Journal of Safety Research – rok 2019, Volume 69

June 2019

Deirdre R. Green, Susan Goodwin Gerberich, Hyun Kim, Andrew D. Ryan, Patricia M. McGovern, Timothy R. Church, Adam Schwartz, Rony F. Arauz. *Knowledge of work-related injury reporting and perceived barriers among janitors*. Pages 1-10.

Introduction: The goal of this study was to evaluate and improve janitors' knowledge of workers' rights and responsibilities for assessing and reporting work-related injuries, and to determine the barriers for reporting occupational injuries. **Methods:** Questionnaires, designed to collect data retrospectively for two, sequential six-month periods, were disseminated to 1200 full-time unionized janitors in the Twin Cities. Immediately following the baseline questionnaire administration, a randomly selected sub-group of janitors (~600) received information on workers' rights and responsibilities for reporting injuries; six-months later a questionnaire comparable to the baseline questionnaire was disseminated to the 1200 janitors. Analyses included basic descriptive analyses and identification of potential differences in proportions of job-specific reporting barriers pre-post-intervention. **Results:** Among the participating janitors (n = 390), approximately half (53%) were initially unsure of what an OSHA 300 Log was; 56% reported not knowing what workers' compensation was. At baseline, in both intervention and non-intervention groups, approximately 25% reported having a perceived barrier to reporting an injury to their employer. Reported barriers included "fear," "reporting takes too long," "being unsure of the reporting process," and an "understanding that injuries are a part of the job." At follow-up, among the intervention group, there was an important reduction (24%–12%) in having a perceived barrier for reporting a work-related injury. **Conclusions:** A majority of janitors lacked knowledge and awareness of OSHA injury reporting and Workers' Compensation. In order to improve reporting, it is essential to educate employees on OSHA and Workers' Compensation and inform janitors of the injury reporting process through training. **Practical applications:** Future intervention efforts must focus on the specific barriers for reporting occupational injuries and be tailored specifically to the janitor population. To reduce underreporting of injuries, they must be encouraged to report their occupational injuries. Barriers to reporting these injuries must be eliminated.

- **Keywords:** Janitors; Injury Reporting; Barriers; Work-Related Injuries

N. Kovácsová, J.C.F. de Winter, M.P. Hagenzieker. *What will the car driver do? A video-based questionnaire study on cyclists' anticipation during safety-critical situations*. Pages 11-21.

Introduction: Many bicycle–car crashes are caused by the fact that the driver fails to give right of way to the cyclist. Although the car driver is to blame, the cyclist may have been able to prevent the crash by anticipating the safety-critical event and slowing-down. This study aimed to understand how accurate cyclists are in predicting a driver's right-of-way violation, which cues contribute to cyclists' predictions, and which factors contribute to their self-reported slowing-down behavior as a function of the temporal proximity to the conflict. **Method:** 1030 participants were presented with video clips of nine safety-critical intersection situations, with five different video freezing moments in a between-subjects design. After each video clip, participants completed a questionnaire to indicate what the car driver will do next, which bottom-up and top-down cues they think they used, as well as their intended slowing-down behavior and perceived risk. **Results and conclusions:** The results showed that participants' predictions of the driver's behavior develop over time, with more accurate predictions (i.e., reporting that the driver will not let the cyclist cross first) at later freezing moments. A regression analysis showed that perceived high speed and acceleration of the car were associated with correctly predicting that the driver will not let the cyclist cross first. Incorrect predictions were associated with believing that the car has a low speed or is decelerating, and with reporting that the cyclist has right of way. Correctly predicting that the driver will not let the cyclist cross first and perceived risk were significant predictors of intending to slow down in safety-critical intersection situations. **Practical applications:** Our findings add to the existing knowledge on cyclists' hazard anticipation and could be used for the development of training programs as well as for cycling support systems.

- **Keywords:** Hazard anticipation; bicycle-car interaction; right-of-way violation; cycling safety; survey

Lingqiao Qin, Zhixia (Richard) Li, Zhijun Chen, M.S. Andi Bill, David A. Noyce. *Understanding driver distractions in fatal crashes: An exploratory empirical analysis*. Pages 23-31.

Introduction: Driver distraction has become a significant problem in transportation safety. As more portable wireless devices and driver assistance and entertainment systems become available to drivers, the sources of distraction are increasing. **Method:** Based on the results of different studies in the literature review, this paper categorizes different distraction enablers into six subcategories according to their fundamental characteristics and how they would affect a driver's likelihood of engaging in non-driving related activities. The review also discusses the characteristics and influence of external and internal distractions. The objective of this study is to examine the effect of different distraction sources in fatal crashes with the consideration of a driver's age and sex. Tukey test, chi-square test of independence, Nemenyi post-hoc test, and Marascuilo procedure have been used to investigate the top distraction sources, the trend of distraction-affected fatal crashes, the effect of different distractions on drives in different age groups, and their influence on female and male drivers. **Results:** It was found that inner cognitive inferences accounted for the greatest proportion of driver engagement in distractions. Young drivers show a larger probability of being distracted by in-vehicle technology-related devices/objects. Within the group of young drivers, female drivers showed a higher probability than their male counterparts of engaging in distracted driving caused by in-vehicle technology-related devices. Among six subcategories of distractions, drivers older than 80 years old were found to be most likely affected by inner cognitive interferences.

- **Keywords:** Driver distraction; Fatal crash; Distraction sources; Age; Sex

Sven Ove Hansson. *Improvement principles*. Pages 33-41.

Introduction: The improvement principles are a group of safety principles whose central message is that no risk level above zero is fully satisfactory, and that we should therefore always strive to improve safety. The major safety principles in this group are: as low as reasonably achievable (ALARA), best available technology (BAT), the substitution principle, vision zero, and continuous improvement. **Method:** This article investigates their similarities and differences, the ways in which they can incorporate compromises with objectives other than safety, and the difficulties that may arise in their application. A particular emphasis is put on comparisons with two major competing groups of principles, namely acceptance principles, which draw a sharp line between acceptable and unacceptable states of affairs, and weighing principles such as CBA that search for an optimized compromise between safety and other objectives. **Results:** In comparison to their main competitors, the improvement principles have the important advantage of consistently encouraging safety enhancements. However, some of the problems in their application can probably best be tackled by including them in a combined approach that also makes use of acceptance and/or weighing principles. Two such combined approaches are proposed. The choice between them should be based on the underlying value structure of the decision problem. **Practical applications:** Guidance is given for the choice of safety principles and for the combined use of more than one such principle.

- **Keywords:** Improvement principles; Aspiration principles; Acceptance principles; ALARA; Continuous improvement

Tahira M. Probst, Linda M. Goldenhar, Jesse L. Byrd, Eileen Betit. *The Safety Climate Assessment Tool (S-CAT): A rubric-based approach to measuring construction safety climate*. Pages 43-51.

Introduction: This paper presents the development and validation of a new rubric-based Safety Climate Assessment Tool (S-CAT). The S-CAT gives companies the opportunity to use rubric descriptors, rather than traditional Likert scale responses, to self-assess their level of safety climate maturity and receive a composite score benchmarked against others in the S-CAT database. **Method:** The S-CAT is composed of 37 separate indicators of 8 safety climate factors identified by construction industry subject matter experts. The eight factors have between three and six indicators each with its own rubric-based response-scale. The scales comprise descriptors for five levels of safety climate maturity ranging from "inattentive" to "exemplary." Nine hundred and eighty-five respondents working in the construction industry completed the S-CAT via our online safety climate website. We used company recordable incident rates (RIR) to assess the S-CAT's criterion-related validity. **Results:** Cronbach alphas for each factor ranged from 0.77 to 0.90 and a confirmatory factor analysis supported the hypothesized eight factor structure with a higher-order safety climate factor. Seven of the eight factor scores, as well as the overall S-CAT score, were significantly negatively correlated with RIR. Moreover, a relative weights analysis indicated that a weighted combination of the eight safety climate factors explained 27% of the variance in organizational RIR. **Conclusions:** These findings provide evidence that the S-CAT is a reliable tool allowing construction companies to self-assess their safety climate along eight different factors. Moreover, the S-CAT was significantly associated with organizational injury rates. **Practical applications:** We discuss how companies can use the rubric descriptors to strengthen their safety management systems and improve their safety climate maturity.

- **Keywords:** Safety climate; Construction; Rubric scale; Scale development and validation

Todd D. Smith, David M. DeJoy, Mari-Amanda Dyal, Yongjia Pu, Stephanie Dickinson. *Multi-level safety climate associations with safety behaviors in the fire service*. Pages 53-60.

Introduction: Limited research associated with safety climate has been completed within the fire service. Given this dearth of information, the present study sought to identify a valid and reliable measure of safety climate at both the workgroup and organizational levels within the fire service. **Methods:** Researchers surveyed 994 firefighters in two large metropolitan fire departments. Preliminary analyses including psychometrics, confirmatory factor analyses, and shared perception analyses were completed. A linear mixed model analysis was then completed to assess the relationships between workgroup safety climate, organizational safety climate, and safety behaviors, including both safety compliance and safety citizenship behaviors. **Results:** Measures of safety climate at the workgroup (WGSC) and organizational levels (OSC) were derived. WGSC factors include supervisor support ($\alpha = 0.92$), vertical cohesion ($\alpha = 0.89$), and horizontal cohesion ($\alpha = 0.94$). OSC factors include management commitment ($\alpha = 0.91$), safety programs/policies ($\alpha = 0.89$), perceived fairness ($\alpha = 0.86$) and incident command ($\alpha = 0.90$). Confirmatory factor analyses confirmed our multi-factor models were a good fit to the data. The linear mixed model analysis found that WGSC positively predicted safety compliance behavior ($B = 0.13$, $p < .001$) and safety citizenship behavior ($B = 0.22$, $p < .001$) and OSC positively predicted safety compliance behavior ($B = 0.16$, $p < .001$) and safety citizenship behavior ($B = 0.15$, $p < .001$). **Conclusions:** This work presents reliable and valid measures of both workgroup and organizational safety climate, which have positive relationships with safety behavior outcomes. Practical application: The measures, which were developed through an extensive multi-method process, provide a means for researchers and practitioners to assess safety climate in the fire service and provides guidance for future safety climate research, including informing intervention research, which could potentially bolster safety climate and enhance safety in the fire service.

Michael A. Nees. *Safer than the average human driver (who is less safe than me)? Examining a popular safety benchmark for self-driving cars*. Pages 61-68.

Although the level of safety required before drivers will accept self-driving cars is not clear, the criterion of being safer than a human driver has become pervasive in the discourse on vehicle automation. This criterion actually means "safer than the average human driver," because it is necessarily defined with respect to population-level data. At the level of individual risk assessment, a body of research has shown that most drivers perceive themselves to be safer than the average driver (the better-than-average effect). **Method:** Using an online sample, this study examined U.S. drivers' ratings of their own ability to drive safely and their desired level of safety for self-driving vehicles. **Results:** This study replicated the better-than average effect and showed that most drivers stated a desire for self-driving cars that are safer than their own perceived ability to drive safely before they would: (1) feel reasonably safe riding in a self-driving vehicle; (2) buy a self-driving vehicle, all other things (cost, etc.) being equal; and (3) allow self-driving vehicles on public roads. **Conclusions:** Since most drivers believe they are better than average drivers, the benchmark of achieving automation that is safer than a human driver (on average) may not represent acceptably safe performance of self-driving cars for most drivers. **Practical applications:** If perceived level of safety is an important contributor to acceptance of self-driving vehicles, the popular "safer than a human driver" benchmark may not be adequate for widespread acceptance.

- **Keywords:** Human-automation interaction; Trust in automation; Self-driving vehicles; Autonomous driving; Vehicle automation

Manon Guay, Monia D'Amours, Véronique Provencher. *When bathing leads to drowning in older adults*. Pages 69-73.

Introduction: Bathing is the most problematic activity of daily living for aging adults, and the ability to perform it is influenced by physical capabilities that decrease with age. Drowning is an under-documented event related to bathing for older adults. This study investigates the circumstances of these tragedies, to prevent them. **Methods:** Census of 2005–2014 bathtub drownings in the province of Quebec (Canada) involving victims aged 65+. Coroner's reports were analyzed using a grid based on factors previously associated with bath-related drownings in literature, iteratively modified. **Results:** Among the 92 bathtub drowning victims inventoried, 42% were aged 65+. The average age of older victims is 79 (65–97, ±9 years). Main probable cause of drowning is a cardiac problem, although only 19% of victims had a medical history of heart disease. Most victims were alone in their apartment or residence when drowning occurred. Risky periods appear to be springtime, Sundays, and evenings. Despite expectations, relevant information about the physical environment is very scarce. **Conclusions:** At least 39 Quebecers, aged 65+, drowned in their bathtubs over a 10-year period. More older adults than children are victims of bathtub drownings in community-dwellings. It seems that bathing may induce heart distress, leading to an appreciable number of drownings. Practical implications: Since cardiac health problems are present in these deplorable events, promoting access to safety devices in the environment (emergency button, grab bars) and modified personal hygiene habits (bathing chair, showering) might be potential ways to prevent drowning and improve safety in older adults while they perform their personal hygiene, an essential activity for health and human dignity.

- **Keywords:** Home safety; Bathing; Bathtub drowning; Older people; Prevention

Boniphace Kutela, Hualiang Teng. *Prediction of drivers and pedestrians' behaviors at signalized mid-block Danish offset crosswalks using Bayesian networks*. Pages 75-83.

Introduction: This study presents the prediction of driver yielding compliance and pedestrian tendencies to press pushbuttons at signalized mid-block Danish offset crosswalks. **Method:** It applies Bayesian Networks (BNs) analysis, which is basically a graphical non-functional form model, on observational survey data collected from five signalized crosswalks in Las Vegas, Nevada. The BNs structures were learnt from the data by the application of several score functions. By considering prediction accuracy and the Area under the Receiver Operating Characteristic (ROC) curves, the BN learnt using the Bayesian Information Criterion (BIC) score resulted as the best network structure, compared to the ones learnt using K2 and the Akaike Information Criterion (AIC). The BIC score-based structure was then used for parameter learning and probabilistic inference. **Results:** Results show that, when considering an individual scenario, the highest predicted yielding compliance (81%) is attained when pedestrians arrive at the crosswalk while the flashes are active, whereas the lowest predicted yielding compliance (23.4%) is observed when the pedestrians cross between the yield line and advanced pedestrian crosswalk sign. On the other hand, crossing within marked stripes, approaching the crosswalk from the near side of the pushbutton pole, inactive flashing lights, and being the first to arrive at the crosswalk result in relatively high-predicted probabilities of pedestrians pressing pushbutton. Furthermore, with a combination of scenarios, the maximum achievable predicted yielding probability is 87.5%, while that of pressing the button was 96.3%. **Practical applications:** Traffic engineers and planners may use these findings to improve the safety of crosswalk users.

- **Keywords:** Drivers yielding compliance; Pedestrians' behaviors; Bayesian networks

Tracy Rice, Reagan Curtis. *Parental knowledge of concussion: Evaluation of the CDC's "Heads up to parents" educational initiative*. Pages 85-93.

Background: Potential negative outcomes associated with sport-related concussion drive the need for resources to educate parents about prevention, recognition, and management of concussion in the youth athlete. Parents play a critical role in the recognition and management of concussion for their child. Purpose: This study aims to (a) investigate current knowledge of concussion among parents whose children age 5–18 years play a club sport and (b) identify effects of an online video versus online print educational intervention on concussion knowledge change and learning. **Methods:** 140 parents whose children played a club sport answered questions regarding their knowledge of sport-related concussion pre- and post-random assignment to an educational intervention: CDC Concussion Awareness video or CDC Concussion Fact Sheet for Parents. **Results:** Participating parents demonstrated a moderate level of pre-intervention knowledge, but critical gaps in knowledge were identified. Knowledge of concussion improved slightly following intervention regardless of intervention type. **Conclusions:** This study confirms the presence of gaps in knowledge of concussion in parents whose children play club sports. Without the protection of concussion legislation, those athletes who participate in club sports are at particular risk due to lack of concussion knowledge and education. This study confirms that education can have a positive impact on parental knowledge of concussion. **Practical applications:** Pre-knowledge of concussion is the greatest predictor of post-knowledge of concussion, therefore pre-assessment of target audience knowledge followed by a custom educational intervention taking into account principles of adult learning, would be the most beneficial to increasing concussion knowledge.

- **Keywords:** Sport-related concussion; Youth sports; Parents; Education; CDC Heads up

Seyed Ebrahim Abdolmanafi, Sina Karamad. *A new approach for resource allocation for black spot treatment (case study: The road network of Iran)*. Pages 95-100.

Currently, spatial and temporal distribution of safety resources in Iran is entirely based on expert opinions, regardless of network priorities. Considering the lack of resources for implementing safety treatments, prioritizing unsafe points is an important and complicated issue where the effectiveness of each safety treatment option should be thoroughly investigated. The political, social, and environmental aspects should also be taken into consideration, including social and political pressures and officials talks on less important topics. Obviously, this inappropriate resource allocation poses a serious challenge to the expected goals. In this study, a methodology based on economic and social issues is proposed to optimize the annual budget allocation for eliminating or reducing the risk of accident-prone points. In this methodology, the spatial and temporal distribution of budget is determined using a mathematical model aimed to maximize the benefits of reducing the accidents after deducting the costs of implementing the safety countermeasures. The outputs of this model include the safety countermeasure alternatives and a five-year time schedule for implementing them, or the alternative of no action with regard to budget, social, and judicial constraints. In order to evaluate the proposed method, it is applied to the road network of Iran and the results are compared with those of the conventional method that is currently used for resource allocation in this country. The results show that the proposed method leads to 15% higher benefits compared to the conventional method. Moreover, this method makes 641 safe points, which is about 17% more than the safe points resulted from the existing method. Therefore, the proposed method brings about a safer network as a result of the optimal allocation of available resources.

- **Keywords:** Resource allocation; Black spots; Accident

Boon Hong Ang, Oxley Jennifer, Won Sun Chen, Shaun Wen Huey Lee. *Factors and challenges of driving reduction and cessation: A systematic review and meta-synthesis of qualitative studies on self-regulation*. Pages 101-108.

Introduction: Older adults are at a greater risk of injury and death in a motor-vehicle accident. While the ability to drive safely can be challenging with aging, the concept of self-regulation and associated support system have attracted more attention in recent years, especially in developed countries. This review describes the mechanism and summarizes the potential factors that influenced self-regulation of driving amongst older adults to provide new insights into a broader framework for transportation and safe mobility. **Methods:** We systematically searched 12 online databases for qualitative studies exploring the experiences of older adults aged 60 years and above on their decision to self-regulate their driving. Thematic synthesis was performed to identify elements influencing driving reduction and cessation. The confidence profile of each findings from the meta-synthesis was appraised using the Confidence in the Evidence from Reviews of Qualitative research (CERQual) tool. **Results:** A total of 17 studies representing views of 712 older adults from four countries were included. Three major themes were identified with each representing a transition phase that can either facilitate or hinder older drivers from ceasing completely or reducing their driving, when transitioning from pre-decision phase to post-cessation phase. **Conclusions:** Our findings suggest that there is a mismatch between the current traffic collation prevention measures, such as age-specific mandatory license renewal system and travel needs of older adults. As such, it is time for the authorities, researchers, and public from various fields and perspectives to collaborate, sustain, and improve safety and mobility in older adults. **Practical applications:** Adequate regulations and guidelines from the medical community and legal authorities are warranted to assist older adults and caregivers. Social support (e.g., feedback, assurance, or transportation support) from family members, friends, and healthcare professionals are crucial for a smooth transition. Provision of alternative transportations in rural areas are needed and future interventions should focus on engaging and educating older adults to consider alternative transportation modes for mobility. Age-specific mandatory license renewal procedure can be useful in screening for at-risk groups.

- **Keywords:** Reduction; Cessation; Mechanism; Mobility; Meta-synthesis

Victor Siskind, Ian J. Faulks, Mary C. Sheehan. *The impact of changes to the NSW graduated driver licensing system on subsequent crash and offense experience*. Pages 109-114.

Introduction: In mid-2007 the State of New South Wales (NSW) in Australia introduced modifications to the existing graduated driver licensing system, lengthening the mandatory number of supervised hours for learner drivers aged under 25 years from 50 to 120 and extending the minimum learner period from 6 to 12 months. Additional driving restrictions were also introduced for young drivers in the two provisional licensed periods, P1, P2. This paper aims to evaluate this change by comparing the crash and offense experiences of young learner drivers before and after it occurred. **Method:** From driver licensing files supplied by the NSW transport authority two cohorts of persons obtaining their initial learner's permits in the year prior to the changes and in the subsequent year were constructed with demographic data, dates of transition to the driving phases, dates of crashes, and dates and types of traffic offenses. Both cohorts comprised around 100,000 individuals. Crash rates per 100 years of person-time under observation post P1 with their standard errors were calculated. Using a survival-analytic approach the proportion of crashes of all types were graphed in three month periods post P1. Sexes were treated separately as were initial learner ages of 16, 17, 18–21, and 22–24 years. The distribution of traffic offense types during P1 and P2 phases were also

compared. With such large numbers formal statistical testing was avoided. **Results:** No meaningful differences in the crash or offense experiences of the two cohorts in either sex or at any age were observed. Delaying progress to unsupervised driving has road safety benefits. **Conclusions:** At least in conditions similar to those in NSW, requiring more than 50 h of supervised driving seems to have few road safety benefits. **Practical applications:** Licensing authorities should be cautious in extending the mandated number of supervised driving hours beyond 50.

- **Keywords:** Learner driver; Program evaluation; Hours of supervised driving; Age at driver licensing; Young drivers

Francesca La Torre, Monica Meocci, Alessandro Nocentini. *Safety effects of automated section speed control on the Italian motorway network*. Pages 115-123.

Introduction: Automated Section Speed Control (ASSC) has been identified as an effective countermeasure to reduce speeds and improve speed limit compliance. **Method:** An Empirical Bayes (EB) before-and-after study was performed in this research in order to evaluate the impact of the ASSC system on the expected crash frequency. The study was carried out on a sample of 125 ASSC sites of the Italian motorway network covering 1252 km, where a total of 21,721 crashes were recorded during a 10-year analysis period from 2004 to 2013. **Results:** Overall, the EB analysis estimated a significant 22% reduction in the expected crash frequency due to the implementation of the ASSC system. The analysis indicated that the effect is slightly larger on property damage only (PDO) crashes (−23%) than on fatal injury (FI) crashes (−18%) and that the highest reductions in crash frequency are expected for multi-vehicle FI crashes (−25%) and multi-vehicle PDO crashes (−31%). Furthermore, the results indicated that the ASSC system is more effective in reducing crash rates when traffic volume increases and it is therefore strongly recommended as a countermeasure to improve safety on high-traffic-volume motorway sections.

- **Keywords:** Road safety; Automated section speed control; Crash modification factor; Before-after study; Empirical Bayes

S.M. Sohel Mahmud, Luis Ferreira, Md. Shamsul Hoque, Ahmad Tavassoli. *Micro-level safety risk assessment model for a two-lane heterogeneous traffic environment in a developing country: A comparative crash probability modeling approach*. Pages 125-134.

Introduction: There have been a number of studies that have led to the development of safety risk assessment models to quantify the probability of crash frequencies on roadway facilities (both at micro- and macro-levels), over a specified time period. However, past research has rarely focused on heterogeneous traffic conditions in developing countries. **Method:** This paper puts forward several models related to the traditional count approach to estimate crash frequency at a micro-level in a non-lane based bi-directional heterogeneous traffic environment. The paper shows the results of dispersion, zero-inflation, and random heterogeneity effects of different exogenous factors by comparing Poisson (P); Negative Binomial (NB); random and fixed parameter Zero-Inflated Poisson (ZIP); and Latent Class Models (LCM). The empirical analysis is based on data from a section of a major national highway in Bangladesh. The performance of the models was validated using different statistical goodness-of-fit measures that compared the estimated and observed average crash frequencies at individual locations. With the identification of the most significant influencing factors, the paper discusses the practical policy implications using partial effects analysis and spatial distribution. **Results:** It was found that the Zero-Inflated Random Parameter model gives a slightly better statistical fit when compared to alternative approaches. **Practical**

applications: This micro-level modeling approach would be useful to identify significant crash risk factors; to prioritize road sections according to their safety level; to select site-specific appropriate counter-measures; and devise proactive target oriented safety management strategies. Thus, the results shown here could be a point of reference in the planning, designing, maintaining, and managing two-lane highway sections in developing countries.

- **Keywords:** Crash prediction models; Random parameter; Zero-inflated; Developing countries; Heterogeneous or mixed traffic

Muhammet Gul, M. Fatih Ak, Ali Fuat Guneri. *Pythagorean fuzzy VIKOR-based approach for safety risk assessment in mine industry*. Pages 135-153.

Introduction: Underground mining is considered one of the most hazardous industries and is often associated with serious work-related fatalities; this paper addresses job-related hazards and associated risks. **Method:** A risk assessment approach is proposed (Pythagorean fuzzy environment) and a case study is carried out in an underground copper and zinc mine. **Results:** Results of the study demonstrate that hazards can be categorized into different risk levels via compromised solutions of the fuzzy approach. Conclusion: The study provides a theoretical contribution by suggesting a Pythagorean fuzzy numbers-based VlseKriterijumska Optimizacija I Kompromisno Resenje (PFVIKOR) approach. Moreover, it contributes to improving overall safety levels of underground mining by considering and advising on the potential hazards of risk management. **Practical applications:** The proposed approach will improve the existing safety risk assessment mechanism in underground copper and zinc mining.

- **Keywords:** Occupational hazards; Risk assessment; Underground copper and zinc mine; Pythagorean fuzzy sets; VIKOR

Damien Kelly, Marina Efthymiou. *An analysis of human factors in fifty controlled flight into terrain aviation accidents from 2007 to 2017*. Pages 155-165.

Introduction: Controlled Flight Into Terrain (CFIT) account for a considerable amount of fatalities when compared to other accident categories. Human factors are deemed significant contributory causes in these accidents. This paper aims to identify the human factors involved with aviation accidents that resulted in CFIT. **Method:** The study used the Human Factors Analysis and Classification System (HFACS) framework to determine the factors involved in 50 CFIT accidents from 24 counties over a 10 year period, i.e. 2007–2017. Interviews with five senior aviation safety experts were used to provide a better comprehension of the human factors affecting the flight safety. **Results:** The study identified 1289 individual causal and contributory human factors with unsafe actions and preconditions for unsafe actions being the main subcategories of the accidents. The study found that CFIT occur across a range of pilot experience and 44% of accidents occurred in cruise flight. Distraction, complacency and fatigue are all elements that flight crews may experience as contributors to CFIT during cruising. **Conclusions:** Human factors represent a major component of CFIT accidents. The analysis revealed a similar pattern of contributory and causal human factors across the various flight categories, with some noteworthy isolated variations. The prevalent factors were decision and skill-based errors along with communication, coordination and planning issues. **Practical applications:** Provision of specific CFIT awareness, pilot training focusing on improved decision-making and revision of basic flight skills, development of specific Global Positioning System routes for transiting high terrain areas are necessary to prevent CFIT accidents. Installation of Terrain Avoidance and Warning System and Ground Proximity Warning System and appropriate equipment training, specific CFIT

Crew Resource Management training and improvement of organizational knowledge on the elements involved in CFIT are also recommended.

- **Keywords:** Controlled flight into terrain; Plane crash; Aviation accidents; Human factors analysis and classification system; Human factors in aviation, aviation safety

Tien-Pen Hsu, Ku-Lin Wen. *Effect of novel divergence markings on conflict prevention regarding motorcycle-involved right turn accidents of mixed traffic flow*. Pages 167-176.

Introduction: In Taiwan, segregated traffic flow countermeasures have long been in place. Although these facilities have decreased the numbers of motorcycle left-turn collisions, right-angle collisions, and sideswipe collisions, they have also induced serious right-turn accidents. The purpose of this research was to evaluate an intervention intended to decrease conflicts and motorcycle-involved crashes. In this study, the reasons why the motorcycle accident rate is higher at intersections with slow lanes than at those without slow lanes are presented, and the theory of the self-explaining road was applied to create divergence markings for a mixed traffic flow environment. An intervention that guides motorcycles and cars into appropriate locations at intersections was applied to three intersection approaches. **Method:** The intervention effectiveness was evaluated by comparing the number of accidents at the intersections before and after the implementation of improvement measures. Moreover, video recordings were used to analyze the traffic distributions at the cross-sections of intersections. T-test was adopted to examine whether the traffic flows at the cross-sections of the intersections before and after the intervention were statistically different. In addition, this research applied the post-encroachment time (PET), the time between the first road user leaving the encroachment zone and the second road user arriving in it, to evaluate traffic conflicts. Finally, the PET and severity index between a straight-through motorcycle and a right-turn vehicle were analyzed. **Results:** PET increased by 3.2%–20.4%, and the rates of right-turn collisions, sideswipe collisions, and rear-end collisions decreased by 64.3%, 77.3%, and 61.5% respectively. **Conclusions:** Eliminating the slow traffic lane and setting divergence markings may not effectively cause vehicles in different driving directions to drive in the proper locations in the lanes. However, divergence markings both reduce the rate of right-turn collisions and decrease the incidence of sideswipe and rear-end collisions. **Practical applications:** The proposed design method may be a good design reference for countries having a high motorcycle density.

- **Keywords:** Before and after; Self-explaining road; Post-encroachment time; Divergence markings

Yu Tu, Wei Wang, Ye Li, Chengcheng Xu, Te Xu, Xueqi Li. *Longitudinal safety impacts of cooperative adaptive cruise control vehicle's degradatio*n. Pages 177-192.

Introduction: The adaptive cruise control (ACC) and cooperative ACC (CACC) systems are critical parts of self-driving vehicles. The ACC vehicles detect front vehicle' information via vehicle-mounted sensors and make longitudinal reactions automatically, while CACC vehicles enhance the performance by vehicle-to-vehicle (V2V) wireless communication. However, CACC vehicles may abruptly degrade to ACC mode in reality due to various reasons, including communication failures, driver manipulations, and cyber-attacks. The sudden degradation will definitely bring negative influences on safety. **Method:**This study quantitatively evaluated the longitudinal safety impacts of vehicles' degradation in a CACC fleet based on microscopic simulations. The realistic CACC and ACC models proposed by the California Partners for Advanced Transit and Highways (PATH) were used for simulation experiments. The time integrated time-to-collision (TIT) was measured to quantify the collision risks. Extensive simulations were conducted via a

fleet of 10 CACC vehicles and speed profiles of vehicles in different scenarios were compared. Key factors, including the leading vehicle's deceleration rate, the number of vehicles between degraded vehicles (NVDVs), threshold of TTC, and visibility were also examined via sensitivity analyses. Results and **conclusions:** Simulation results indicate that degradation has significant negative influences on longitudinal safety of degraded vehicles under the driving state of deceleration. Degradation at middle positions in a CACC fleet, such as fourth and fifth positions, is much safer than that at others. Moreover, nonadjacent degradation is much riskier than adjacent degradation at the front positions of a fleet. NVDVs can bring inverse impacts on safety with different degradation positions. Speed profiles imply that the hysteresis of degraded vehicles' speed control is the major reason for high collision risks. **Practical applications:** Appropriately, hierarchical countermeasures have the potential to reduce the longitudinal safety impacts of degradation. Findings of this study can contribute to determining the applicable length of CACC fleets.

- **Keywords:** Cooperative adaptive cruise control; Adaptive cruise control; Safety; Collision risk; Degradation

Syyed Adnan Raheel Shah, Naveed Ahmad, Yongjun Shen, Mumtaz Ahmed Kamal, Muhammad Aamir Basheer, Tom Brijs. *Relationship between road traffic features and accidents: An application of two-stage decision-making approach for transportation engineers*. Pages 201-215.

Introduction: An efficient decision-making process is one of the major necessities of road safety performance analysis for human safety and budget allocation procedure. **Method:** During the road safety analysis procedure, data envelopment analysis (DEA) supports policymakers in differentiating between risky and safe segments of a homogeneous highway. Cross-risk, an extension of the DEA models, provides more information about risky segments for ranking purpose. After identification of risky segments, the next goal is to identify the factors that are major contributors in making that segment risky. **Results:** This research proposes a methodology to analyze road safety performance by using a combination of DEA with the decision tree (DT) technique. The proposed methodology not only provides a facility to identify problematic road segments with the help of DEA but also identifies contributing factors with the help of DT. **Practical applications:** The applicability of the proposed model will help policymakers to identify the major factors contributing to road accidents and analysis of safety performance of road infrastructure to allocate the budget during the decision-making process.

- **Keywords:** Transportation; Roads; Decision-making; Accidents; Risk evaluation; DEA-DT

Bruce J. Ladewski, Ahmed Jalil Al-Bayati. *Quality and safety management practices: The theory of quality management approach*. Pages 193-200.

Introduction: Safety management is frequently treated as non-essential and incidental to core business functions. Accordingly, the importance of safety management is often underestimated. The Theory of Quality Management was investigated in this study to find the degree of linkage between the management of quality and safety. **Method:** Data derived from a 40-item online survey were used to test the Theory of Quality Management model factors among quality and safety professionals. The surveys were distributed to quality and safety professionals represented by the American Society for Quality (ASQ) and American Society of Safety Engineers (ASSE), for a total of 144 completed surveys, with the largest number coming from manufacturing organizations. **Results:** the findings suggest good internal consistency for the variables and good

correlations between the quality and safety professional responses. **Conclusions:** This study offers evidence that the organizational functions of safety and quality can follow the same management model, broadening the understanding of the Theory of Quality Management from focusing only the management of quality, to embracing the management of safety. Practical Application: The finding could help establishments improve overall worker safety and health using quality tools and techniques.

Kelly Sarmiento, Jill Daugherty, Lara DePadilla. *Youth and high school sports coaches' experience with and attitudes about concussion and access to athletic trainers by sport type and age of athlete coached*. Pages 217-225.

Introduction: Concussions are a commonly reported injury in youth and high school sports and much of the responsibility related to concussion identification and response for young athletes is allocated to sports coaches. This paper presents findings on concussion-related education, access to resources, experiences, and attitudes among a large number of youth and high school sports coaches across a variety of sports nationwide. Methodology: Data were collected among coaches who completed the Centers for Disease Control and Prevention's (CDC) HEADS UP online concussion training pre-test between November 2016 and November 2017. Coaches' concussion-related education, access to resources, experiences, and attitudes were compared by age of athlete coached and level of contact of sport. Medium and large effect sizes were considered of practical significance for interpretation. **Results:** During the study period, 187,801 youth sports or high school sports coaches completed the CDC HEADS UP online training and corresponding pre-test. Access to previous concussion training significantly varied among respondents by age of athlete coached. For example, 27.4% of coaches of athletes aged 5 and younger had taken previous training compared to 72.9% of coaches of athletes aged 14–18. About one-quarter (27.4%) of all coaches reported ever having had to pull an athlete out of a game because of a possible concussion and 19.5% reported access to an athletic trainer at all games and practices. These variables differed significantly among coaches by age of athletes coached; coaches of older athletes were more likely to report access to an athletic trainer and having had to pull an athlete out of a game compared to coaches of younger athletes. No statistical differences by level of contact were considered to be of practical significance based on effect size. Conclusion: Most coaches in this study report having access to education and hold attitudes consistent with best practices about concussion safety; however, overall access to concussion-related resources is limited. While differences in access to concussion-related education, experience, resources, and attitudes among coaches of varying levels of contact were small, medium to large variations were identified by age of athlete coached. **Practical applications:** Coaches bear an important part of the responsibility to prevent, identify, and manage concussions in young athletes. Tailored educational efforts may assist coaches of young athletes with recognition of concussion signs and symptoms and with feeling comfortable deciding whether an athlete needs to be evaluated for a possible concussion.

- **Keywords:** Concussion; Coach; Education; Sports; Training