial logit model

Huitao Lv, Haojie Li, N.N. Sze, Gang Ren. *The impacts of non-motorized traffic enforcement cameras on red light violations of cyclists at signalized intersections*. Pages 310-322.

Introduction: With a significant increase in accidents involving cyclists, more attention has been paid to cycling safety. Previous studies on traffic accident revealed that red-light violations of non-motorized vehicles have become the leading cause of crashes at signalized intersections. The objective of this study is to investigate the impact of non-

motorized traffic enforcement cameras (NTECs) on the red-light running behavior of cyclists, including ordinary e-bike riders, delivery e-bike riders, and bicyclists. Method: An observational study of 5,217 cyclists was conducted at six primary intersections in the downtown areas of Nanjing, China. A random parameter logit model was used to explore the safety effect of the NTECs and other factors related to red-light violation behavior. Results: The results indicate higher reductions in red-light violations at intersections with the NTECs compared than at the non-adjacent intersections without the NTECs. Furthermore, the NTECs demonstrated a beneficial but smaller impact on the reduction of violations at adjacent intersections. Another primary finding was that the effects of the NTECs varied among three types of cyclists (ordinary e-bike riders, delivery e-bike riders, and bicyclists). Conclusions: The NTECs were found to be most effective in the case of delivery e-bike riders, followed by ordinary e-bike riders and bicyclists. In addition, the factors associated with the red-light violation behaviors of these three groups were also found to be different. In general, group size, maximum waiting time, waiting position, and visual search were significantly related to the probability of red-light violations in all three groups. Practical Applications: Based on these findings, this study provides some feasible suggestions for improving the effect of the NTECs and for the future extension of the NTECs installation, such as the randomization of the enforcement and publicity campaigns.

- **Keywords:** Non-motorized traffic enforcement camera; Red-light violation; Cyclist safety; Signalized intersection

Erika Scott, Liane Hirabayashi, Kevin Luschen, Nicole Krupa, Paul Jenkins. *Ensuring data quality and maximizing efficiency in coding agricultural and forestry injuries: Lessons to improve occupational injury surveillance.* **Pages 323-328.**

Introduction: Specialized occupational injury surveillance systems are filling the gap in the undercount of work-related injuries in industries such as agriculture and forestry. To ensure data quality and maximize efficiency in the operation of a regional occupational injury surveillance system, the need for continued dual coding of occupational injury records was assessed. Methods: Kappa scores and percent agreement were used to compare interrater reliability for assigned variables in 1,259 agricultural and forestry injuries identified in pre-hospital care reports. The variables used for the comparison included type of event, source of injury, nature of injury, part of body, injury location, intentionality, and farm and agriculture injury classification (FAIC). Results: Kappa (κ) ranged from 0.2605 for secondary source to 0.8494 for event and exposure. Individual coder accuracy ranged from medium to high levels of agreement. Agreement beyond the first digit of OIICS coding was measured in percent agreement, and type of event or exposure, body part, and primary source of injury continued to meet levels of accord reaching 70% or greater agreement between all coders and the final choice, even to the most detailed 4th digit of OIICS. Conclusions: This research supports evidence-based decision making in customizing an occupational injury surveillance system, ultimately making it less costly while maintaining data quality. We foresee these methods being applicable to any surveillance system where visual inspection and human decisions are levied. Practical Applications: Assessing the rigor of occupational injury record coding provides critical information to tailor surveillance protocols, especially those targeted to make the system less costly. System administrators should consider evaluating the quality of coding, especially when dealing with free-text narratives before deciding on single coder protocols. Further, quality checks should remain a part of the system going forward.

- **Keywords:** Kappa score; OIICS; FAIC; Free-text; Pre-hospital care reports; Percent agreement

Joannah Ogden, Patricia M. Brown, Amanda M. George. *Young drivers and smartphone use: The impact of legal and non-legal deterrents.* **Pages 329-338.**

Introduction: Young drivers continue to be overrepresented in road crash statistics and smartphone use has been identified as a dangerous form of driver distraction. Previous research has identified factors encouraging drivers to use their mobile phone, with few examining what deters drivers. This study examines the influence of legal and non-legal deterrents on smartphone use while driving (SWD) in a young adult sample. Method: An online survey was administered to a sample of 524 Australian drivers aged 17–25 years. Measures included demographic variables, legal deterrents (certainty, severity, and swiftness), and non-legal deterrents: social loss (peers and parents), internal loss (anticipated regret) and physical loss (injury to self/others). Self-reported SWD was the outcome variable, measured separately for initiating SWD and responding SWD behaviors. Results: Responding behaviors were reported more frequently than initiating, and social, internal, and physical loss were perceived as higher for initiating versus responding behaviors. Anticipated action regret and physical loss were significant negative predictors of SWD across both modalities of communication. Anticipated inaction regret was also a significant positive predictor of initiating behaviors. Both legal deterrents and social loss were non-significant predictors for both modalities of SWD. Conclusions: The results reinforce previous evidence showing that legal deterrence variables are not consistently effective at reducing offending behaviors. Future research should continue to explore the effect of non-legal deterrents across different modalities of SWD. Practical applications. Road safety interventions aimed at young drivers should evaluate the impact of highlighting anticipated regret and potential injury to self and others associated with risky driving behaviors, such as SWD.

▪ **Keywords:** Phone use while driving; Young drivers; Novice drivers; Deterrence; Cell phones

Predrag Stanojević, Timo Lajunen, Dragana Jakšić, Dragan Jovanović, Boško Matović. *Effectiveness of implementing a Graduated Driver Licensing (GDL) law among young Serbian drivers.* **Pages 339-348.**

Introduction: Young novice drivers have higher rates of engagement in road crashes worldwide, often owing to unfavorable attitudes toward road safety or lack of knowledge, experience, and risk consciousness. However, the implementation of graduated driver licensing (GDL) systems has proven effective in reducing the high incidence of young drivers involved in crashes. Method: The purpose of this study was to compare the change in driving outcomes (e.g., attitudes toward traffic safety, behavior patterns while driving, risk assessment in traffic, assessment of personal driving skills, and involvement in traffic crashes) of young drivers prior to and following the implementation of a GDL law. Respondents (n = 642) completed a battery of questions, including a driver attitudes questionnaire (Behaviour of Young Novice Drivers Scale), a self-assessed driving ability questionnaire, and a risk perception questionnaire. Of the total sample size, 324 drivers passed the old system of training driver's license candidates, and 318 drivers passed the new GDL system. Results: The results showed that drivers licensed with GDL reported safer attitudes toward traffic rule violations and speed, and higher levels of safety orientation with regard to their driving abilities. They also reported much higher levels of risk perception and lower exposure to risky situations (risky driving exposure). There were no differences between GDL drivers and non-GDL drivers in terms of self-reported crashes or transient or fixed violations. In addition, GDL was not related to the number of traffic crashes, the number of fatalities, or serious and slight injuries in crashes involving young drivers in crashes obtained from official records. Conclusions: The results suggest that GDL contributed to the improvement of drivers' attitudes and understanding of risk but did not contribute to significant changes in the behavior of young drivers and traffic crashes. In addition, the GDL program in Serbia only ranks fair on the Insurance Institute

for Highway Safety (IIHS) scale. Strengthening the GDL program in Serbia with additional components in line with GDL programs rated as good by the IIHS scale could improve the safety of young and novice drivers in traffic.

- **Keywords:** Young drivers; Graduated driver licensing; Attitudes; Risk behavior

Sara Wuellner, David Bonauto. *Are plumbing apprentice graduates safer than their non-apprentice peers? Workers' compensation claims among journey level plumbers by apprenticeship participation*. Pages 349-356.

Introduction: Apprenticeships combine mentored on-the-job training with related instruction to develop a workforce with the skills sought by employers. Workplace safety is an important component of apprenticeship training. Whether that training results in fewer work injuries, however, is largely unknown. Method: We linked Washington's registered apprenticeship data, plumber certification (licensing) data, employment data, and workers' compensation claims to compare claim rates among journey level plumbers (JLP) by apprenticeship participation. We used negative binomial regression models to estimate rates of total claims, wage replacement/disability claims, acute injuries, and musculoskeletal disorders (MSD), adjusted for worker characteristics. Results: Among JLP certified between 2000 and 2018, rates among JLP with no apprenticeship training were 46% higher for total workers' compensation claims (adjusted Rate Ratio (aRR) = 1.46, 95% CI: 1.26–1.69) and 60% higher for wage replacement/disability claims (aRR = 1.60, 95% CI: 1.22–2.11), compared to rates among JLP who completed a plumbing apprenticeship. Apprentice graduates experienced a greater decline in the rate of total claims between the 5 years preceding JLP certification and the years after certification (55.3% vs. 41.4% among JLP with no apprenticeship training). Greater rate reductions among JLP apprentice graduates were also observed for acute injuries and MSD, although the decline in MSD was not significantly different from the decline among JLP with no apprenticeship training. Conclusions: Successful completion of a plumbing apprenticeship program is associated with fewer work injuries throughout the career of a JLP. Apprenticeships appear to play a key role in reducing work injuries among JLP, especially acute injuries. Practical Applications: Apprenticeships are an effective model for reducing workplace injuries. The mechanisms by which apprenticeship training improves workplace safety should be identified to better inform injury prevention efforts among apprentices as well as among workers outside of a formal apprenticeship arrangement.

- **Keywords:** Work; Injury; Occupational injury; Apprenticeship; Workers' compensation

Aimee E. Cox, Jessica B. Cicchino, Eric R. Teoh. *Changing vehicles to reduce older driver fatalities: An effective approach?* Pages 357-363.

Introduction: Age-related frailty leaves older drivers with the greatest fatality risk when involved in a crash compared with younger demographics. This study explored how vehicle features differed between crash-involved older and middle-aged drivers and estimated how those differences contribute to excess older driver fatalities. Methods: We merged Florida's crash data from 2014–2018 with Insurance Institute for Highway Safety and Highway Loss Data Institute databases. We compared the distribution of passenger vehicle age, type, size, and safety features among crash-involved older drivers (ages 70 and older) with crash-involved middle-aged drivers (ages 35–54). From logistic regression models, we estimated declines in older driver fatalities if they drove vehicles like those driven by middle-aged drivers under all and side-impact crash scenarios. Results: Older drivers in crashes were more likely to be in vehicles that were lighter, older, and without standard electronic stability control, standard head-protecting side airbags, and ratings of good in two IIHS crash tests than middle-aged drivers. In adjusted models, the fatality risk for older drivers in all crashes was significantly higher when ESC was not standard (odds ratio [OR], 1.37; 95% confidence interval [CI], 1.12–

1.68) or when driving small passenger cars relative to large SUVs (OR, 2.02; 95% CI, 1.25–3.26); in driver-side crashes, the fatality risk doubled when vehicles did not have standard head-protecting side airbags (OR, 2.03; 95% CI, 1.58–2.62). If older drivers drove vehicles similar to middle-aged drivers, we estimated 3.3% and 4.7% fewer deaths in all and side-impact crashes, respectively. Conclusions: These results contribute to evidence suggesting that newer, more crashworthy vehicles with crash mitigation features benefit older drivers because of their heightened risk of crash-related fatality. Practical Applications: At a minimum, older drivers should aim to drive equipped vehicles with widely available features proven to reduce fatalities.

- **Keywords:** Side airbags; Electronic stability control; Vehicle size; Vehicle age

Mohammad Z. Shanti, Chung-Suk Cho, Borja Garcia de Soto, Young-Ji Byon, Chan Yeob Yeun, Tae Yeon Kim. *Real-time monitoring of work-at-height safety hazards in construction sites using drones and deep learning*. Pages 364-370.

Introduction: The construction field is considered one of the most dangerous industries. Accidents and fatalities take place on a daily basis in construction projects. Globally, different levels of government have implemented strict rules and regulations to protect workers on job sites. However, despite the efforts to implement the rules and regulations, accidents occur frequently. Falling from heights is considered the most common cause of death in construction. This study developed a novel system integrating deep learning and drones to monitor workers in real-time when performing at-height activities. Method: Specifically, a pre-trained deep learning model was used to detect Personal Fall Arrest System components (e.g., safety harness, lifeline, and helmet). The drone was utilized to take images and videos from the construction site, and the data were relayed to the model to detect safety violations. The system was tested and validated in real construction sites and in a controlled lab environment to verify the model's effectiveness under different light and weather conditions. Results: The overall accuracy of the system was 90%. The model's precision and recall were 97.2 % and 90.2%, respectively. The average time taken to detect a violation was around 12 seconds. Conclusions: Moreover, the Area Under Curve - Receiver Operating Characteristics chart showed that the trained model was very good and precise in detecting and differentiating the desired objects. Practical Applications: This fast, reliable, and economical system can aid in saving many lives if implemented and utilized properly in real construction sites.

- **Keywords:** Machine learning; Real-time detection; Unmanned Aerial Vehicles (UAV); Fall from heights; Personal Fall Arrest System (PFAS)

Shahin Shooshtari, Verena Menec, Brenda M. Stoesz, Dimple Bhajwani, Nick Turner, Caroline Piotrowski. *Examining associations between work-related injuries and all-cause healthcare use among middle-aged and older workers in Canada using CLSA data*. Pages 371-378.

Introduction: Prior studies examining the relationship between work- related injuries and healthcare use among middle-aged and older workers were mainly cross-sectional and reported inconsistent results. Objective: The objective of this study was to examine the associations between work-related injuries and 10 types of healthcare service use for any cause among middle-aged and older Canadian workers using longitudinal data. Methods: Our study involved longitudinal analysis of baseline and 18-month follow-up Maintaining Contact Questionnaire data from the Canadian Longitudinal Survey on Aging (CLSA) for a national sample of Canadian males and females aged 45–85 years who worked or were recently retired (N = 24,748). Results: Among CLSA participants who worked or were recently retired, 361 per 10,000 reported a work-related injury within the year prior to

the survey. Work-related injuries decreased with increasing age. Work-related injury was associated with emergency department visits, overnight hospitalization, visits to dentists, and visits to physiotherapists, occupational therapists, or chiropractors at follow-up in bivariate analyses. Compared to those with no work-related injuries, Canadians with work-related injuries had used, on average, a significantly higher number of health services within the last 12 months prior their survey. When controlling for the contribution of various socio-demographic, work-related, and health-related characteristics, work-related injuries remained a significant predictor of emergency department visits and visits to physiotherapists, occupational therapists, or chiropractors. Conclusions: The relationship between work-related injuries, emergency department visits, and visits to physiotherapists, occupational therapists, or chiropractors in middle-aged and older workers in Canada suggests that workplace injuries can be associated with ongoing health problems. Practical Applications: Healthcare services used by injured employees must be considered priorities for employment insurance coverage, if not already covered. Future research should more fully examine whether pre-existing health conditions predict both work-related injury and subsequent health problems. Injury-specific healthcare use following work-related injuries in middle-aged and older workers, as well as economic costs, should also be examined.

Matthew L. Brumbelow. *Light where it matters: IIHS headlight ratings are correlated with nighttime crash rates*. Pages 379-387.

Introduction: Vehicle headlights are the primary means of providing visibility illumination for drivers at night, when crash rates are several times higher than during the day. Based on research indicating a wide range of headlight performance in the passenger vehicle fleet and the absence of a comprehensive and objective consumer evaluation program, the Insurance Institute for Highway Safety (IIHS) began testing and rating headlight systems in 2015. The purpose of this study was to examine the relationship between headlight visibility, as quantified by IIHS, and real-world crash occurrence. Methods: Poisson regression was used to estimate the effects of the headlight rating and the underlying demerits on the rate of police-reported nighttime single-vehicle crashes per vehicle mile traveled. Results: Results indicate that vehicles with better headlight visibility have lower nighttime crash rates after controlling for differences in daytime rates and other factors. A reduction of 10 visibility demerits, the equivalent of one overall rating band, was estimated to reduce the nighttime crash rate by 4.6% (95% CI: 2.1%–7.0%). While statistical significance was limited by small sample sizes, good-rated headlights were estimated to reduce crash rates by 12 to 29% relative to those with poor ratings for the different types of single-vehicle crashes studied. Among different components of the IIHS rating, the assessments of low and high beam curve visibility were associated with the greatest crash rate reductions. Conclusions: This study demonstrates that the IIHS evaluation program encourages headlight designs that reduce the risk of nighttime single-vehicle crashes. Practical applications: Headlight systems have a meaningful effect on nighttime crash rates. Drivers can reduce their crash risk by selecting a vehicle with one of the best designs.

Peter Simeonov, Ashish Nimbarte, Hongwei Hsiao, Richard Current, Douglas Ammons, Hee-Sun Choi, Md Mahmudur Rahman, Darlene Weaver. *Evaluation of advanced curve speed warning system to prevent fire truck rollover crashes*. Pages 388-399.

Introduction: A disproportionately high number of deadly crash-incidents involve fire-tanker rollovers during emergency response driving. Most of these rollover incidents occur at dangerous horizontal curves ("curves") due to unsafe speed. This study examined the effects of a curve speed warning system (CSWS) on fire tanker drivers' emergency response behavior to develop system improvement suggestions. Method: Twenty-four firefighters participated in driving tests using a simulator. A fire tanker model, carrying a full tank of water, was used in emergency driving tests performed with and without CSWS. The CSWS was designed using the algorithm for passenger vehicles with a few initial modifications considering the unique requirements of heavy fire tanker and emergency driving. Results: The results indicated that the CSWS was effective in issuing preemptive warnings when the drivers were approaching curves with unsafe speed during emergency response. Warnings occurred more frequently at curves with smaller radius. Although the CSWS improved driving performance, it did not significantly reduce the number of rollover events. A detailed analysis of the rollover events provided suggestions for improvement of CSWS algorithms. Conclusions: To further improve the CSWS algorithm, the following may be considered: including increased safety speed margin below the rollover critical speed, moving the speed warning trigger from the curve apex to the curve entry point, extending the safe speed-control zone to cover the entire curve, and employing artificial intelligence to accommodate individual driving styles. Practical Applications: Fire tankers continue to be at increased risk of rollover during emergency response due to unsafe negotiation of dangerous curves. Development and use of advanced driver assist systems such as CSWS evaluated in this study may be an effective strategy to prevent deadly rollover crash-incidents. The knowledge generated by this study will be useful for system designers to improve the CSWS specifically designed for heavy emergency vehicles.

- ▪ **Keywords:** Fire tanker; Horizontal curves; Emergency response; Speeding; Overturn

Noah Bosshart, Angela Bearth, Stephanie Wermelinger, Moritz Daum, Michael Siegrist. *Seeing household chemicals through the eyes of children - Investigating influential factors of preschoolers' perception and behavior*. Pages 400-409.

Introduction: Children who encounter household chemicals run the risk of unintentional injury. The aim of this study was to understand which factors heighten children's attention or misguide their decision-making concerning household chemicals. We hypothesized that certain product attributes (i.e., label, packaging, closure types), storage context, and parental beliefs play a role in this setting. Method: We conducted a laboratory study with $N = 114$ children ($M = 45$ months, $SD = 6.5$) and their parents ($M = 38$ years, $SD = 4.92$). Children completed a series of behavioral tasks in which they had to choose between products with different attributes, identify products in different storage contexts, and sort household chemicals. Results: The results confirmed that the children preferred products with cartoon-style labels compared to products without such labels. However, children's decision-making did not differ for products with different closure types (child-resistant vs sprayer-type closures). Regarding the storage context, our results showed that the children particularly struggled to identify dishwashing tabs when they were stored with other food items rather than household chemicals. In terms of parental beliefs, our study found that parents rated more household chemicals as child-safe than their children did. Practical Application: Parents should buy household chemicals with neutral labels and pay attention to how their household chemicals are

stored. Manufacturers should consider potential adverse effects when developing new product designs.

Sharon Newnam, Renee St Louis, Amanda Stephens, Dianne Sheppard. *Applying systems thinking to improve the safety of work-related drivers: A systematic review of the literature*. **Pages 410-417.**

Introduction: Light vehicles (<4.5 tons) driven for work purposes represent a significant proportion of the registered motor vehicles on our roads. Drivers of these vehicles have significant exposure to the dangers of the road transport environment. To optimize safety for these workers, it is critical to understand the factors contributing to risk of being involved in an incident. This information can then be used to inform the review and revision of existing risk controls and the development of targeted prevention activities. Method: The aim of the study was to undertake a systematic review of the literature to identify the factors associated with work-related driving incidents. The factors identified in the review were represented within an adapted version of Rasmussen's risk management framework (Rasmussen, 1997). Fifty studies were analyzed following data screening and review of full text. The highest proportion of risk factors were categorized at the lower levels of the system, including the 'Drivers and Other Road Users' level (n = 20, 44.4%) and the 'Equipment, Environment, and Meteorological Surroundings' level (n = 19, 42.2%). There were no risk factors identified at the 'Regulatory and Government Bodies' levels of the framework, confirming the narrow investigative scope of past research and the need to acknowledge a broader range of factors within and across higher levels of the system. Conclusions: The findings of this study inform the direction of future research and design of targeted prevention activities capable of creating system change for the safety of work-related drivers.

Alexis B. Peterson, Hong Zhou, Karen E. Thomas. *Disparities in traumatic brain injury-related deaths - United States, 2020*. **Pages 419-426.**

Introduction: Traumatic brain injury (TBI) affects how the brain functions and remains a prominent cause of death in the United States. Although preventable, anyone can experience a TBI and epidemiological research suggests some groups have worse health outcomes following the injury. Methods: We analyzed 2020 multiple-cause-of-death data from the National Vital Statistics System to describe TBI mortality by geography, sociodemographic characteristics, mechanism of injury (MOI), and injury intent. Deaths were included if they listed an injury International Classification of Diseases, Tenth Revision (ICD-10) underlying cause of death code and a TBI-related ICD-10 code in one of the multiple-cause-of-death fields. Results: During 2020, 64,362 TBI-related deaths occurred and age-adjusted rates, per 100,000 population, were highest among persons residing in the South (20.2). Older adults (≥75) displayed the highest number and rate of TBI-related deaths compared with other age groups and unintentional falls and suicide were the leading external causes among this older age group. The age-adjusted rate of TBI-related deaths in males was more than three times the rate of females (28.3 versus 8.4, respectively); further, males displayed higher numbers and age-adjusted rates compared with females for all the principal MOIs that contributed to a TBI-related death. American Indian or Alaska Native, Non-Hispanic (AI/AN) persons had the highest age-adjusted rate (29.0) of TBI-related deaths when compared with other racial and ethnic groups. Suicide was the leading external cause of injury contributing to a TBI-related death among AI/AN persons. Practical application: Prevention efforts targeting older adult falls and suicide are warranted to reduce disparities in TBI mortality among older

adults and AI/AN persons. Effective strategies are described in CDC's Stopping Elderly Accidents, Deaths, & Injuries (STEADI) initiative to reduce older adult falls and CDC's Preventing Suicide: A Technical Package of Policy, Programs, and Practices for the best available evidence in suicide prevention.