Safety science special issue “safety in low- and middle-income countries”

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Editorial

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1. Introduction

Despite the ever-increasing interest in safety and subsequent developments over time, fatality rates in low- and middle-income countries (LMICs) are considerably higher than the rates in high-income countries, as for example, regarding road safety (WHO, 2018). Baseline information about the magnitude of physical and psychological trauma and injuries from safety-related causes and contributory factors has been scarce in most developing countries. This has deprived us of obtaining a full picture of the situation and realise the specific safety needs of LMICs.

Moreover, although the professional and academic capacity in LMICs is growing and safety issues can be studied more extensively, only a few studies have been dedicated to safety challenges in LMICs and tailored solutions. Admittedly, there have been studies examining the implementation of safety methods, tools, and interventions to LMICs. However, these are still often based on research and practice paradigms generated in developed countries with different political, social, scientific, and professional contexts.

To fill the gap outlined above, this Special Issue shares empirical safety research and respective case studies that were carried in or used data from African, South American and Asian LMICs with the aim to offer deeper safety insights in these countries and stimulate new research directions for the next decades. Following our invitation to researchers, we feel extremely satisfied from the high response rate and the number and quality of the paper featuring in this special issue and covering various sectors (e.g., land transport, aviation, textile, mining, manufacturing, construction and education), different safety disciplines and affiliated disciplines (e.g., road, occupational and public safety; fire safety; human factors and ergonomics) and several types of qualitative and quantitative data and analyses methods.

The diverse and rich body of research from LMICs hosted in this special issue serves as a testament to the vast knowledge and experience that these regions contribute to the field. The studies conducted in LMICs encompass a wide range of topics and contexts, addressing unique challenges and conditions specific to these countries. Most of the 35 articles included in this special issue regard land transport (n = 24), with these studies covering various specific areas of concern, such as drivers, motorcycles, pedestrians, and policy making. The rest 11 papers present a mosaic of focus areas, including government-level safety initiatives, organisational safety management, risk assessments and musculoskeletal disorders.

Regardless of the background and interests of the readers of this Special Issue, we are confident that everyone can benefit from the messages coming out of each article and summarised in the sections below. We also envisage that the collection of relevant empirical work under this issue could inform decision-making to set priorities and coordinate safety initiatives within and across LMICs, as well as allocate resources to resolve safety issues and support regions with more needs. This Special Issue showcases the diversity of perspectives, innovative approaches, and valuable insights that emerge from studying safety, and especially road safety, in LMICs.

2. Land transport

Despite ongoing efforts, LMICs continue to face poor road safety outcomes. Indeed, land transport was an area of special consideration among the contributors to this special issue, who collectively provide a comprehensive discussion of the entire field. Nevertheless, the scientometric study by Haghani et al. (2022) highlights a stark underrepresentation of LMICs in road safety research, despite these nations suffering the highest number of road traffic fatalities. This study identifies limited research activity, particularly in Africa, and a slower growth rate of publications in LMICs compared with high-income countries. Haghani et al. (2022) reveal a concentration of research on China and India, a lack of sophisticated research methodologies, and the underrepresentation of vulnerable road users in studies. The authors above advocate for increased international collaboration, diverse research methods, and investment in research resources to improve road safety in LMICs.

Driver safety was a common research topic in the special issue, with several articles investigating the factors determining the occurrence of road crashes. Regarding accident analysis, the study by Hamim and Ukkusuri (2022) stands out for its utilisation of methodologies that have predominantly been applied in high-income countries. They effectively applied well-known techniques, including AcciMap and network analysis methods, to examine road crashes in Bangladesh. While shedding light on the distinct factors that contribute to road crashes in Bangladesh, the specific study also contributes to broadening the applicability and significance of these methodologies, extending their utility beyond their traditional boundaries and enabling a more comprehensive comprehension of road safety challenges on a global scale.

Concerning crash risk, Koramati et al. (2022) developed a comprehensive methodological approach to identify and segment key risk factors associated with fatal road crashes in Hyderabad, India. Their results showed that measures to support road safety could include improved pedestrian infrastructure, restricting slow-moving vehicles during peak hours, enhancing street lighting, and addressing the specific challenges of night-time driving. Paul and Ghosh (2021) looked specifically at the mechanisms behind the severity of injuries among motor vehicle drivers.

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They introduced a novel conflict severity index (CSI) to predict the potential severity of crashes at unsignalized intersections on intercity highways. The CSI, based on crash risk, expected collision severity, and various other parameters, such as vehicular speed, mass, and conflict angle, offers a significant improvement over existing indicators. The specific study suggests that the CSI could be instrumental in enhancing road safety measures, estimating under-reported crashes, preventing large-scale traffic bottlenecks, and guiding future research to include other types of crashes.

The study by Chauhan et al. (2023) focuses on analysing the safety aspects at signalised intersections, particularly in relation to potential conflicts and collisions. Their research highlights the higher incidence of rear-end conflicts in heterogeneous traffic conditions with weak lane discipline compared to homogeneous traffic conditions and underscores the increased safety risks associated with diverse vehicle types and traffic behaviours. Whereas Chauhan et al. (2023) suggest implementing various measures (e.g., reducing lateral movement of smaller vehicles and establishing speed reduction zones near stop-lines), further investigation is needed to address challenges in data acquisition and defining conflict thresholds for heterogeneous traffic conditions. This will expectedly ensure the development of effective and tailored safety measures for such complex traffic environments.

Regarding behavioural studies, Kumar Yadav and Velaga (2022) examined the impact of different Blood Alcohol Concentration (BAC) levels on the driving errors in India, using a driving simulator and 82 volunteers. The study found significant increases in driving errors, such as speed limit violations and lane excursions, as BAC levels increased from 0% to 0.08%. It was also observed that awareness about drunk driving laws significantly reduced driving errors, emphasising the need for public awareness programs and strict drink and drive deterrence education during driver licensing. In the same country, Pawar and Velaga (2022) investigated the impact of time pressure on drivers' safety, focusing on gap-acceptance behaviours at unsignalized intersections. Their study found that higher time pressure conditions significantly increased the probability of accidents, and merge distance, speed reduction, gender, regular exercise, and driving profession were some factors significantly influencing gap-acceptance decisions. The findings of Pawar and Velaga (2022) underscore the necessity of strict traffic rule enforcement and driver education, particularly about intersection priority rules, to improve road safety.

In Latin America, Cendales et al. (2023) investigated the correlation between driving stress and risky behaviours among Colombian commuters. They found that exposure to driving stressors was a significant risk factor for dangerous driving, with subjective outcomes such as psychological strain and fatigue partially mediating this relationship. Their findings indicate interventions aimed at managing driving stress could enhance both psychological well-being and commuting safety. In south Europe, Vankov et al. (2022) used the Theory of Planned Behaviour and explored factors influencing driving under the influence of drugs or alcohol (DUI) in young Bulgarian drivers. They found that descriptive norms significantly predicted DUI intentions and past behaviour, and the latter was significantly associated with DUI intentions. In South-East Asia, the study by Thibenda et al. (2022) emphasised the importance of adopting a holistic approach to road safety strategies, taking into consideration infrastructure, vehicles, and human factors. The particular research highlighted the crucial role of cognitive factors, particularly attitudes, in shaping road user behaviour. By addressing these multifaceted aspects, road safety interventions can effectively promote safer attitudes and behaviours amongst drivers, contributing to improved road safety outcomes.

Two studies examined the impact of infrastructure on road safety, focusing on different aspects. Paul et al. (2022) investigated the effectiveness of a green signal countdown timer (GSCT) in reducing dilemma zones (DZs) at signalised intersections that often result in red light violations, unexpected stoppages, and severe collisions. Their study found that GSCT significantly reduced the length of DZs, resulting in a decrease in crossing and rear-end conflicts. Wang et al. (2021) revealed that optimising sign configurations, such as adding signage for lane-specific speed limits and recommended vehicle types, can enhance safety at median openings. Both studies above highlight the importance of infrastructure in improving road safety outcomes and provide valuable insights for developing effective interventions in diverse contexts. By considering infrastructure-related measures, policymakers and practitioners can work towards creating safer road environments for all road users.

Two-wheeled road users were represented in three of the papers published in this Special Issue. In the case of motorised two-wheeled users, Nguyen et al. (2021) examined a set of contributors to severe crashes involving motorcycle riders in Vietnam. Their results highlight that age, time of the crash, pillion passenger presence, riding speed, and both vehicle and road types are significant predictors of these crashes. In a second study, Nguyen et al. (2022) collected and analysed qualitative data to understand in-depth the typical characteristics of small-displacement motorcycle crashes in Vietnam. The authors above found that, apart from emphasising drink-riding, speeding, and distracted riding as very dangerous behaviours, motorbike riders expressed safety–critical concerns about weather conditions and infrastructural shortcomings. Another research, conducted by Chang et al. (2022), covered the case of Chinese E-bike riders and examined the effects of demographics, environmental factors, road traffic and crash characteristics on crash severity, finding that road design-related factors (i.e., horizontal curves and high-speed roads), environmental issues (i.e., poor lighting) and crash features (i.e., angular crashes) can significantly increase crashed E-bike riders' injury severity, especially among aging adults and cyclists riding in rural areas.

Another field substantially covered by the articles appended in this Special Issue was walking safety in LMICs, comprising four studies. Escobar et al. (2021) tested the role of age and road infrastructure on risky walking behaviours in a Latin American city; except for some specific behavioural settings, most pedestrian misbehaviours were independent of the age group. Anik et al. (2021) studied jaywalking trajectories of Bangladeshi pedestrians, finding that microscopic variables such as jaywalkers' speed, flow, and density clearly differentiate them from other pedestrians, even though gender differences should not be underestimated. In India, Kumar and Ghosh (2022) examined pedestrians' violations at signalised intersections and revealed that factors such as traffic condition and individual and situational characteristics affect the severity level of pedestrian-vehicle conflicts. In another study in India, Raoniar and Maurya (2022) assessed the effects of social information (e.g., norms and social cues) and non-social information (e.g., crosswalk characteristics, traffic attributes) on pedestrians' red-light violations. Their research concluded that, although non-social factors had greater statistical effects, social influences remain crucial in understanding pedestrian violations in Indian cities.

The infrastructure concerned, Nair and Bhavathrathan (2022) proposed a hybrid segmentation approach to identify susceptible crash locations on large road networks in India. This approach can help to cater for dissimilarity in design and functionality of intersections from the mid-blocks in the road network, and the proposed method is directly adaptable by practitioners for the road network level crash analysis. Also in India, Singh Bisht and Tiwari (2022) analysed the effects of paved shoulders on rural highway on safety of different road users. The results showed that, although up to 1.5 m shoulder width benefited all road users, paved shoulders of more than 2 m resulted in reduced safety of motorised two-wheelers. On the side of human performance, distracted driving and its effects on road safety, which has been rarely studied in LMICs, was investigated by Arevalo-Tamara et al. (2022) through a questionnaire study. They reported that there was a significant association between self-reported crashes and road distractions, thus highlighting the need for strong countermeasures to limit the prevalence of distracted driving in LMICs. In another cross-sectional study, Šeibokaitė et al. (2022) examined the effectiveness of an online hazard prediction

training for learner drivers and explored the role self-efficacy and road safety attitudes play in training program effectiveness. Their results showed the program was effective for male learner drivers, and the self-efficacy and safety attitudes did not moderate the training effects.

The case of passenger safety was addressed by Quy Nguyen-Phuoc et al. (2023) who examined determinants associated with self-protective intentions of Vietnamese ride-hailing passengers during the COVID-19 pandemic. Amongst other key variables, subjective knowledge, self-efficacy, perceived infection risk and perceived efficacy of measures stood out as having the most significant associations with protective behavioural intentions. Also, interestingly, this research suggests that psychosocial factors such as self-efficacy could mediate the relationship between the perceived effectiveness of preventive measures implemented by transport organisations and individuals' intention to engage in self-protective behaviours.

3. Other sectors

After applying a Causal Analysis based on STAMP (CAST) to boiler accidents in Brazil, Landi et al. (2022) revealed additional several risk factors not previously identified, including deficiencies in government agencies, and they suggested the consideration of new paradigms of risk and accident analyses in the efforts to improve safety. From a combined organisational and government perspective, Karanikas and Hasan (2022) analysed 201 inspection records and revealed average compliance OHS levels and significant differences in the compliance scores across factories and OHS items. These findings suggested the inapplicability of a risk-based approach by the inspectorate, as often recommended for developed countries, and the need for improvements in the inspection checklist, skills of inspectors and technical and financial support available to factories. Similar issues of not viewing OHS as an organisational priority were identified by Ali et al. (2021) who searched whether OHS was a topic of annual corporate reports by 181 Pakistani manufacturers and found that only three companies had fully disclosed OHS information as per global standards. The authors above also revealed an association between poor OHS reporting and low overall corporate accountability.

From a broad and inclusive perspective that incorporates several systemic factors, survey research of 236 miners in artisanal and small-scale mining operations in Kenya demonstrated severe injuries occurred because of the combination of individual behaviours (e.g., alcohol and drug consumption), organisational practices (e.g., low wages, lack of safety training, inexistent risk controls, poor management-miners interactions and communication) and inadequate government support (Ajith et al., 2021). In the gold mining sector of Ghana, Aram et al. (2021) investigated the disparities in health, safety and environmental conditions (HSE) between large and small companies and identified statistically significant differences in educational levels, abilities to self-protect at work, work-related health problems and HSE conditions, with workers in smaller companies being more disadvantaged. In the same country, data from 25 interviews with public clients and contractors in construction showed that OHS promotion could occur in various stages of construction procurement and through a range of management actions, including an agreement on clear OHS objectives and targets with associated costs and specific provisions, appointment of competent designers and inclusion of OHS criteria in their selection (Boadu et al., 2022).

A risk assessment of fatal accidents because of falls from heights in Malaysia was based on the statistical analysis of respective records and the use of the Fault Tree Analysis technique and found that most of the accidents were attributed to the combination of poor supervision and leadership, followed by inadequate work standards and the non-use of personal protective equipment (Zermane et al., 2022). Regarding musculoskeletal disorders (MSDs), Taifa (2022) applied Six Sigma and ergonomic principles in a classroom context and, based on a sample of 478 Indian students, showed the impact of prolonged use of poorly designed furniture on the risk of developing MSDs and recommended ergonomically designed desks by considering anthropometrics and other parameters of Indian populations. Another investigation of MSD problems in workplace contexts in poor Brazilian regions with the participation of 420 workers from various industries found that whereas the number of psychosocial factors contributing to MSDs was higher, mechanical and individual factors were more influential (Bispo et al., 2022).

Last, regarding human behaviour and performance, Guevara Arce et al. (2021) analysed video footage from responses to a large fire in Costa Rica and offered valuable insights into the interactions of key stakeholders involved amongst them and with their local context of informal settlements. In aviation, and specifically Iranian air traffic control services, a study examined the relationships between cognitive functions, personality and age on human error and revealed mixed results suggesting various similarities and differences between controllers with error history and others without such a history and leading to recommendations for employing cognitive and personality screening instruments (Hedayati et al., 2021).

4. The path forward

The research papers hosted by this Special Issue, on the one hand, provide rich insights into the state of safety challenges within low- and middle-income countries (LMICs), and on the other hand, represent an excellent foundation for future research initiatives. Nonetheless, the exploration of safety in LMICs is far from inclusive and conclusive, and several avenues warrant further investigation. Some of the key areas we identified include:

1. Expanding Geographical Scope: The research summarised above highlighted safety issues across select African, South American, and Asian countries. However, the global landscape is diverse, and safety issues are not uniformly distributed. Thus, further studies should aim to extend into other regions, including those that may have been overlooked or understudied in the past, to gain a more holistic understanding of safety challenges worldwide.

2. Context-specific Safety Solutions: Much of the safety knowledge and practices adopted in LMICs are often borrowed from high-income countries. While this has yielded some progress, the unique socio-political, scientific, and professional circumstances of each LMIC necessitate the development of more context-specific safety methodologies and tools. Research aimed at understanding these unique contexts and leveraging them for safety improvement would be particularly valuable.

3. **Broadening Sectoral Focus of Safety Research:** The articles in this issue primarily centred on the transport sector, a crucial area in LMICs. However, to truly appreciate and address safety in LMICs, a more diverse sectoral focus is necessary. Future research should thus delve into other vital safety disciplines (e.g., occupational health and safety, process and fire safety, services and operations safety, product and food safety) and more diverse sectors, such as healthcare, education, agriculture, and the service sector, each of which contributes significantly to the economies of LMICs.

4. Risk Factors and Systems Thinking: In this special issue and past publications, we have only begun to scratch the surface of the intricate network of risk factors contributing to safety incidents in LMICs. Future research should adopt a systems-thinking approach, examining deeper these risk factors, understanding how they interact and influence one another within the wider system, and developing interventions that account for this complexity.

5. Safety Education and Training: A key finding across the studies was the need for more robust safety education and training programs within LMICs. Exploring innovative, context-specific strategies for safety education that consider local cultural elements and nuances and available resources should be a priority.

6. Methodological and Technological Enhancements: The

evolution of technology and research methodologies offers an avenue to address safety concerns in LMICs in a more sophisticated manner. Future research should seek to validate the use of advanced methods, like artificial intelligence and computational modelling, and apply them to unique LMIC contexts. Additionally, assessing the effectiveness of emergent safety technologies within these settings is also vital for improving safety outcomes.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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