



**Shitan Wang, Chenglong Feng, Xinpeng Chen, Mianjia Shan, Wenxin Niu.**  
***A biomechanical evaluation of firefighters' musculoskeletal loads when carrying self-contained breathing apparatus in walking and running.***  
**Pages 1-14.**

**Introduction:** Musculoskeletal loading data are needed to design ergonomic intervention for firefighters. This study aimed to quantify the firefighters' musculoskeletal loads during self-contained breathing apparatus (SCBA) carriage and evaluate the effectiveness of shoulder strap length variation for the prevention of SCBA-related injuries. **Method:** Twelve firefighters (height:  $174.6 \pm 2.4$  cm, mass:  $67 \pm 3.5$  kg, BMI =  $22 \pm 1$  kg/m<sup>2</sup>) participated the walking and running protocols with no SCBA equipped and three varying-shouldered SCBAs conditions. Joint range of motion and surface electromyography (sEMG) were synchronously measured. Subsequently, joint kinematics was inputted for subject-specific musculoskeletal modeling to estimate muscle forces and joint reaction forces, while the sEMG was used to validate the model. Repeated measures analysis of variance was used for the main effects ( $p < 0.05$ ). Independent samples t-test was performed to determine differences between walking and running. **Results:** Walking with SCBA increased the rectus femoris force and hip reaction force by 34.92% [ $F = 53.629$ ;  $p < 0.001$ ;  $\eta^2 = 0.317$ ] and 34.71% [ $F = 53.653$ ;  $p < 0.001$ ;  $\eta^2 = 0.517$ ], the growth rate was 54.2% [ $F = 76.487$ ;  $p < 0.001$ ;  $\eta^2 = 0.418$ ] and 51.19% [ $F = 69.201$ ;  $p < 0.001$ ;  $\eta^2 = 0.652$ ] during running, respectively. Running with SCBA significantly increased the knee reaction force by 63.04% [ $F = 83.960$ ;  $p < 0.001$ ;  $\eta^2 = 0.797$ ], while only 18.49% increase during walking. Adjusting SCBA shoulder strap length significantly altered the rectus abdominis force and L4/L5 reaction force during walking and running. **Conclusions:** Results revealed that rectus femoris activity, hip and knee exertion was sensitive to SCBA carriage. The variation of shoulder strap length has potential to influence the risk of low back pain (LBP). **Practical applications:** The findings suggest that fire services promote targeting physical training at firefighters' hip and knee regions. Test firefighters in this study were not advisable to adjust their shoulder strap at loose-fitting condition. The compatibility design of the trunk morphology and SCBA back-mounted frame was suggested for the management of LBP.

- **Keywords:** Firefighters; Musculoskeletal disorders; Biomechanical model; Self-contained breathing apparatus; Personal protective equipment

**Jun-Ming Su, Jer-Hao Chang, Ni Luh Dwi Indrayani, Chi-Jane Wang.** *Machine learning approach to determine the decision rules in ergonomic assessment of working posture in sewing machine operators.* Pages 15-26.

**Introduction:** There are some inherent problems with the use of observation methods in the ergonomic assessment of working posture, namely the stability and precision of the measurements. This study aims to use a machine learning (ML) approach to avoid the subjectivity bias of observational methods in ergonomic assessments and further identify risk patterns for work-related musculoskeletal disorders (WMSDs) among sewing machine operators. **Methods:** We proposed a decision tree analysis scheme for ergonomic assessment in working postures (DTAS-EAWP). First, DTAS-EAWP used computer vision-based technology to detect the body movement angles from the on-site working videos to generate a dataset of risk scores through the criteria of Rapid Entire Body Assessment (REBA) for sewing machine operators. Second, data mining techniques (WEKA) using the C4.5 algorithm were used to construct a representative decision tree (RDT) with paths of various risk levels, and attribute importance analysis was performed to determine the critical body segments for WMSDs. **Results:** DTAS-EAWP was able to recognize 11,211 samples of continuous working postures in sewing machine operation and calculate the corresponding final REBA scores. A total of 13 decision rules were constructed in the RDT, with over 95% prediction accuracy and 83% path coverage, to depict the possible risk tendency in the working postures. Through RDT and attribute importance analysis, it was identified that the lower arm and the upper arms exhibited as critical segments that significantly increased the risk levels for WMSDs. **Conclusions:** This study demonstrates that ML approach with computer vision-based estimation and DT analysis are feasible for comprehensively exploring the decision rules in ergonomic assessment of working postures for risk prediction of WMSDs in sewing machine operators. **Practical Applications:** This DTAS-EAWP can be applied in manufacturing industries to automatically analyze working postures and identify risk patterns of WMSDs, leading to the development of effectively preventive interventions.

- **Keywords:** Musculoskeletal disorders; Ergonomics; Risk assessment; Emergent technologies; Occupational health

**Ying-yi Li, Jing Gan.** *Effect of wearable chair on gait, balance, and discomfort of new users during level walking with anterior loads.* Pages 27-37.

**Introduction:** Walking with anterior loads is common in industrial scenarios, but as exoskeletons are increasingly used in work environments to alleviate musculoskeletal disorders (MSDs), this new "human-robot" system composed of the human body and exoskeleton may be associated with new risks and harm that warrant further investigation. Therefore, this study will discuss the effect of a wearable chair on the gait, balance, and discomfort of new users with different weights of anterior loads during level walking. **Method:** Twenty-two healthy subjects (sex balanced) participated in the experiment. Each exposure comprised one of two exoskeleton states (with/without) and four load conditions: No carried load, carrying an empty box (0.3 kg), 5%Body Weight (BW), and 10%BW. The order of exoskeleton states and load conditions was randomly assigned. Using an eight-camera motion capture system to record the entire movement. And the subjective discomfort and perceived balance after each exposure were recorded on an 11-point numeric rating scale, respectively. Using SPSS 26.0 software (IBM Inc., Chicago) to conduct statistical analyses. **Results:** Level walking with a wearable chair in different load conditions significantly affected gait parameters (like cadence) and gait

balance. The perceived balance decreased with the exoskeleton, consistent with objective results. For subjective discomfort, wearing the exoskeleton significantly impacted global discomfort. Also, it increased the local discomfort of the shoulders, waist, thighs, shanks, and feet/ankles. **Conclusions:** For new users, the risk of losing balance or falling may be increased when wearing an exoskeleton for non-target task behaviors (level walking/anterior load), and caution is recommended when the anterior load exceeds 5% BW. Practical Application: The proposed strategy for assessing human gait, balance, and discomfort in wearable chairs may be applied during the iterative design of the product. These controls will help develop training programs and implementation guidelines for this exoskeleton type.

- **Keywords:** Wearable Chair; Gait Balance; Discomfort; Ergonomics; Occupational Health

**Paul Schepers, Eline Theuwissen, Pablo Nuñez Velasco, Matin Nabavi Niaki, Otto van Boggelen, Winnie Daamen, Marjan Hagenzieker. *The relationship between cycle track width and the lateral position of cyclists, and implications for the required cycle track width. Pages 38-53.***

**Introduction:** Sufficient cycle track width is important to prevent single-bicycle crashes and collisions between cyclists. The assumptions on which the minimum width is based in guidelines is founded on only a few studies. The aim of the present study is to investigate the relationship between cycle track width and lateral position of cyclists. **Method:** We conducted an experiment to evaluate the lateral position of cyclists along cycle tracks with different widths (Study 1). Participants cycled on an instrumented bicycle with a LIDAR to measure their lateral position. Five conditions were defined: cycle track width of 100 cm, 150 cm and 200 cm without interaction, and cycle track width of 150 cm and 200 cm with an oncoming cyclist simulated by a parked bicycle. The cross-sectional Study 2 is based on the collected lateral position measurements at cycle tracks with varying width reported in Dutch studies since 2010. **Results:** The experimental Study 1 with 24 participants shows that an increase in cycle track width causes cyclists to ride further away from the verge and keep more distance from an oncoming cyclist. The cross-sectional Study 2 was based on lateral position measured at 33 real-life Dutch cycle tracks. Study 2 yielded similar results, indicating that doubling pavement width increases lateral position by some 50%. Study 2 shows that, compared with a solo cyclist without interaction, a right-hand cyclist of a duo and a cyclist meeting an oncoming cyclist ride around 30% closer to the verge. **Conclusions:** The wider the cycle track, the more distance cyclists maintain from the verge. Cyclists ride closer to the verge due to oncoming cyclists. **Practical applications:** Given a cyclists' lateral position while meeting, common variations between cyclists' steering behavior, and vehicle width and circumstances, a cycle track width of 250 cm is needed for safe meeting maneuvers.

- **Keywords:** Cycling; Cycling safety; Road design; Cycle track width

**Bjørn Olsson. *Increased bicycle helmet use in the absence of mandatory bicycle helmet legislation: Prevalence and trends from longitudinal observational studies on the use of bicycle helmets among cyclists in Denmark 2004–2022. Pages 54-63.***

**Introduction:** Using a bicycle helmet reduces the risk of serious head injuries among cyclists substantially. This makes it highly relevant to increase the use of helmets and to measure the prevalence of bicycle helmet use over time and across different groups. **Method:** Since 2004, the use of bicycle helmets in Denmark has been measured observationally in two nationwide time series: one among cyclists in city traffic across all age groups, and one among cycling school children (aged 6–16) around schools. The

observations have been conducted on a regular basis in different parts of the country following the same methodology over the years. **Results:** Bicycle helmet use among cyclists in city traffic in Denmark has increased from 6% in 2004 to 50% in 2022. Among cycling school children, helmet use has increased from 33% in 2004 to 79% in 2022. Throughout the years, helmet wearing rates have been highest among young children and lowest among young adults. Since 2015, female cyclists in city traffic have had a slightly higher helmet use than male cyclists. Discussion: Several factors might have affected bicycle helmet use in Denmark. One possible factor is a nationwide focus on traffic safety education and behavior change campaigns to encourage helmet wearing. Furthermore, among stakeholders on cycling safety there has been consensus on recommending bicycle helmet use and supporting the promotion of helmets while not recommending or promoting helmet legislation. Finally, more safety-oriented behavior in road traffic in general, and self-reinforcing effects of increased helmet use have plausibly been important factors. **Practical Applications:** Increasing bicycle helmet use in a country where cycling is popular is possible in the absence of mandatory bicycle helmet legislation. Persistent behavior change campaigning and education, stakeholder consensus, higher levels of road safety-oriented behaviors, and self-reinforcing processes could potentially be important factors.

- **Keywords:** Road safety; Protective equipment; Behavior change; Cyclist behavior; Road safety campaigns; Education; Consensus; Stakeholders; Road safety-oriented behaviors; Self-reinforcing processes; Legislation

**Martin Bärwolff, Regine Gerike. *Cyclist's travel distances and risk of falls in snowy and icy conditions in German cities. Pages 64-75.***

**Introduction:** So far, no studies are known that estimate distance-based risks for cyclist falls in snowy/icy conditions compared to other conditions to account for differences in cycling levels in the different weather situations. **Method:** The number of cyclist falls was gathered from retrospective surveys in Germany. Cycling distances were obtained from the German Household Travel Survey "Mobility in cities - SrV," assigned to meteorological data, and validated against counts and own surveys. The number of falls per distance cycled and Risk Ratios for snowy/icy versus other weather conditions were estimated. **Results:** An average decrease of 53% in the distance travelled per person and day is estimated for snowy/icy days versus other days. This decrease is lower in regions with higher general cycling mode shares. We find average risks of falls from 9.5 to 16 (field surveys) up to 76.5 falls per 10,000km (online survey) and average Risk Ratios for cycling in snowy/icy conditions of 20 (field survey conducted in times of other weather) to 36 (field survey conducted in times of snow/ice) and 38 (online survey conducted in times of snow/ice). The risk of suffering an injury in the event of a fall is lower in snowy/icy compared to other weather conditions. **Conclusions:** Seeing the current trend of growing general cycling levels in Germany, we expect more cycling in winter and, in case of unchanged winter weather and maintenance, a substantial increase of cyclist falls. The reduced risk of being injured in the event of a fall in snowy/icy conditions does not outweigh the higher risk of falling in the first place. **Practical Applications:** Improved winter maintenance on cycling facilities can help increase winter cycling and reduce the risk of falls at the same time.

- **Keywords:** Winter Cycling; Distance Cycled; Cycling Safety; Single Bicycle Accidents; Survey Effects

**Alexander Rasch, Yury Tarakanov, Gustav Tellwe, Marco Dozza. *Drivers passing cyclists: How does sight distance affect safety? Results from a naturalistic study. Pages 76-85.***

**Introduction:** Cycling is popular for its ecological, economic, and health benefits. However, especially in rural areas, cyclists may need to share the road with motorized

traffic, which is often perceived as a threat. Overtaking a cyclist is a particularly critical maneuver for drivers as they need to control their lateral clearance and speed when passing the cyclist, possibly in the presence of oncoming vehicles or view-obstructing curves. An overtaking vehicle can destabilize the cyclist when passing with low clearance and high speed. At the same time, the cyclist may get scared and eventually stop cycling. In this work, we investigated how visibility regarding available sight distance—an important factor for infrastructure design and regulation—affects drivers' behavior when overtaking cyclists. **Method:** Using four roadside-based traffic sensors, we collected naturalistic data that contained kinematics of drivers overtaking cyclists on a rural road in Sweden. We modeled lateral clearance and speed at the passing moment in response to variables such as sight distance and oncoming traffic with a Bayesian multivariate approach. **Results:** Fitted on 81 maneuvers, the model revealed that drivers reduced lateral clearance under reduced sight distance. Speed was similarly reduced, however, not as clearly. When an oncoming vehicle was present, it had a similar—yet stronger—effect than sight distance. While we found an overall correlation between clearance and speed, some maneuvers were recorded at critically low clearance. **Conclusions:** Cyclists' safety is endangered when passed by drivers under reduced visibility or close to oncoming traffic. **Practical Applications:** Decision-making for infrastructure and policymaking should aim at prohibiting overtaking in areas with reduced visibility or close oncoming traffic. The model developed in this study may serve as a reference to vehicle active-safety systems and automated driving. The collected and processed data may support evaluating driver models fitted on less ecologically valid data and simulated active-safety systems.

- **Keywords:** Cyclist safety; Overtaking; Sight distance; Naturalistic data; Bayesian model

**Elisabeth Rubie, Narelle Haworth, Naohide Yamamoto. *Passing distance, speed and perceived risks to the cyclist and driver in passing events.* Pages 86-95.**

**Introduction:** Up to 38% of crashes between motor vehicles and cyclists involve overtaking and close passes, contributing to a fear of cycling for both current and potential riders. Consequently, most research has focused on the cyclist's perceptions of risk in passing events; but the driver's perceptions may be more influential determinants of passing distances and thus, objective crash risk. **Method:** In an online cross-sectional survey, participants viewed 24 video clips of naturalistic passing events (external view akin to being a following driver) on urban roads in Queensland, Australia and judged distance and safety for both the portrayed cyclist and the passing driver. The passing events were filmed at a low-speed site (40 km/h speed limit) and a high-speed site (70 km/h speed limit). **Results:** The 240 cyclist participants were more likely to rate the pass as unsafe for the portrayed cyclist than the 71 non-cyclist participants. Narrow passing distance, parked vehicles, oncoming vehicles, and higher motor vehicle speeds were significant predictors of rating the pass as unsafe for the portrayed cyclist and the passing driver. In addition, female participants were more likely to rate the pass as unsafe for the driver. Participant age, attitudes toward cyclists and frequency of passing cyclists did not significantly affect safety judgments. Discussion: Traffic and roadway characteristics largely underlie perceptions of safety for both the cyclist and the driver when passing, even after accounting for passing distance. External, objective factors are more important than attitudes toward cyclists. **Practical Applications:** Attempts to improve the subjective and objective safety of passing events may be more successful if their focus is on modifying traffic and roadway characteristics, rather than attempting to change drivers' attitudes toward cyclists. Limitations on motor-vehicle passing speed should be incorporated as part of safe bicycle passing laws.

- **Keywords:** Bicyclist; Lateral passing distance; Overtaking; Perceived risk; Attitudes

**Roni Utriainen, Markus Pöllänen, Steve O'Hern, Niina Sihvola. *Single-bicycle crashes in Finland – Characteristics and safety recommendations.* Pages 96-106.**

**Problem:** Increasing the role of cycling is necessary to reduce physical inactivity. While promoting cycling, attention should also be given to traffic safety. Hence, a better understanding on the underlying factors and safety recommendations of cyclist crashes is needed. This study aims to increase knowledge on fatal single-bicycle crashes (SBCs), where other road users are not collided with. **Method:** Data from in-depth investigated fatal cyclist crashes in Finland is analyzed from 2010 to 2019. The study presents descriptive analysis of the characteristics, underlying factors, and safety recommendations of SBCs (n=82) and other cyclist crashes (n=151). Logistic regression analysis and chi-squared tests were performed to identify significant characteristics for SBCs. **Results:** Fatal SBCs commonly involved people aged 60 or older, males, and cyclist not wearing a helmet. Cyclist's health issues influenced the crash in 62.2% of the SBCs. Compared to other cyclist crashes, health issues, alcohol, males, other crash locations than intersections, and weekends were highlighted in SBCs. Safety recommendations emphasized human factors, such as informing cyclist about underlying factors and the use of safety equipment. **Discussion:** In addition to human factors, the safety recommendations included suggestions regarding the bicycle, the traffic environment, and traffic regulations. This highlights the need to focus on different safety improvement actions to reduce SBCs. This study identified key characteristics of SBCs, which may help traffic safety authorities address this road safety issue and ultimately help to promote cyclist safety. **Practical Applications:** Cooperation between the actors including health care providers and the police is also proposed to address cyclists' health issues that contribute to SBCs.

- **Keywords:** Cyclist; Bicycle; Crash; Road safety; Single-bicycle crash

**Stefanie Ruf, Jan-Michael Druba, Carmen Hagemeister. *Stuck in a (literal) tight spot: Cycling between tram rails, sharrows and parked cars.* Pages 107-121.**

**Problem:** Cyclists riding next to parked vehicles are at risk of crashes with opening vehicle doors. A central position, out of this dooring zone, decreases such a risk but comes with other problems like potentially smaller passing distances kept by overtaking motorists or having to cross tram rails. **Method:** Factors influencing cyclists' choice of position were investigated by showing a total of 3,444 German cyclists different traffic situations in two online surveys. In the first study (N = 1,850), parked cars, the position of a cyclist riding ahead in the presented images (towards the curb/center of the lane), and presence and kind of sharrows were varied. As the variation in results for the different sharrow types was negligible, in Study 2 (N = 1,594), only the most common type was used. Whether cyclists prefer to accept the risk of falling while crossing tram rails or the risk of being too close to the curb or parked cars was investigated, varying the presence of tram rails, which has not been previously researched. In both studies, respondents indicated which position on the road they would choose in the depicted situations and answered questions about subjective safety, a factor closely related to cyclists' choice of position. **Results:** Cyclists chose positions farther towards the center of the road if there were parked cars and they chose an even more central position with tram rails. Respondents felt safer with sharrows on the road as well as in situations without parked cars and in situations without tram rails. **Discussion and practical implications:** The results indicate that, in addition to infrastructure characteristics, other cyclists' behavior (descriptive norm) influences cyclists' position on the road as well as their perceived safety. Implications for infrastructure design, especially regarding (the removal of) parked cars, are discussed.

- **Keywords:** Cycling; Parked cars; Safety; Sharrows; Tram rails

**Shumayla Yaqoob, Salvatore Cafiso, Giacomo Morabito, Giuseppina Pappalardo. *Deep transfer learning-based anomaly detection for cycling safety*. Pages 122-131.**

**Introduction:** Despite the general improvements in road safety, with the growing number of bicycle users, cycling safety is still a challenge as demonstrated by the fact that it is the only road transport mode with an increase in the number of fatalities in EU cities. **Problem:** Moreover, to analyze the problem to improve the road transport system, the traditional network screening based on crash statistics is a reactive approach and less effective due to the lack of suitable bicycle data availability, as well. In such a framework, new opportunities for data collection in smart cities and communities are emerging as proactive approaches to identify critical locations where safety treatments can be effectively applied to prevent bicycle crashes. **Method:** This research applied a deep transfer learning model to detect anomalies in cycling behavior that can be associated with traffic conflicts or near-miss crashes. **Results:** The paper presents how to build a users' tailored riding model named DTL AD to detect and localize riding anomalies by using a set of data in the National Marine Electronics Association (NMEA) string of Global Navigation Satellite System (GNSS) recorded with instrumented bicycles by different cyclists. **Conclusion:** More specifically, DTL AD exploits a convolutional autoencoder (CAE) with transfer learning to reduce data labelling and training effort. **Practical Application:** A case study demonstrates the identification of anomalies in cycling behavior visually represented on Geographic Information Systems (GIS) maps, showing how data clustering is well located in high-risk areas.

- **Keywords:** Anomaly detection; Road safety; Deep transfer learning

**Bettina Schröter, Sebastian Hantschel, Stefan Huber, Regine Gerike. *Determinants of bicycle crashes at urban signalized intersections*. Pages 132-142.**

**Problem:** Bicycle volumes are increasing in many regions worldwide leading to higher relevance of an in-depth understanding of bicyclist safety mechanisms. Detailed studies on bicyclist safety that consider exposure and distinguish by intersection category and crash types are missing for urban signalized intersections, which are of particular relevance for bicyclist safety. **Method:** Based on a comprehensive dataset of motorist and bicyclist volumes and infrastructure characteristics for a sample of 269 signalized intersections in two German cities, we utilize a top-down approach to analyze firstly, bicycle crashes of all types and secondly, bicycle crashes by type including turning, right-of-way and loss-of-control. A combination of descriptive statistics and Accident Prediction Models (APM) are applied as analysis methods. **Results:** Bicycle volumes are relevant for all types of intersections and crashes, whereas the effect of motor vehicle volumes differ between these different applications. The separation of bicyclists from motor vehicles in time and space increases their safety but also leads to behavioral adaption and risk compensation. The likelihood of right-of-way crashes even increases with more separation in the signaling scheme. The main predictor for loss-of-control crashes in terms of infrastructure are tram tracks. **Summary:** This study provides insights on relevant determinants of bicycle crashes at urban signalized intersections at several levels of detail. Exposure variables as well as the physical separation of bicyclists from motor vehicles show consistent effects on bicycle crash numbers whereas the effects of signaling differ between crash types. **Practical Applications:** The different types of intersections and crashes follow each specific mechanism of bicyclist safety. The separation of bicyclists and motorists in time and space are paramount at intersections with high bicycle volumes. Risk compensation such as red light running becomes more important as intersections get smaller and motor vehicle volumes decrease.

- **Keywords:** Bicycling; Accidents; Risk compensation; Safety-in-numbers; Urban street design

**David Friel, Sina Wachholz, Theresa Werner, Liesa Zimmermann, Oliver Schwedes, Rainer Stark. *Cyclists' perceived safety on intersections and roundabouts – A qualitative bicycle simulator study. Pages 143-156.***

**Introduction:** Although cycling provides both individual and societal benefits, the mode share in Germany remains at a relatively low level. One reason described in literature is the lack of perceived safety due to the cycling infrastructure, especially at junctions. The study addresses the influence of junction design on cyclists' perceived safety. **Method:** Three intersections (BS: Berlin Standard, PI: protected intersection, CbC: cycle lanes between car lanes) and one roundabout were modeled in a virtual environment. Using a bicycle simulator, n = 46 participants cycled through each junction design, followed by a qualitative interview. We conducted a structured content analysis on the interview transcripts. **Results:** Regarding the quality of statements, PI provides the highest level of perceived safety whereas CbC provides the lowest level. Both roundabout and BS provide medium to low perceived safety. Specific design features, such as continuous cycling infrastructure, physical separation and elements enhancing cyclists' visibility improve participants' perceived safety. On the other hand, curbs, bends, and elements obstructing visibility decrease perceived safety. Our findings also point towards a difference between overextending and manageable interactions between cars and cyclists. While manageable interactions raise attention to an appropriate extent, overextending interactions diminish the quality of the cycling experience so that some cyclists rather violate rules instead of using the designated cycling infrastructure. Furthermore, three factors influence participants' perception of infrastructure design: comprehensibility, comfort, and perceived safety. **Conclusions:** To provide a cycling friendly infrastructure, planners should consider cyclists' perceived safety as well as comfort and comprehensibility. Furthermore, in contrast to isolated segments, a continuous high-quality cycling infrastructure network should be implemented. Lastly, infrastructure might focus on manageable interactions rather than cause overextending interactions. Practical Application: The findings should be considered in future cycling infrastructure planning. Planners may test and modify temporary solutions to find appropriate designs for each junction.

- **Keywords:** Perceived Safety; Cycling; Bicycle Infrastructure Design; Qualitative Research; Bicycle Simulator

**Frauke Luise Berghoefer, Mark Vollrath. *Prefer what you like? Evaluation and preference of cycling infrastructures in a bicycle simulator. Pages 157-167.***

**Problem:** Previous research on cyclists' route evaluations and preferences already identified influencing factors and relevant evaluation criteria, but studies mostly focused on selected aspects like safety or comfort. This study examined the evaluation of routes more comprehensively considering five evaluation criteria, and further aims to compare the evaluation with the preference of routes. For this, we used the experimental approach of a bicycle simulator. **Method:** Our participants cycled route segments that varied in certain route characteristics. Each segment was rated in total and on five criteria generated in a previous study, namely Mental Comfort, Interaction, Environment, Ease of Use, and Physical Comfort. At the end, all route segments were ranked according to their quality. **Results:** Results showed that separated paths were rated the best, while busy footpaths and uphill segments were rated the worst. Interestingly, interacting with pedestrians was described to be more attention-demanding but not as mentally uncomfortable as interacting with motor traffic. The evaluation and preference of routes mostly went hand in hand but differed for the footpath, which was ranked better than it was rated. Results further indicated that gradient has such a strong impact on the



physical comfort of a route that it even influenced the overall evaluation. Discussion: Our findings suggest that the evaluation and preference of routes is influenced by the degree of separation, traffic volume, the type of the road user that the cyclists may need to interact with, but most importantly, it is influenced by the interaction of these three aspects. Practical Implications: The five criteria we used can reliably assess the evaluation and preference of routes. They help to differentiate the reason for negative evaluation of routes. This differentiation is crucial to improve cycling routes, as different causes for dissatisfaction among cyclists require different consequences.

- **Keywords:** Cycling routes; Comfort; Safety; Interaction with other road users; Evaluation criteria

**Ana María Pérez-Zuriaga, Juan Dols, Martín Nespereira, Alfredo García, Almudena Sajurjo-de-No. *Analysis of the consequences of car to micromobility user side impact crashes. Pages 168-175.***

**Introduction:** The strong rise in modes of travel commonly referred to as micromobility has changed the mobility patterns and lifestyles in cities worldwide, especially after the COVID-19 pandemic. It has led to a significant increase in the number of crashes involving these types of vehicles, especially bicycles and stand-up e-scooters. The risk of crashes is higher at intersections where motor-vehicles perform a turning maneuver crossing a bike lane. **Method:** The consequences of a passenger car-to-micromobility vehicle side-impact crashes, considering both bicycle and e-scooter, were studied based on the results of the simulation of several scenarios with PC-Crash software. Two injury criteria were applied: Head Injury Criterion (HIC15) and 3 ms chest acceleration criterion. **Results:** When motor-vehicle speed is lower than 50 km/h, the 3 ms chest acceleration never exceeds the 60 g threshold. However, at 50 km/h, it is close to 50 g in the case of e-scooter rides. At this speed, HIC15 is considerably greater than 1000, both for bicycles and for e-scooters, and the safety margin of 700 is exceeded at 45 km/h for e-scooters. **Conclusions:** In case of motor vehicle-to-micromobility vehicle side-impact crash, riding a bicycle is safer than riding an e-scooter since the observed HIC15 experienced by the cyclists is lower than that experienced by the e-scooter rider when motor vehicle speed is greater than 30 km/h. **Practical Applications:** To reduce micromobility users injury risk at intersections, motor vehicle speed limit should be equal or lower than 40 km/h. At this impact speed, the activation of hood or bumper airbags could be justified.

- **Keywords:** Micromobility; Road safety; PC-Crash; Head Injury Criteria; Chest acceleration

**Masha J.M. Odijk, Mehrnaz Asadi, M. Baran Ulak, Karst T. Geurs. *The interactions between accessibility and crash risk from a social equity perspective: A case study at the Rotterdam-The Hague metropolitan region. Pages 176-186.***

**Problem:** Transport policies generally prioritize improving safety and accessibility levels, as they are regarded as the most important indicators of the quality of the transport system serving the public. However, inequalities associated with safety and accessibility issues are generally overlooked in these policies. Despite the importance and necessity of transport policies to address equity issues, there is still scarce knowledge on the interactions between equity, safety, and accessibility. This research aims to address this gap in the literature by creating a better understanding of the relationships between accessibility levels and traffic safety with a focus on social equity perspectives. **Method:** A crash risk evaluation method and a Gravity model are utilized to analyze cycling safety and accessibility to jobs by bicycle. Two linear regression models (LM) were conducted to investigate the statistical correlations between cycling crash risk and accessibility. Moreover, the Bivariate local Moran's I method was employed to assess the spatial

inequalities of distribution of crash risk and job accessibility over different income-level populations. **Results:** The analyses showed that low-income people are not only disadvantaged in terms of job accessibility by bicycle but are also exposed to higher cycling crash risks, compared to high-income groups. Furthermore, most disadvantaged zones that have the highest need for road safety and accessibility improvements are identified as areas where low-income populations are exposed to higher crash risk and/or have lower access to jobs by bicycle. **Summary:** This study contributes to the transport literature by investigating the interactions between safety and accessibility and the impacts on transport equity. The findings of the statistical and spatial analysis are beneficial for the decision-makers, considering the probable mutual implications of land-use and transport developments and projects aiming to improve safety, accessibility, or both for different population groups.

- **Keywords:** Job accessibility; Cycling safety; Safety-accessibility interactions; Social equity; Disadvantaged populations

**Katja Schleinitz, Tibor Petzoldt. *Development of German pedelec (and bicycle) crashes between 2013 and 2021. Pages 187-201.***

**Introduction:** The continuous growth in the use of e-bikes (in Germany mostly pedelecs that support pedaling up to 25 km/h) raises questions about the use of historic crash data for the development of road safety measures. The aim of this study was to address this issue, by conducting a longitudinal analysis of pedelec and bicycle crash data over a period of nine years to identify trends and to clarify whether such trends are specific to pedelecs. **Method:** We analyzed 95,338 police reported pedelec and bicycle injury crashes from 2013 through 2021. The dataset consisted of crashes from three federal states of Germany: Brandenburg, Hesse and Saxony. Data were analyzed with respect to sex and age distribution, time, location and type of accident, conflict partner, cause of crash and injury severity. **Results:** Many of the analyzed variables showed a considerable degree of temporal stability, with differences as well as similarities between the two bicycle types staying quite consistent over the years. One notable difference was the mean age of the involved riders, with crashed pedelec riders being significantly older than conventional cyclists. At the same time, however, the mean age of these pedelec riders has decreased by eight years over time. Single vehicle crashes were consistently more common for pedelec riders than for cyclists. Similarly, pedelec rider crashes went with a higher injury severity over all the years. **Conclusions and practical applications:** While, on a more detailed level, we found differences between the two bicycle types, overall crash characteristics were remarkably similar and consistent over time. Our findings provide no clear argument for road safety measures that are specifically designed to target pedelecs. Instead, the stable crash total, and the increases in ridership of both bicycles and pedelecs, highlight the demand for new, innovative solutions to improve cycling safety in general.

- **Keywords:** Electric bicycle; E-bike safety; Accident analysis; Crash characteristics; Longitudinal; Rider age; Crash severity; Single vehicle crashes

**Kevin Gildea, Daniel Hall, Clara Mercadal-Baudart, Brian Caulfield, Ciaran Simms. *Computer vision-based assessment of cyclist-tram track interactions for predictive modeling of crossing success. Pages 202-216.***

**Introduction:** Single Bicycle Crashes (SBCs) are common, and underreported in official statistics. In urban environments, light rail tram tracks are a frequent factor, however, they have not yet been the subject of engineering analysis. **Method:** This study employs video-based analysis at nine Dublin city centre locations and introduces a predictive model for crossing success on tram tracks, utilising cyclist crossing angles within a Surrogate Measure of Safety (SMoS) framework. Additionally, Convolutional Neural Networks (CNNs) were explored for automatic estimation of crossing angles. **Results:**

Modeling results indicate that cyclist crossing angle is a strong predictor of crossing success, and that cyclist velocity is not. Findings also highlight the prevalence of external factors which limit crossing angles for cyclists. In particular, kerbs are a common factor, along with passing/approaching vehicles or other cyclists. Furthermore, results indicate that further training on a relatively small sample of 100 domain-specific examples can achieve substantial accuracy improvements for cyclist detection (from 0.31AP0.5 to 0.98AP0.5) and crossing angle inference from traffic camera footage. **Conclusions:** Ensuring safe crossing angles is important for cyclist safety around tram tracks. Infrastructural planners should aim for intuitive, self-explainable road layouts that allow for and encourage crossing angles of 60° or more – ideally 90°. **Practical Applications:** The SMoS framework and the open-source SafeCross11<https://github.com/KevGildea/SafeCross/>. application offer actionable insights and tools for enhancing cyclist safety around tram tracks.

- **Keywords:** Single bicycle crashes; Tram tracks; Video analysis; Surrogate measures of safety; Computer vision

**Laura Ringel, Clemens Kielhauser, Bryan T. Adey. *Wider view over bicycle crashes: Complementing and extending bicycle crash statistics in urban areas using surveys.* Pages 217-231.**

**Introduction:** In pursuit of sustainability goals, many cities are introducing measures to increase the usage of bicycles as a means of transportation. City planners aim to ensure that this increase does not lead to an increase in crashes, but must make corresponding infrastructure decisions with limited information. Sufficient data to perform a statistical analysis of location-specific crash frequencies is rarely available. For example, only approximately 10% of all bicycle crashes are reported to the police (Shinar et al., 2018). Therefore, urban planners often rely on expert opinion, which may lead to suboptimal prioritization and realization of infrastructure improvements. **Method:** This paper demonstrates how surveys on bicycle crashes can be used to aid urban planners in making infrastructure decisions. In addition to confirming the location and characteristics of reported crashes, surveys can uncover characteristics of crashes that are not reported to the police, situations in which a crash almost occurred, and locations perceived by cyclists to be dangerous. Surveys also allow urban planners to investigate non-infrastructure related causes of crashes, such as the frequency with which individual cyclists use other modes of transportation. **Practical Applications:** The usefulness of surveys in the determination of urban cycling safety is demonstrated in this paper through analysis of survey results from the city of Zurich in 2018.

- **Keywords:** Crash reports; Unreported crashes; Crash types; Crash statistics; Bicycle crashes; Tram tracks

**Tianyou Li, Jordanka Kovaceva, Marco Dozza. *Modeling collision avoidance maneuvers for micromobility vehicles.* Pages 232-243.**

**Introduction:** In recent years, as novel micromobility vehicles (MMVs) have hit the market and rapidly gained popularity, new challenges in road safety have also arisen. There is an urgent need for validated models that comprehensively describe the behavior of such novel MMVs. This study aims to compare the longitudinal and lateral control of bicycles and e-scooters in a collision-avoidance scenario from a top-down perspective, and to propose appropriate quantitative models for parameterizing and predicting the trajectories of the avoidance—braking and steering—maneuvers. **Method:** We compared a large e-scooter and a light e-scooter with a bicycle (in assisted and non-assisted modes) in field trials to determine whether these new vehicles have different maneuverability constraints when avoiding a rear-end collision by braking and/or steering. **Results:** Braking performance in terms of deceleration and jerk varies among the different types of vehicles; specifically, e-scooters are not as effective at braking as

bicycles, but the large e-scooter demonstrated better braking performance than the light one. No statistically significant difference was observed in the steering performance of the vehicles. Bicycles were perceived as more stable, maneuverable, and safe than e-scooters. The study also presents arctangent kinematic models for braking and steering, which demonstrate better accuracy and informativeness than linear models.

**Conclusions:** This study demonstrates that the new micromobility solutions have some maneuverability characteristics that differ significantly from those of bicycles, and even within their own kind. Steering could be a more efficient collision-avoidance strategy for MMVs than braking under certain circumstances, such as in a rear-end collision. More complicated modeling for MMV kinematics can be beneficial but needs validation.

**Practical Applications:** The proposed arctangent models could be used in new advanced driving assistance systems to prevent crashes between cars and MMV users. Micromobility safety could be improved by educating MMV riders to adapt their behavior accordingly. Further, knowledge about the differences in maneuverability between e-scooters and bicycles could inform infrastructure design, and traffic regulations.

- **Keywords:** E-scooters; Bicycles; Cycling safety; Micromobility vehicles; Active safety

**Sven Lißner, Maike von Harten, Angela Francke, Stefanie Ruf, Carmen Hagemeister. *Safe cycling in winter: Results of a case study on the role of de-icing in the city of Hamburg, Germany. Pages 244-256.***

**Introduction:** In parts of Europe and North America, cycling volumes decrease in winter due to a reduction in subjective safety. To counter this, high-quality winter maintenance is required on cycle paths. At the moment, grit and sodium chloride are considered state-of-the-art gritting/de-icing materials in Germany. However, grit has to be removed after winter because it poses a serious injury risk on dry streets, and, in various German cities, using sodium chloride is prohibited on segregated bike paths due to the harmful impact on surrounding trees. Therefore, there is a need for alternative gritting/de-icing materials. **Method:** We used a mixed-methods approach consisting of qualitative and quantitative surveys together with laboratory investigations and a life cycle assessment to find suitable alternatives to sodium chloride and grit for use on segregated bike paths, and tested four de-icing materials (sodium chloride as a reference, sodium formate, calcium magnesium acetate or CMA, and potassium acetate) at two sites in Hamburg, Germany. The tests were accompanied by on-site cyclist surveys. **Results:** The results show that the use of alternative (non-sodium chloride) de-icing materials either reduces or eliminates negative impacts on the environment at a local level, for example on trees along the cycle path. However, this reduction goes hand in hand with increasing negative environmental impacts at a global level due to higher overall emissions associated with the tested alternative de-icing materials. Regarding cyclists' safety, sodium formate was the only de-icing material which delivered comparable results to sodium chloride and should therefore be tested in extended conditions. **Conclusions:** Further research is needed on the large-scale application of the investigated de-icing agents on cycle paths in different cities, along with a survey of a larger number of cyclists. A final evaluation of the environmental aspects can only be made when the supply and production conditions for large-scale use are clear. **Practical Applications:** Basically there are two options for the practical application of de-icing materials: The usage of the costlier alternatives with better properties at a local level in the hope of fast development towards a better global GHG footprint in their manufacturing processes, or sticking to the use of grit and sodium chloride (where it is possible) while committing to improving clean-up after the snow and ice melt to prevent unsafe road conditions in spring.

- **Keywords:** Winter cycling; Winter road maintenance; Safety; De-icing

**Felix Wilhelm Siebert, Christoffer Riis, Kira Hyldekær Janstrup, Hanhe Lin, Frederik Boe Hüttel. *Computer vision-based helmet use registration for e-scooter riders – The impact of the mandatory helmet law in Copenhagen. Pages 257-265.***

**Problem:** E-scooters are a new form of mobility used more frequently in urban environments worldwide. As there is evidence of an increased risk of head injuries, helmets are recommended and (less frequently) legislated. Denmark has enacted mandatory e-scooter helmet use legislation from January 1, 2022. So far, it is unclear how this newly implemented law influenced helmet use of e-scooter riders in Denmark immediately after its implementation. **Method:** In this observational study, we register and compare e-scooter helmet use before the mandatory helmet use legislation (December 2021) and after (February 2022). As observational survey data collection in the field can be highly time-consuming, we conducted a video-based observation survey. We trained and applied a computer vision algorithm to automatically register e-scooter helmet use in the video data. **Results:** The trained algorithm produces accurate helmet use data, which does not differ significantly from human-registered helmet use. In applying the algorithm to video data collected in December 2021 and February 2022, we register an overall e-scooter helmet use of 4.4% in  $n=1054$  riders. Splitting the observation between the time before and after the implementation of the helmet use law reveals a significant increase in helmet use from 1.80% to 5.56%. **Discussion:** In this study, we successfully train and apply an object detection algorithm to register accurate helmet use data in videos collected in Copenhagen, Denmark. Using this algorithm, we find a significant impact of a new mandatory e-scooter helmet use law on e-scooter riders' helmet use behavior. Limitations of the study as well as future research needs, are discussed. **Practical Applications:** Computer vision algorithms can be used for accurate e-scooter helmet assessments. Implementing a mandatory helmet use law can increase helmet use of e-scooters at specific observation sites.

- **Keywords:** E-scooter; Injury prevention; Helmet use; Computer vision; Helmet use legislation

**Sabine Springer-Teumer, Isabel Kreißig, Josef F. Krems. *Anticipatory information makes the difference: Behavioral effects and user assessments of a cyclist warning system to enhance cyclists' situation awareness. Pages 266-284.***

**Problem:** Increasing numbers of crashes involving pedelecs, and particularly older pedelec users, induce a need to enhance cycling safety. We evaluated a prototype cyclist warning system (CWS) that aims to increase situation awareness (SA) by alerting to safety critical events (SCE) with trimodal (auditory, visual, tactile). **Method:** To investigate the effects of CWS usage, we conducted a 2x2 mixed design bicycle simulator study with factors (1) CWS usage (within: rides WITH vs. WITHOUT CWS) and (2) age group (between: younger vs. older cyclists) on braking reaction time, gaze behavior, mental workload, and perceived safety. In sum,  $N=64$  participants ( $n=32$  younger, 18–40 years;  $n=32$  older,  $\geq 55$  years) took part in the study and experienced two balanced blocks of short rides including SCE of particular relevance for cycling safety. **Results:** CWS usage resulted in earlier braking reactions to all investigated SCE and partly earlier fixation on the critical interaction partners (CIP) indicating increased cyclists' SA. Consistently to behavioral measures, participants' assessments regarding perceived safety further supported the safety improvements derived from CWS independently of age group. Moreover, CWS usage did not add to mental workload ratings. Age effects were selectively found for gaze data showing that across all SCE, older adults fixated longer and more frequently on street alignment, and less frequently on other road users. **Discussion:** Taken together, the CWS evaluation showed promising results indicating the potential of the tested CWS to increase SA and enhance cyclists' safety both on a

behavioral level and regarding subjective assessments. Further research should address the systems' safety potential under real-world conditions and for situations of higher complexity. **Practical Applications:** Understanding the potential impact of road safety measures such as CWS is important to contribute effectively to reducing SCE.

- **Keywords:** Cycling safety; Safety critical events; Cyclist warning system; Situation awareness; Braking reaction

**Dawei Wang, Wenxu Mao, Chaoyue Zhao, Feng Wang, Yixin Hu. *The cross-level effect of team safety-specific transformational leadership on workplace safety behavior: The serial mediating role of team safety climate and team safety motivation.* Pages 285-296.**

**Introduction:** Workplace safety not only impairs individual health but also affects economic and social development. **Method:** Based on social learning theory, collective social learning theory, and expectancy-valence theory, using cluster random sampling method, 630 employees from 66 different work teams out of around 800 employees in a domestic petroleum enterprise were selected to participate in the research. The safety-specific transformational leadership, safety climate, safety motivation and workplace safety behavior scales were used. Data were collected in two stages. SPSS22.0 and Mplus7.0 were used to analyze the data to explore the relationship between team safety-specific transformational leadership and workplace safety behavior, as well as the serial mediating effect of team safety climate and team safety motivation. **Results:** The results showed that: (a) team safety-specific transformational leadership can positively influence safety compliance and safety participation; (b) team safety climate mediates the relationship between team safety-specific transformational leadership and safety compliance and safety participation; (c) team safety motivation mediates the relationship between team safety-specific transformational leadership and safety compliance and safety participation; and (d) team safety climate and team safety motivation play a serial mediating role between team safety-specific transformational leadership and safety compliance and safety participation. **Practical Applications:** This research has both theoretical and practical significance.

- **Keywords:** Workplace safety behavior; Team safety motivation; Team safety climate; Social learning theory; Expectancy-valence theory

**Cristian Arturo Arias-Ulloa, Juan Gómez-Salgado, Kenny Escobar-Segovia, Juan Jesús García-Iglesias, Javier Fagundo-Rivera, Carlos Ruiz-Frutos. *Psychological distress in healthcare workers during COVID-19 pandemic: A systematic review.* Pages 297-312.**

**Objectives:** Healthcare workers serving during the COVID-19 pandemic may have been exposed to high work overload, which may have had an impact on their physical, mental, and social health. The aim of this study was to assess the risk factors associated with psychological distress among healthcare workers serving during the COVID-19 pandemic from January 2020 to December 2022. **Methods:** A systematic review was conducted based on the 2020 PRISMA statement. Articles were searched in the Pubmed, Scopus, Web of Science, CINAHL, and PsycINFO databases. **Results:** A total of 59 articles were included in this systematic review. It was observed that the prevalence of psychological distress during the COVID-19 pandemic was high. Female sex, being a nurse, being young, living alone/being single, and having a chronic disease or psychiatric disorder history are the main risk factors at the personal level. Other occupational and pandemic-related factors such as having many years of work experience, the presence of COVID-19 symptoms and contact history, not enough sleep, having lower family support and limited social relationships, fear of infecting friends and family, having a reduced perception of protection by personal protective equipment, working on the frontline, and having longer

service duration were found to be factors influencing the development of psychological distress during the COVID-19 pandemic. **Conclusions:** There are personal, interpersonal, and organizational risk factors that can lead to the occurrence of psychological distress among healthcare staff working during the COVID-19 pandemic.

- **Keywords:** Burnout; Psychological distress; Work engagement; Healthcare professionals; COVID-19

**Bonnie Huang, Natalie Watson-Brown, Verity Truelove. *Low-range, mid-range and high-range speeding: The association with speeding habits, perceived legitimacy and deterrence.* Pages 313-322.**

**Introduction:** Speeding is a global road safety concern contributing to an excessive number of fatal crashes and serious debilitating injuries. Research identifying amendable factors associated with speeding to inform interventions is critical. **Method:** This study examined the association of habit, perceived legitimacy of enforcement, and deterrence elements with three levels of speeding behavior; low- (<10 km/hr over the posted speed limit), mid- (10–20 km/hr), and high-range (>20 km/hr) speeding. An online survey of 870 participants aged over 17 years (M=37 years) was administered. **Results:** Approximately 80% of participants reported low-range speeding, 40% mid-range speeding, and 20% high-range speeding. Differences were found between speeding on urban and open roads with the proportion of participants greater for mid- and high-range speeding on open roads. Multiple linear regressions were run finding habit and deterrence variables to be significant predictors of all three levels of speeding. Perceived legitimacy of enforcement was a significant predictor of high-range speeding only. **Practical Applications:** These findings suggest countermeasures that encourage good speed-related habits would be promising. It is also concluded that additional deterrence measures that reduce punishment avoidance experiences (e.g., better detection of speeding behaviors) are needed to further curb speeding behaviors. Nevertheless, the current punishment for all levels of speeding is perceived to be an effective deterrent. These recommendations inform policy, training and education, and campaigns that target engagement in speeding.

- **Keywords:** Speed; Habit; Legitimacy; Sanction; Enforcement; Road safety

Neng Zhang, Mohammad Fard, John Laurence Davy, Sibashis Parida, Stephen R. Robinson. Is driving experience all that matters? Drivers' takeover performance in conditionally automated driving. Pages 323-331.

**Introduction:** In conditionally automated driving, drivers are allowed to engage in non-driving related tasks (NDRTs) and are occasionally requested to take over vehicle control in situations that the automation system cannot handle. Drivers may not be able to adequately perform such requests if they have limited driving experience. This study investigates the influence of driving experience on takeover performance in conditionally automated driving. **Method:** Nineteen subjects participated in this driving simulator study. The NDRTs consisted of three tasks: writing business emails (working condition), watching videos (entertaining condition), and taking a break with eyes closed (resting condition). These three NDRTs require drivers to invest high, moderate, and low levels of mental workload, respectively. The duration of engagement in each NDRT before a takeover request (TOR) was either 5 minutes (short interval) or 30 minutes (long interval). **Results:** Drivers' driving experience and performance during the control period are highly correlated with their TOR performance. Furthermore, the type and duration of NDRT influence TOR performance, and inexperienced drivers exhibit poorer TOR performance than experienced drivers. **Conclusions and Practical Applications:** These findings have relevance for the types of NDRTs that ought to be permitted during automated driving, the design of automated driving systems, and the formulation of regulations regarding the responsible use of automated vehicles.

- **Keywords:** Autonomous vehicle; Conditional automation; Non-driving related tasks; Simulated driving

**Martin Grill, Amanda Ulfdotter Samuelsson, Erik Matton, Edit Norderfeldt, Max Rapp-Ricciardi, Christine Räisänen, Pernilla Larsman. *Individualized behavior-based safety-leadership training: A randomized controlled trial. Pages 332-344.***

**Introduction:** Construction site managers play a critical role in occupational safety in the construction industry. This study aimed to develop and test a method for training construction site managers in positive feedback and active listening by incorporating the behavioral training components of behavior analysis, goal setting, practice with behavior feedback, homework, and maintenance planning into individualized behavior-based safety-leadership training (IBST), and to assess the effect of IBST on construction site managers' safety-leadership behaviors and performance. **Method:** In a naturalistic randomized controlled trial, construction site managers were randomly assigned to an experimental group (n=16) or a control group (n=19). The experimental-group managers received IBST, while the control-group managers received no training. Paired sample t-tests on pre- to post-training (i.e., six weeks after the final training session) were performed separately for the experimental- and control-group managers. **Results:** The safety-leadership behaviors of the experimental-group managers improved in terms of favorable feedback (d=0.99, p<.01), safety-specific feedback (d=0.89, p=.02), behavior-specific feedback (d=0.66, p=.02), antecedent listening (d=0.68, p=.02), and consequential listening (d=0.78, p=.01). In addition, safety-leadership performance improved in terms of transformational leadership (d=0.78, p=.01) and contingent-reward leadership (d=0.64, p=.02). No significant change was found for the control-group managers. **Conclusions:** The results indicate that behavior analysis, goal setting, practice with behavior feedback, homework, and maintenance planning are effective behavioral training components of safety-leadership training. Positive feedback and active listening were also found to be important behavioral requisites for transformational and contingent-reward leadership. **Practical applications:** IBST can be used to develop occupational safety in the construction industry by improving construction site managers' safety-leadership behaviors and performance.

- **Keywords:** Construction site managers; Positive feedback; Active listening; Behavior analysis; Goal setting; Practice with behavior feedback; Homework; Maintenance planning

**Suvin P. Venthuruthiyil, Diwas Thapa, Sabyasachee Mishra. *Towards smart work zones: Creating safe and efficient work zones in the technology era. Pages 345-366.***

**Introduction:** Work Zones (WZs) have long been identified as a source of traffic fatalities and delays. Despite considerable technological advances that have alleviated many operational challenges associated with a WZ, social concerns about safety and mobility near WZs remain. Notably, the concept of a Smart Work Zone (SWZ) emerged from the compelling need to improve the safety and mobility of traffic and other WZ participants. This study reviewed the literature to assimilate studies related to SWZ Systems (SWZSs), report their findings, and ascertain a future path forward. **Method:** To accomplish this, the existing WZ-related literature base was clustered into safety and traffic mobility topics using Latent Dirichlet Allocation (LDA) modeling. A thorough investigation of the pivotal inferences for the research topics was undertaken to comprehend current SWZ technologies and the need for further research. **Results:** The review uncovered the prominent features of SWZSs reported in the literature and the hindrances to their adoption. The most reported hindrances are the cost and effort associated with development, installation, and relocation. We uncover that Connected



Autonomous Vehicles, vehicle-to-vehicle, and vehicle-to-infrastructure communication, along with technology-based worker training are the most promising next frontier for SWZ. **Conclusion:** Significant research gaps exist in the literature regarding developing and implementing SWZS. Additionally, little effort has been directed toward developing workers' skills and competency. Practical approaches such as Virtual Reality (VR)-based training are necessary to bring workers up to pace with the developing SWZ technologies. **Practical Applications:** Future research should be directed towards interconnecting and implementing available safety technologies to automate WZ safety and management. Workers should be trained using more practical techniques. In this context, using VR will enable the simulation of hazardous events in a safe environment while also improving workers' skill retention.

- **Keywords:** Intelligent transportation system; Highway safety technologies; Latent Dirichlet Allocation; Literature review study; Worker adaptation

**Dana Waltzman, Kelly Sarmiento, Xinjian Zhang, Gabrielle F. Miller. *Estimated prevalence of helmet use while bicycling, rollerblading, and skateboarding among middle school students in selected U.S. States—Youth Behavior Risk Survey, 2013–2019. Pages 367–374.***

**Background:** Helmet use helps prevent severe and fatal head and brain injuries from bicycle, rollerblade, and skateboard crashes. This study explores the prevalence of self-reported helmet use among middle school students while bicycling, skateboarding, and rollerblading. **Methods:** Data from the Middle School Youth Risk Behavior Survey (YRBS) for selected states were analyzed. Self-reported prevalence (frequency) of helmet use while bicycling, rollerblading, or skateboarding and other variables (sex, grade level, and race/ethnicity) are reported. **Results:** The overall prevalence of rarely or never wearing a helmet while bicycling among middle school students in selected states was 68.6%; decreasing from 71.7% in 2013 to 67.1% in 2019. The overall prevalence of rarely or never wearing a helmet while rollerblading or skateboarding in middle school students in selected states was 74.6%; decreasing from 76.4% in 2013 to 73.5% in 2019. Students in 7th and 8th grade and students of non-Hispanic race/ethnicity had significantly higher odds of rarely or never wearing a helmet while bicycling or while rollerblading and skateboarding than students in 6th grade and non-Hispanic White students. **Conclusions:** While helmet use among middle school students improved over time, overall helmet use during bicycling, rollerblading, and skateboarding remained low. These estimates illustrate the continued call for universal implementation of helmet use efforts among kids using established strategies. **Practical Applications:** Future research on helmet use among youth who rollerblade and skateboard, as well as multi-pronged efforts to promote helmet use among middle schoolers who bicycle, skateboard, and rollerblade (inclusive of education, helmet distribution, and social marketing techniques, as well as the provision of helmets at no-cost) may be beneficial for addressing perceived risks for injury and other barriers.

- **Keywords:** Brain injury; Head injury; TBI; Concussion; Skull fracture

**Laurel Kincl, Laura Syron, Devin Lucas, Amelia Vaughan, Viktor Bovbjerg. *Relationship of personal, situational, and environmental factors to injury experience in commercial fishing. Pages 375–381.***

**Introduction:** Commercial fishing work involves a variety of activities and is hazardous. While much is understood to mitigate fatalities in this industry, research must further explore nonfatal injury characteristics, factors related to injury, and potential injury prevention strategies. This paper determines if fishing experience is associated with injury risk and explores common work activities associated with injury. **Method:** Key informant interviews and a survey of fishermen were conducted to refine work activity

codes and collect injury experiences. Independent sample t-tests compared the means of the years fishing by injury incident for all crab fishermen then stratified by position. Descriptive statistics explored the nature of injury in relation to work activity. **Results:** The level of experience was significantly lower for injured fishermen compared to fishermen who reported no injuries, but when stratified by position at the time of the injury, the association of injury to experience was only significant for owners. This stratified result demonstrates that the work activity, rather than experience, drives the apparent relationship of experience to injury. Being tired (24%) and weather (26%) were indicated as contributing factors at the time of injury. **Conclusion:** Modifying the work environment to better control hazards would benefit all fishermen, regardless of their experience, age, or position. Further work into effective interventions that fishermen would adopt is needed to reduce injury risk. Any formal or informal training of new fishermen should focus on the most hazardous activities, but more experienced fishermen would also benefit. Additionally, effective training or interventions for fatigue management, and decision support tools for weather- and navigation-related decisions would further reduce risk of at sea injuries. **Practical Applications:** Injury prevention training, for all fishermen, regardless of their position and years of experience, should cover the most hazardous tasks, fatigue risk management strategies, and weather decisions.

- **Keywords:** Fishermen; Work processes; Crew experience; Crew position; Injury prevention

**Ahmed Hossain, Xiaoduan Sun, Mahir Shahrier, Shahrin Islam, Shah Alam. *Exploring nighttime pedestrian crash patterns at intersection and segments: Findings from the machine learning algorithm.* Pages 382-394.**

**Introduction:** Pedestrian safety at nighttime is an ongoing critical traffic safety concern. Although poor visibility is primarily associated with nighttime pedestrian crashes, other contributing factors such as humans, vehicles, roadways, and environmental factors interact with each other to cause a crash. Additionally, the pattern of nighttime pedestrian crashes differs significantly according to the intersection and segment location, which requires further exploration. Data: This study applied Association Rules Mining (ARM), a rule-based machine learning method, to reveal the association of nighttime pedestrian crash risk factors according to the intersection and segment locations using 2,505 nighttime pedestrian fatal and injury crashes in Louisiana (2015–2019). Results and **conclusions:** Based on the generated rules, the results show that nighttime pedestrian crashes at the intersection are associated with right-turn vehicle movement, older drivers (>64 years) at the high-speed intersection, senior pedestrians (>64 years) in rainy weather conditions, violation by pedestrian age group '<15 years', and alcohol-intoxicated pedestrian violation in business/industrial areas. Additionally, 'careless operation' at the intersection is associated with alcohol-involved drivers. Most of the nighttime pedestrian crashes at segments are associated with roadways with no physical separation and the absence of streetlights. Driver alcohol involvement and their physical condition (inattentive/distracted) are also associated with pedestrian crashes associated at the segment location at night. Other segment pedestrian crashes are linked to the interstate in dark conditions, open country locations, and high-speed roadways. Additionally, the crash site investigation identified several critical pedestrian safety concerns including the lack of crosswalk facilities, high driveway density, and pedestrian behavioral patterns (e.g., crossing at roadway segments close to the intersection location). **Practical Applications:** The findings of this study can be used for selecting the appropriate countermeasures based on a case-by-case basis. The exposure patterns can be used in educational campaigns to strategically reduce nighttime pedestrian crashes.

- **Keywords:** Machine learning; High-speed intersection; Fatal; Alcohol; Interstate; Dark conditions

**Adheesh Kumar Vivek, Smruti Sourava Mohapatra. *An observational study on pedestrian and bicyclist violations at railroad grade crossings: Exploring the impact of geometrical and operational attributes.* Pages 395-406.**

**Introduction:** In order to enhance the existing body of research regarding the prevalence of violations committed by pedestrians and bicyclists, this observational study utilized personal-specific, train-specific, operational, and behavioral data extracted from recorded videos at seven railroad grade crossings (RRGCs). **Method:** A total of 7,332 pedestrians and 1,684 bicyclist crossing events were observed during 279 gate operation phases at seven study locations. First, two separate violation models (binary logit) for pedestrians and bicyclists were developed to determine the influence of personal-specific characteristics and other behavioral traits on probability of pedestrians' and bicyclists' violation. Later, the impact of various geometrical (railway track, distance between gates, distance between gate and nearest track, and road width) and operational (train vehicle unit) parameters on the factors that caused non-motorist violations was examined by developing distinct binary logit models. **Results:** The probability of pedestrians' and bicyclists' violation was found to be significantly influenced by train characteristics (train speed and train occupancy time), gate operational attributes (warning time and gate blockage duration), and personal-specific characteristics (gender, age, crossing speed, and looking both side). Furthermore, geometrical attributes along with train vehicle unit were observed to have impact over various factors that significantly influenced the behavior of pedestrians and bicyclists to violate. **Practical Applications:** The findings of this research provide essential information that could be applied in the initiatives of user awareness and enforcement program, emphasis on situational awareness and design of operational and geometrical elements to significantly limit the effects of risky walking and bicycling behavior at RRGCs.

- **Keywords:** Railroad grade crossings; Safety; Pedestrian behavior; Bicyclist behavior; Binary logit models

**Eric J. Kim, Arjun Ganga, Leo A. Kim. *The forgotten protection factor: A nationwide score-based assessment of motorcycle eye protection legislation.* Pages 407-415.**

**Introduction:** Motorcycle accidents cause millions of deaths and injuries globally. It is estimated that billions of dollars would be saved in the United States alone if safety equipment, such as helmets and eye protection, was ubiquitously worn. Legislation concerning eye protection specifically is understudied and poorly characterized. **Method:** We reviewed all motorcycle-related safety equipment laws in all 50 states of the United States for information regarding eye protection. We graded the rigor of each statute using our six-category Eye Safety Metric and performed a comparative analysis of statutes across all jurisdictions. **Results:** Fourteen states did not have any statutes regarding eye protection. Among states that did, 23 states had weak statutes (0–2 points), 20 states had moderately stringent statutes (3–4 points), and 7 states had strong statutes (5–6 points). States in western United States tended to have less strict eye protection laws. Twenty-six states had eye protection exemptions for windshields, which are a poor form of eye protection. Six states that had universal helmet laws had no laws requiring eye protection. **Conclusions:** We characterized eye protection legislation across the country and found great diversity in the stringency of laws across all jurisdictions. Despite only two states lacking helmet laws, we found that 14 states lacked eye protection laws. These findings from our Eye Safety Metric can be used as a springboard for future research, which can be used to determine the need for and

significance of eye safety legislation for motorcyclists and to inform legislative decision-making. **Practical Applications:** With this research, we hope to further the understanding of legislation regarding eye protection for motorcyclists and help policymakers identify states that need improved eye safety standards.

- **Keywords:** Motorcycle accidents; Eye protection; Legislation; Stringency; United States

**Benjamin T. Sharpe, Marcus S. Smith, Steven C.R. Williams, Jo Talbot, Oliver R. Runswick, Jenny Smith. *An expert-novice comparison of lifeguard specific vigilance performance.* Pages 416-430.**

**Introduction:** Lifeguards must maintain alertness and monitor an aquatic space across extended periods. However, lifeguard research has yet to investigate a lifeguard's ability to maintain performance over time and whether this is influenced by years of certified experience or the detection difficulty of a drowning incident. The aim of this study was to examine whether lifeguard experience, drowning duration, bather number, and time on task influences drowning detection performance. **Method:** A total of 30 participants took part in nine 60-minute lifeguard specific tasks that included 11 drowning events occurring at five-minute intervals. Each task had manipulated conditions that acted as the independent variables, including bather number and drowning duration. **Results:** The experienced group detected a greater number of drowning events per task, compared to novice and naïve groups. Findings further highlighted that time, bather number, and drowning duration has a substantial influence on lifeguard specific drowning detection performance. **Practical Applications:** It is hoped that the outcome of the study will have applied application in highlighting the critical need for lifeguard organizations to be aware of a lifeguard's capacity to sustain attention, and for researchers to explore methods for minimizing any decrement in vigilance performance.

- **Keywords:** Lifeguard; Expertise; Drowning detection; Vigilance; Perceived workload

**Verity Truelove, Michelle Nicolls, Kayla B. Stefanidis, Oscar Oviedo-Trespalacios. *Road rule enforcement and where to find it: An investigation of applications used to avoid detection when violating traffic rules.* Pages 431-445.**

**Introduction:** One of the primary countermeasures in place to prevent road rule violations is legal enforcement, yet there are numerous applications that can undermine such efforts by notifying drivers of enforcement locations. However, the capabilities of these applications and how they can impact offending behavior is currently unknown. **Method:** Two studies were conducted to understand which of these applications are being used by drivers and how these applications are impacting road rule violations. Study 1 consisted of a content analysis that involved searching the Google Play Store and Apple iTunes Store for applications that could be used to avoid road rule violations using pre-determined keywords. Meanwhile, Study 2 consisted of 468 licensed Australian drivers (54.5% males) over the age of 17 years (Mage = 35 years) who completed a survey. **Results:** A total of 73 applications were identified for Study 1, with most of the applications displaying speed camera locations. It was found that applications that notify drivers of traffic enforcement locations are widely prevalent, can be used on a variety of interfaces and include numerous additional features. Study 2 found that those who use the applications were more willing to speed than those who do not use the applications, while there was no difference in phone use while driving between those who do and do not use the applications. **Practical Applications:** The findings have important implications for stakeholders, policy, and future research. For example, it is suggested that specific functions of these applications need to be regulated to reduce road rule

violations and crash risk. Meanwhile, enforcement initiatives need to evolve at a faster rate to keep up to date with the changing technology that can undermine them.

- **Keywords:** Distraction; Technology; Deterrence; Punishment avoidance; Road safety

**Linda Foettinger, Friederike Doerwald, Birte Marie Albrecht, Imke Stalling, Carina Recke, Karin Bammann. *Exploring parental risk perception regarding childhood unintentional home injuries: A cross-sectional study. Pages 446-452.***

**Introduction:** While previous studies on childhood injury focused mainly on the relationship between parents' preventive behavior and its determinants, knowledge about parental risk perception that can help to develop, implement, and evaluate successful interventions to prevent childhood unintentional home injuries is still limited. The aim of this study was to gain a deeper understanding of parental risk perception regarding unintentional home injuries of children under six years of age. **Method:** A convenience sample of 469 parents, residing in Germany, completed a web-based questionnaire assessing factors potentially associated with parental risk perception on the child, parental, and environmental level. Descriptive statistics,  $p$  for trend, and Spearman's Rho correlation coefficients were calculated. **Results:** Key factors influencing parental risk perception included children's sex, age, migrant status, emotionality, and injury risk as well as parents' parenting style and external locus of control. While parental risk perception was positively associated with children's injury risk, the analyses showed no associations between parental risk perception and parents' preventive behavior. **Conclusions:** Our findings add to a better understanding of parental risk perception, provide practical implications for injury prevention, and indicate that the relationship between parental risk perception and parents' preventive behavior is based on a complex mechanism which is possibly moderated by parents' locus of control. **Practical Applications:** The identified key factors help to assess parental risk perception more accurately. Therefore, they should be considered in the development of tailored interventions to prevent unintentional home injuries of children, for instance, by targeting specific groups of parental risk perception.

- **Keywords:** Childhood injury; Home; Parental risk perception; Preventive behavior; Interventions

**Sabrina Islam, Kunal Gide, Tilak Dutta, Z. Shaghayegh Bagheri. *The effect of tread patterns on slip resistance of footwear outsoles based on composite materials in icy conditions. Pages 453-464.***

**Introduction:** Falls on icy surfaces are the leading cause of injuries for outdoor workers. Footwear outsole material and geometrical design parameters are the most significant factors affecting slips-and-falls. Recently, composite materials have been incorporated into outsoles to improve traction, yet the best design parameters are not fully understood. **Method:** In this effort, based on Taguchi orthogonal array design, 27 outsole prototypes were fabricated with different tread pattern features using our patented composites and tested in a simulated winter condition. **Results:** An analysis of variance (ANOVA) showed that surface area ( $p = 0.041$ , Contribution = 15.63%) was the only factor significantly affecting the slip-resistance of our prototypes. The best performance was observed for the maximized surface area covered by our composite material with circular and half circular plugs laid obliquely, mostly in the forefoot area. **Practical Applications:** These findings suggest that some tread design features of composite-based footwear have a great role in affecting slip-resistance properties of composite-based footwear.

- **Keywords:** Slips; Falls; Slip-resistant footwear outsole; Icy conditions; Taguchi method

**Minsoo Park, Dai Quoc Tran, Jinyeong Bak, Almo Senja Kulinan, Seunghee Park. *Real-time monitoring unsafe behaviors of portable multi-position ladder worker using deep learning based on vision data.* Pages 465-480.**

**Introduction:** Fatal fall from height accidents, especially on construction sites, persist, underscoring the importance of monitoring and managing worker behaviors to enhance safety. Deep learning showed the possibility of substituting the manual work of safety managers. However, applying detection results to determine compliance with safety regulations has limitations. **Method:** This study estimated the actual working height depending on the height of the object detection bounding box by specifying the consistent hinge part as a target marker based on ladder manufacturing regulations. Furthermore, an attempt was made to improve the separation between workers, coworkers, and persons unconnected to ladder activities by applying an optimized loss function alongside an attention mechanism. **Results:** The experimental results showed that an average precision increased from 87.60% to 90.44%. The performance of the monitoring unsafe behavior of ladder worker following the Korea Occupational Safety and Health Agency (KOSHA) guide was evaluated by 91.40 F1-Score, which accumulated sorted according to the working height. **Conclusions:** Experimental results show the feasibility of the real-time automate safety monitoring in ladder work. **Practical Applications:** By linking the estimated working height and deep learning multi-detection results to established safety regulations, the proposed method shows the potential to automatically monitoring unsafe behaviors in construction site.

- **Keywords:** Unsafe behaviors detection; Safety management; Fall from height; Construction safety; Computer vision

**Curtis G. Calabrese, Brett R.C. Molesworth, Julie Hatfield. *The effect of punishment and feedback on correcting erroneous behavior.* Pages 481-487.**

**Introduction:** Understanding the consequences of non-punitive sanctions and feedback for nonintentional deviations (i.e., errors) is important to effective safety policy. This study aims to address a lack of research on the effects of punishment and feedback on correcting erroneous behavior in the context of multitasking. **Method:** A Multi-Attribute Task Battery (MATB-II) was employed to simulate the demands of aviating, an important area of applied safety. Sixty participants were randomly assigned to one of four experimental groups (no intervention, punishment, feedback, punishment + feedback) and asked to perform the MATB-II. Punishment, feedback, and punishment + feedback decreased error and increased performance, with punishment alone having the greatest effect. **Results:** The results highlight the need for behavioral consequences or feedback to reduce erroneous behavior. **Practical Applications:** From an applied perspective, these results have implications for policy and training.

- **Keywords:** Error; Multitasking; Punishment; Feedback; Restorative justice; Retributive justice

**Michal Allman, Zuzana Dudáková, Martin Jankovský. *Long-term temporal analysis of fatal and severe occupational accidents in Central European forests of the Slovak Republic.* Pages 488-495.**

**Introduction:** Forestry is one of the most dangerous industries worldwide. Workers handle heavy loads and are exposed to numerous adverse factors of the work

environment. This study was focused on analyzing severe and fatal occupational accidents over a long period. **Methods:** Data were gathered from occupational safety and health databases of the State Forests of the Slovak Republic, which manages 879,113 ha of forests in Slovakia. Between 2007 and 2021, 210 severe and 64 fatal accidents were recorded. The data analyses included contingency tables, Pearson  $\chi^2$  test, and Cramer's V coefficient to analyze the relationships between studied variables. **Results:** The mean annual number of fatalities was 14, occurring to workers aged 42 on average. Almost 80% of all fatal accidents were suffered by contractors of harvesting operations, who were 5.23 times more likely to suffer a fatality than company employees. On average, 1.28 severe and 0.75 fatal accidents occurred per 1 million m<sup>3</sup> of harvested timber. The outcomes of the correlation analysis showed a decreasing trend in incidence in the case of severe accidents. Workers  $\leq 30$  years or between 51 and 60 years of age were the most vulnerable in the case of fatal accidents. In the case of severe accidents, workers between 51 and 60 were the most vulnerable group. Most fatal accidents were suffered by tree fellers (72.2%) during felling (69.8%), who were in contact with falling trees and tree parts (93.7% share for this material agent). **Conclusion and Practical Applications:** The presented study identified the most vulnerable worker groups as well as the effects of factors on the occurrence of severe and fatal occupational accidents in forestry. The results will serve in development of occupational safety and health strategies in forest enterprises.

- **Keywords:** Fatal occupational accidents; Occupational safety and health; Timber harvesting; Occupational risks

**Khaled Lahlouh, Aïcha Oumessaoud, Richard Huaman-Ramirez, Hajar Ouhannour. COVID-19 safety leadership, perceived severity, and emotional exhaustion: Does safety culture matter? Pages 496-507.**

**Introduction:** Emotional exhaustion is a major health-related issue that employees face, especially during crises such as pandemics. This study seeks to understand how safety leadership applied to the COVID-19 pandemic relates to emotional exhaustion, and to examine its mechanisms (i.e., perceived severity) along with its boundary condition (i.e., safety culture). **Method:** A time lag study was conducted to collect data from 229 employees working in the service industry in Morocco. Data were analyzed through the Partial Least Squares Structural Equation Modeling (PLS-SEM) technique using SmartPLS 4. **Results:** The results demonstrate that safety leadership is negatively related to emotional exhaustion. Additionally, they suggest that the relationship between COVID-19 safety leadership and perceived severity depends on the level of the moderating variable (i.e., safety culture). Specifically, the relationship is positive when safety culture is low, but is negative when safety culture is high. **Practical Applications:** The results of this study are important as they extend our knowledge of the nature of safety leadership and emotional exhaustion, and offer managers practical implications that can help to optimize safety leadership practices.

- **Keywords:** Safety Leadership; Safety Culture; Emotional exhaustion; Perceived Risk Severity; COVID-19

**Andrea E. Carmichael, Natalie H. Lennon, Judith R. Qualters. Analysis of social determinants of health and individual factors found in health equity frameworks: Applications to injury research. Pages 508-518.**

**Introduction:** This research evaluated existing health equity frameworks as they relate to social determinants of health (SDOHs) and individual factors that may impact injury outcomes and identify gaps in coverage using the Healthy People (HP) 2030 key domains. **Methods:** The study used a list of health equity frameworks sourced from previous literature. SDOHs and individual factors from each framework were identified and categorized into the Healthy People 2030 domains. Five injury topic areas were used

as examples for how SDOHs and individual factors can be compared to injury topic-specific health disparities to identify health equity frameworks to apply to injury research. **Results:** The study identified 59 SDOHs and individual factors from the list of 33 health equity frameworks. The number of SDOHs and individual factors identified varied by Healthy People 2030 domain: Neighborhood and Built Environment contained 16 (27.1%) SDOHs and individual actors, Social and Community Context contained 22 (37.3%), Economic Stability contained 10 (16.9%), Healthcare Access and Quality contained 10 (16.9%), and Education Access and Quality contained one (1.7%). Twenty-three (39.0%) SDOHs/individual factors related to traumatic brain injury, thirteen (22.0%) related to motor vehicle crashes and suicide, 11 (18.6%) related to drowning and older adult falls. Eight frameworks (24.2%) covered all HP 2030 key domains and may be applicable to injury topics. **Conclusions:** Incorporating health equity into research is critical. Health equity frameworks can provide a way to systematically incorporate health equity into research. The findings from this study may be useful to health equity research by providing a resource to injury and other public health fields. **Practical Applications:** Health equity frameworks are a practical tool to guide injury research, translation, evaluation, and program implementation. The findings from this study can be used to guide the application of health equity frameworks in injury research for specific topic areas.

- **Keywords:** Injury; Framework; Health equity; Social determinants of health; Healthy People 2030