International Journal of Transportation Engineering and Technology
2025, Vol. 11, No. 2, pp. 85-97
https://doi.org/10.11648/j.ijtet.20251102.14

Research Article

Application of Haddon Matrix Model for Traffic Injury Prevention in Cameroon Cities: Using Samples from Bamenda City

Japhet Kuma Chianebeng*

Department of Geography and Planning, The University of Bamenda, Bamenda, Cameroon

Abstract

Road Traffic Injuries (RTIs) represent a significant public health issue in developing countries. Of recent, cities in Cameroon have shown consistent upward trends in road traffic accidents and fatal injuries, resulting in the deaths of road users. There is a nuanced understanding of the countermeasures in place to halve road injuries cases in the country, despite implementation of the Second Decade of Action for Road Safety target 2030 in Cameroon since 2016. This paper aims to (i) assess crash injury situation in Bamenda from 2015 to 2023, (i) evaluate pre-event factors of crashes/injuries among hosts (taxi drivers, motorcycle riders and private vehicle owners) and, (iii) identify sustainable strategies to reduce road crashes/injuries in the city. The study made used of 156 survey participants, made up of motorcycle riders, taxi drivers, and pedestrians, to gather their views on crash/injury cases in Bamenda city. The Regional Delegation of Transport (RDT) and its Department of Road Safety (DRS) provided relevant records on injury cases, which were crucial for analyzing their patterns and developing potential strategies for mitigating these incidents. The Haddon model introduced a conceptual framework that helped identify hosts, agents, and physical/social environmental risk factors for crash/injury cases that needed prevention. Key findings indicate that traffic injuries have significantly increased in the city, mainly due to factors such as speeding, overloading, overtaking, reckless driving, traffic congestion, poor road quality, and the absence of road/traffic signals. The findings derived from the Haddon matrix demonstrated its effectiveness in training emerging researchers in Cameroon to engage in conceptual analysis regarding the incidence of automobile crashes in urban areas and to develop innovative strategies for implementing preventive countermeasures.

Keywords

Haddon's Matrix, Community-based, Injury Prevention, Cameroon Cities, Bamenda

1. Introduction

Road traffic accidents, particularly those related to injuries and fatalities, have raised public health concerns globally. The World Health Organization Report estimate that, nearly 1.19 million people die each year from road accidents [30], while 50 million suffer from serious injuries and disabilities. This has constantly kept road accidents at the third position as the leading cause of mortality in the world. These fatalities impose significant economic burdens on communities, including the cost of treatment, rehabilitation, investigation, and loss of productivity for those affected. The leading cause

*Corresponding author: chianebeng@yahoo.com (Japhet Kuma Chianebeng)

Received: 14 November 2024; **Accepted:** 10 June 2025; **Published:** 25 June 2025

are distracted driving [5] and increase use of alcohol that poses a serious risk factor [15]. Studies have also demonstrated that vehicle-related environmental risk factors of injuries and fatalities account for 30 percent and 10 percent of traffic crashes, while human behavioral actions for up to 90 percent of crashes [1]. These rates are under-estimated particularly in developing countries because of underreporting and lack of testing [25]. The state of the art about the incidence and burden of road injuries in sub-Saharan Africa remained scanty. Official government statistics of road injuries are substantially lower than statistically modeled national estimates [2]. Many researchers and agencies recognized that non-fatal crashes are under-reported in official statistics. While these rates are decreasing in developed countries, the situation in low- and middle-income countries are on the rise due to large proportions of vulnerable road users [27]. Data from crash studies demonstrates that the introduction of new traffic regulations results in a subsequent rise in crash frequencies and while the impacts of police enforcement and infrastructural measures are well-documented [8], effectiveness of road safety education remains uncertain. Others have largely blamed the cause to increasing presence of mobile phones usage by drivers during driving [4]. Enough literature is available on the causes of road accidents, injuries and fatalities on the African continent, many of which are attributed to risky road user behavior such as drink-driving among motorbike taxis [9], drug use, road-crossing by commuters and unsafe driving among bus drivers [7]. Other factors included poor road conditions and traffic signs [18], narrow roadways [23], traffic congestion affecting post-crash care [20], and corruption affecting enforcement. Only very few studies are available on intervention planning approaches to reduce road accidents, injuries and fatalities [13].

Alarming with the impact of road traffic casualties, injuries, and fatalities in Low-and Middle-Income Countries (LMICs) [28], many state governments have brought in road safety experts in the continent with community participation in injury prevention increasingly becoming a matter of concern though with insufficient initiatives [21, 12]. This is due to lack of or insufficient resources for injury prevention and a top-down approach in decision-making [6]. Community engagement is crucial in global health and is widely recognized for its positive effects on health and its ability to reduce inequalities [11]. Participation is seen not only as a way to efficiently and effectively meet the goals of road safety programs but also as a valuable end in itself, empowering communities to take charge of their health and development [17]. A major setback for efforts to reduce the causal factors of road accidents, crashes and injuries is the lack of data and reliable information about the magnitude of the problem [22]. Relatively, scanty information is available on alcohol use among those sustaining road traffic injuries in Sub-Saharan Africa. Most researches on this subject are from South Africa, where there are very high rates of alcohol use in road traffic injuries [14, 19]. However, South Africa is an upper-middle income country that is very different from its poorer neighboring countries, and results from here might not be relevant for the rest of the region.

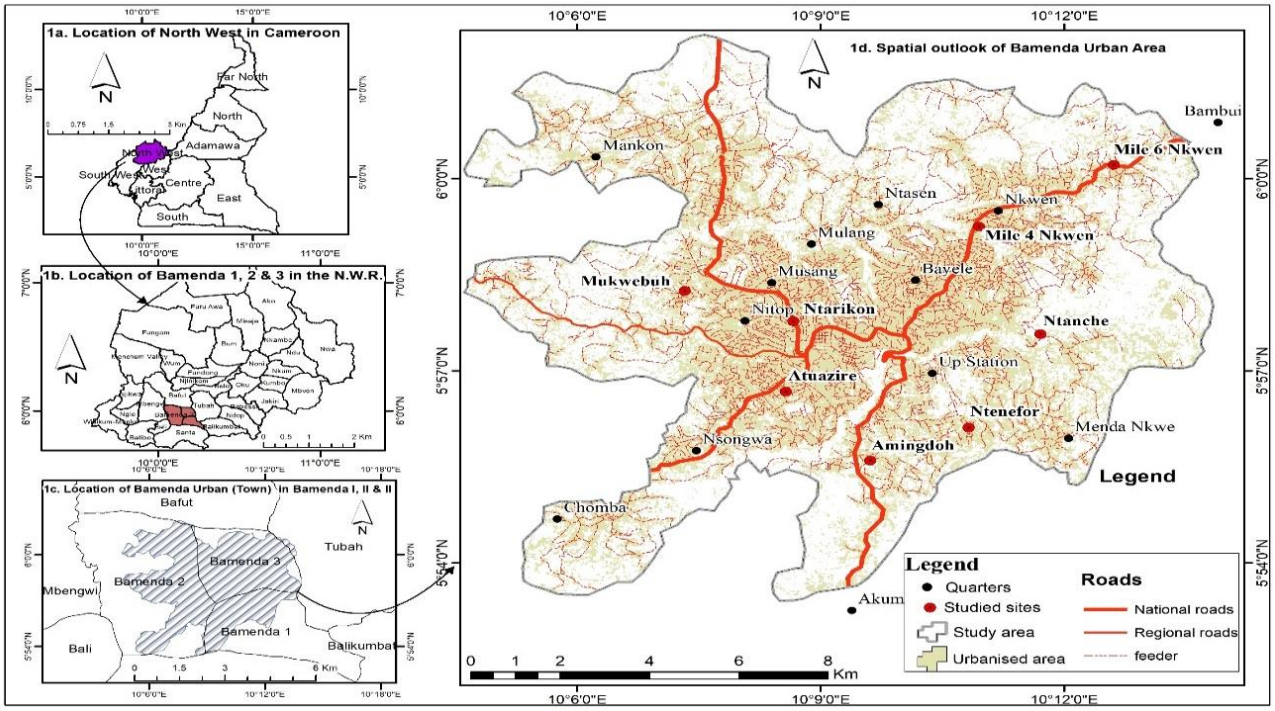
The World Health Organization has warned that if current trends continue, road traffic crashes will become the third leading cause of death by 2030 [29]. Recently, progress underway to reduce road traffic injuries and fatalities. In European countries, the Safe System approach has been introduced [24, 10, 16], and widely implemented in countries such as Australia, New Zealand with slogan ‘Towards zero’ road safety ambition [3], and Norway (‘Vision Zero’). To reduce the number of road traffic casualties to (nearly) zero, the Safe System approach became the best tool towards reaching such a goal. The results of this framework have proven effective in achieving road safety outcomes and promoting sustainable road infrastructure, leading to reductions in road crashes and injuries. In American cities, the Haddon Matrix approach have also demonstrated strong impact in reducing the incidence of traffic injuries as well. While these models have gained significant attention from researchers in developed countries, and their successful applications in road crash and injury prevention, developing countries, particularly those in Sub-Saharan Africa, have yet to test these models in their contexts. This study offers a fertile ground for applying the Haddon Matrix framework in Cameroon’s Bamenda city.

2. Haddon’s Metrix Approach to Injury Prevention

William Haddon, a public health expert developed an injury matrix to analyze road injury causation around 1960s. Haddon wanted to understand the realm of traffic safety by applying basic principles of public health. Since then, the matrix has become a tool for developing implementation strategies in injury prevention at various points in the sequence of the injury event. A logical system for preventing injury and death in motor vehicle crashes is based on the sequence of events (pre-crash, crash, and post-crash) and types of factors involved (human, vehicle and equipment, physical environment and roadway, and socioeconomic environment). By forming a matrix, various options and evidence of their effectiveness becomes easy to evaluate. Improving road safety involves identifying the risk factors that contribute to crashes and injuries, then identifying the interventions that reduce the risks associated with those factors [26]. A reference framework for identifying factors that have an impact on road traffic injuries is the Haddon Matrix, which divides factors into human, vehicular and environmental causes across three temporal phases - pre-crash, crash and post-crash.

3. Materials and Methods

The study area is Bamenda, a prime city, well known for its transportation services in the North West Region. As a major transport hub, the city has a diverse informal transportation modes ranging from transport agencies, trucks, traditional township taxis, motorcycles and a host of private vehicles, dispatching the residents to different neighborhoods within and out of the Bamenda city. The city is located between Latitudes 5° 56' and 5° 58' north of the Equator and longitudes 10° 09' and 10°11' east of the Greenwich Meridian. With a total surface area of 3125Km2 (Figure 1). Momo Division and Bali Sub-Division bound the city to the West and South West respectively. To the North, by Bafut Sub-Division, North East by Tubah Sub-Division, and to the South by Santa Sub-Division. It is made up of three Sub-Divisions which the municipal councils (Bamenda I, II & III). Bamenda is a fast-growing urban center in the entire region. Its rapid growth and expansion owes to its nodal position as a gateway to the rest of the country's regions. Bamenda maintains its dominant position with an urban population of 469,530 inhabitants in the region according to Bamenda City Council (BCC) population statistics in 2020.



Source: Geo Database of Cameroon, NIS, 2024

Figure 1. *Location of Bamenda city in Mezam Division, North West Region of Cameroon.*

Haddon's approach was use to analyze the pre-event, event and post event factors of injuries for road safety in Bamenda as shown in Figure 2. The Haddon matrix was the best tool to assist in developing ideas for preventing injuries of many types. As such, it provided a compelling framework for understanding the origins of injury problems while identifying the multiple countermeasures in place to address the problems. The Haddon model identified the most prevalent motor vehicle features that contributed to more severe injuries, predominant road environment features, and the most likely unsafe road behaviors contributing to crashes and injuries. The model also enabled to identify clusters of road injury factors within the matrix using survey research method. Such analysis of data on the contributing factors to, and circumstances of, crashes/injuries formed the basis of the prevailing strategic approach adopted for road safety management and injury prevention in the study area.

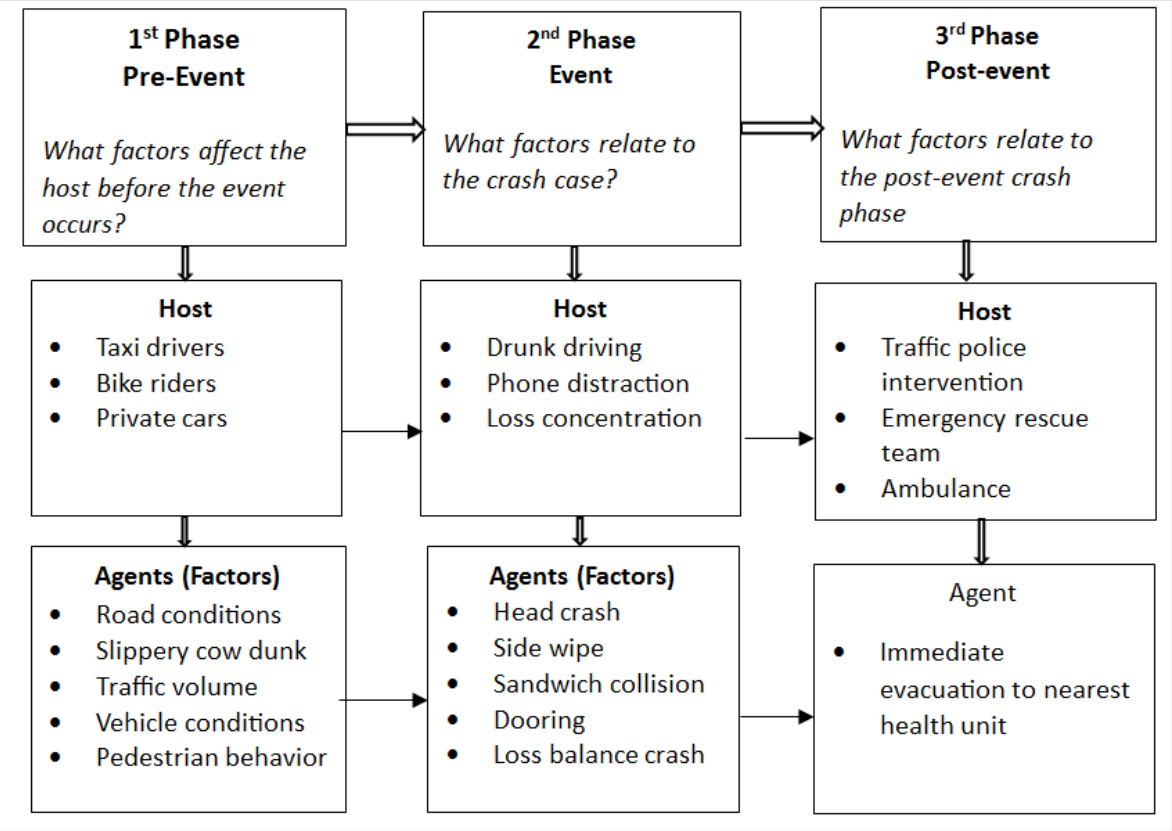


Figure 2. *Road injury phase framework design for this work.*

Altogether, 156 survey questionnaires guided the collection of firsthand information from road users in Bamenda (taxi drivers, bike riders, roadside vendors and commuters), patterning to community-based injury prevention initiatives identified, in-depth insights, attitudes, and behaviors related to road safety and injury prevention. A research authorization from the University of Bamenda, Department of Geography and Planning guided to collect valuable information from target stakeholders. Secondary data from the Road Safety Department at the Regional Delegation of Transport (RDT) in Bamenda enabled to evaluate the effectiveness of the current road safety measures and the potential for innovative strategies that could further reduce the road crashes and injuries in the city consonance to road safety target 2030.

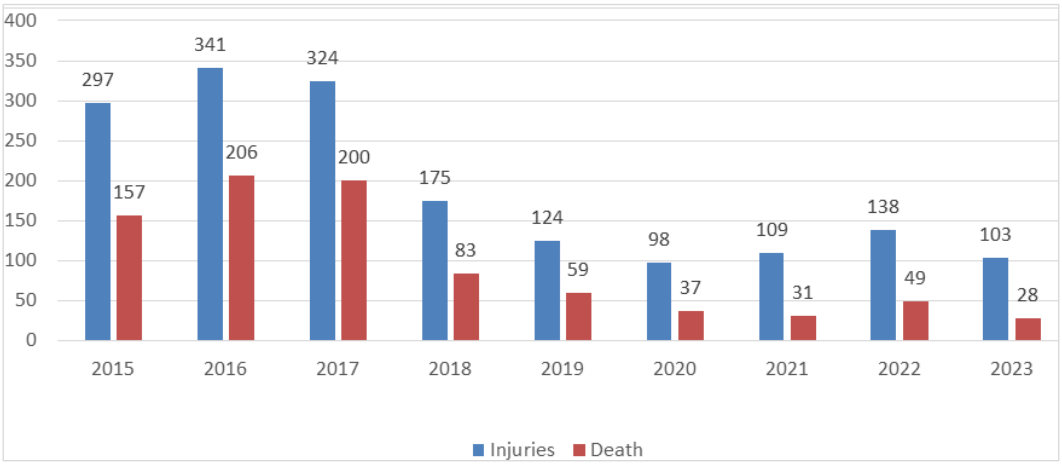
4. Results

4.1. Crash Injury Situation in Bamenda (2015-2023)

To evaluate crash injury situation in Bamenda, secondary data on road injury records from the RDT was collected, which scaled across nine (9) years period from 2015 to 2023. As shown in figure 3, crash injury situation in Bamenda from 2015 to 2023 reveals significant fluctuations in both injuries and fatalities, indicating a critical trend concerning road safety in the city. In particular, 2016 stands out as the peak year for injuries, with 341 cases reported, coinciding with the highest number of deaths at 206. Factors such as socio-political instability in the region, increased vehicular traffic, inadequate road infrastructure, insufficient enforcement of traffic regulations greatly contributed to spike up these cases. Following this peak, there was a general decline in both injuries and fatalities particularly from 2018 onward, indicating potential improvements in road safety measures especially the implementation of the injury prevention interventions, and public awareness campaigns. The year 2020 marks a notable low for both injuries and deaths, with only 98 injuries and 37 fatalities. This sharp decline was due to the COVID-19 pandemic, which led to reduced travel and transportation activities. The subsequent years (2021 to 2023) show a gradual recovery in the number of injuries but continued improvement in reducing fatalities, with deaths dropping to just 28 by 2023.

Overall, the data indicates a positive trend in fatalities reduction in Bamenda, even as the number of injuries fluctuates. The injury-to-death ratio has improved significantly over the years, indicating enhanced emergency medical services and public health responses. However, the increase in injuries calls for a renewed focus on comprehensive road safety strategies, including better road infrastructure, stricter enforcement of traffic laws, and community education on safe driving practices, to further

mitigate the risks associated with road traffic incidents.



Source: Regional Delegation of Transport, Road Safety Department, Bamenda

Figure 3. *Crash injury situation in Bamenda from 2015 to 2023.*

4.2. Pre-event Factors of Crash Injury Cases in Bamenda

As indicated on table 1, reckless driving is the leading pre-event factor, with a staggering 97.4% of participants identifying it as a key contributor to accidents in Bamenda. Additionally, factors such as bad roads 96.1%, and unsafe driving 92.3%, are also strong pre-event factors contributing to crash injuries. Given this high rates, addressing both driver behavior and infrastructure issues in order to reduce crash-related injuries is paramount. The presence of overloading 87.2% and drunkenness 89.7%, as substantial pre-event factors also raises serious concerns about compliance with existing traffic regulations. These rates suggest that not only are drivers engaging in risky behavior, but there is also a potential lack of enforcement regarding vehicle capacity and alcohol consumption while driving. Traffic congestion 76.9%, and the absence of traffic signals 87.8%, further compound the risks associated with road safety in Bamenda. These factors highlight the need for improved urban planning and traffic management strategies. Addressing congestion may involve optimizing road use and implementing traffic signal systems to regulate vehicle flow effectively. 77,5% of vendors occupy the main roads and streets in Bamenda, this presents a unique challenge, as it increases pedestrian risks and distracts drivers.

Table 1. *Pre-event factors of crash injury cases in Bamenda.*

Pre-event factors	Target responses	Percentage (%)
Over speeding	125	80,1
Over load	136	87,2
Reckless driving	152	97,4
Traffic congestion	120	76,9
Absence of traffic signals	137	87,8
Sleepy road	113	72,4
Unsafe driving	144	92,3
Vendors closeness to the road	121	77,5
Drunkenness	140	89,7
Bad roads	150	96,1
Wrong driving	118	75,6
Break failure	60	38,4

Source: Fieldwork, 2025

4.2.1. Traffic Crash/Injury Hosts and Factors Affecting Hosts in Bamenda

Three crash/injury hosts in the study area included taxis, motorbikes, and private vehicles and a good number of factors affect these hosts for crash/injury to occur. As indicated on Table 2, bad roads is a consistent factor affecting all hosts, with 100% frequency reported. The high rates of unsafe driving 96.2% for taxis and 88.4% for motorbikes suggest a prevalence of risky behaviors that aggravate the dangers associated with already poor road conditions. In addition, over-speeding emerges as a leading factor, particularly affecting taxis at 75% and motorbikes at 58.9%. This stem

from behavioral norm among drivers that prioritizes speed over safety. In contrast, private vehicles show a lower frequency of this behavior 40.4%, potentially indicating different driving patterns or a more cautious approach among private vehicle owners. The marked difference also reflect the pressures faced by taxi and motorbike drivers to meet passenger demands and time constraints. Additionally, reckless driving and traffic congestion are significant contributors to accidents with motorbikes experiencing the highest rates of reckless driving at 95.5% and taxis facing considerable traffic congestion at 55.1%. From the three hosts, the interplay between these factors indicates that motorbike drivers are more prone and engaged in dangerous driving practices to navigate congested conditions. The poor traffic management only necessitate this scenario, particularly in areas known for high congestion and accident rates. Finally, event factors such as head-on collisions 89.7% for taxis and rollovers 86.5% for taxis highlight the severity of the consequences resulting from these pre-event factors. The significant frequency of these incidents points to the critical need for enhanced driver education, particularly regarding the dangers of distracted driving 81.4% for taxis, and the role of alcohol in crash scenarios 56.4% for taxis. This situation need actionable policies from the city authorities in addressing both infrastructural shortcomings and driver behavior towards reducing traffic-related injuries and fatalities in the study area.

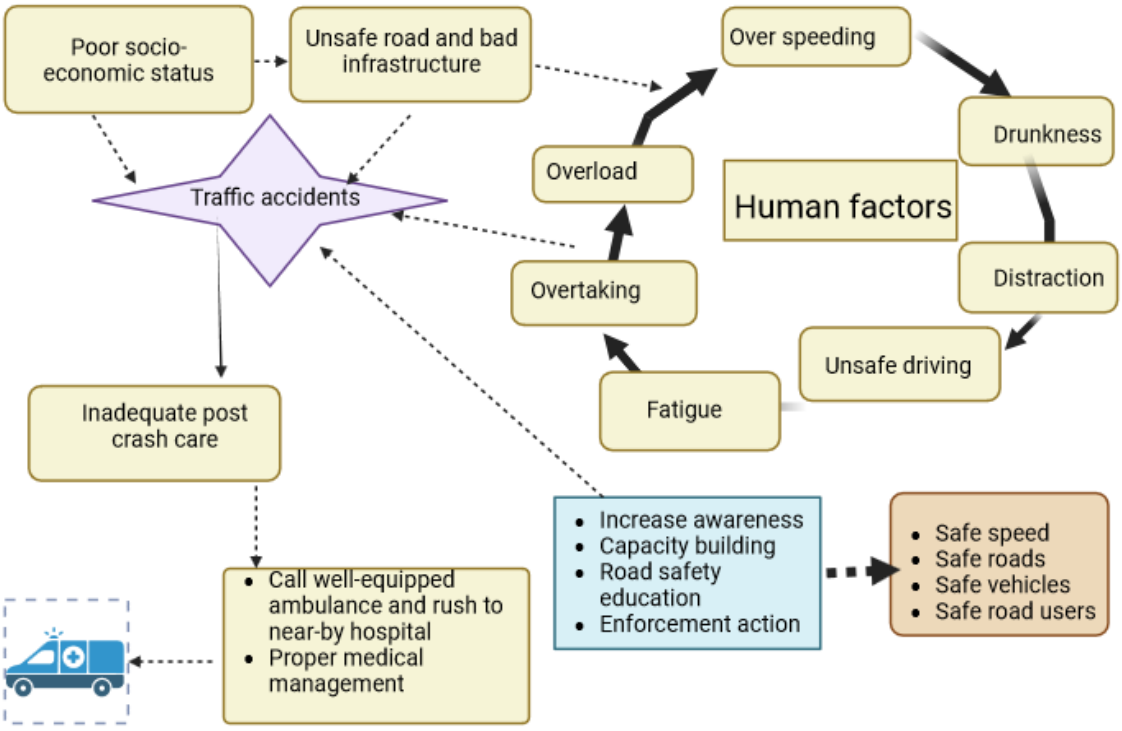
Table 2. *Traffic crash/injury hosts and factors affecting hosts in Bamenda.*

	Hosts					
Pre-event factors affecting host	**Taxi**		**Motor-bikes**		**Private vehicles**	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Over speeding	117	75,0	92	58,9	63	40,4
Over load	98	62,8	114	73,1	15	9,6
Reckless driving	102	65,4	149	95,5	39	25,0
Traffic congestion	86	55,1	142	91,0	99	63,4
Absence of traffic signals	79	50,6	109	69,8	125	80,1
Sleepy road	57	36,5	76	48,7	52	33,3
Unsafe driving	150	96,2	138	88,4	55	35,2
Vendors near road	58	37,2	65	41,6	46	29,5
Drunkenness	88	56,4	106	67,9	33	21,2
Bad roads	156	100,0	156	100,0	156	100,0
Wrong driving	83	53,2	147	94,2	64	41,0
Break failure	46	29,5	13	8,3	34	21,7
Pedestrian fault	62	39,7	57	36,5	73	46,7
Event factors affecting host	drunk driving		Phone distraction		Loss balance	
Head-on collision	140	89,7	127	81,4	42	26,9
Side-wipe	43	27,2	69	44,2	138	88,4
Sandwich collision	116	74,3	31	19,8	34	21,7
T-bone	120	76,9	84	53,8	93	59,6
Rear-end collision	51	32,6	23	14,7	125	80,1
Rollover	135	86,5	26	16,6	137	87,8

Source: Fieldwork, 2024

4.2.2. Traffic Accidental/ Injuries Framework for Bamenda City

Figure 4 provides a comprehensive overview of the critical elements contributing to traffic accidents and injuries in Bamenda and salient precautionary measures to put in place. At its core, it highlights the prevalence of human induce traffic incidences, illustrating how these accident incidences are not isolated events but rather the result of interrelated risk factors. In examining the risk factors presented, the risk factors cycle likely identifies key contributors such as reckless driving, poor road conditions, and driver distractions, such as mobile phone usage during driving. These elements are crucial for understanding the broader context of traffic safety; recognizing that these behaviors and environmental conditions significantly heighten the likelihood of accidents/injuries. By visually representing these factors, it emphasizes the importance of addressing both individual driver behavior and systemic infrastructure issues to create a safer road environment. The highlighted salient precautions, safety rules, and management strategies embodied the proactive measures necessary for reducing traffic injuries. These include among others educational campaigns on safe driving practices, the enforcement of traffic laws, and the implementation of community awareness initiatives. These initiatives serves as a roadmap for stakeholders such as government agencies, municipal councils in Bamenda city, and community organizations outlining the approaches to improving road safety. Finally, this framework acts as a call to action, emphasizing that through cooperation and awareness, significant strides can be made in reducing traffic-related injuries and fatalities in Bamenda.



Sources: Designed by biorender.com program, 2025

Figure 4. *Traffic accidental/ injuries framework.*

4.3. Strategies to Reduce Road Crash/Injuries in the City

In Bamenda city, the Road Traffic Police, the Bamenda City Council Delegate, and the Municipal Mayors and Councilors manage the road safety and road traffic systems. These stakeholders organized road safety initiatives and programs, provide road infrastructures, set standard rules and enforce them through road safety management policies. In matters of road traffic accidents and injury prevention, the Road Traffic Police control these aspects. Since 2015, many road safety initiatives are underway in the city in a bit to reduce road traffic injuries and fatalities to near half by 2030. The work of the Cameroon Association for the Defense of Victims of Accident (CADVA) through capacity-building workshops and the "Save Kids Lives" campaign have created road safety awareness not only focus on drivers but have also educated pedestrians and children about traffic safety. The CADVA empowers community members to advocate for

safer roads. The inclusion of educational materials, such as pamphlets on traffic signs and signals, makes vital information accessible, reinforcing the importance of community involvement in promoting road safety.

Table 3. Stakeholders involved in Road Safety Initiatives in Bamenda city.

Stakeholders	Road safety initiative	Target groups	Content deliver
Ministry of Transport and Transport Syndicates	Road Safety Education campaigns	Taxi drivers, bike riders, teachers, private vehicle owners	Understanding road safety measures and responsible conduct, statistics, challenges, and risk factors; Distribution of tracks to drivers on driving behaviors
Cameroon Association for the Defence of victims of Accident (CADVA)	Capacity-building workshops, Save Kids Lives Campaign	Taxi drivers, bike riders, private vehicle owners	Road safety awareness; Traffic rules and guideline; Road safety measures and best practices; pedestrians' safety; Traffic sign and signals; Traffic Laws and Regulations; road safety props
The Municipal Councils	Enforcement measures by the local Traffic Police Officers.	Taxi drivers, bike riders, private vehicle owners	Control of driving particulars, license, overload, status of car

Source: Fieldwork, 2025

4.3.1. Accidents/Injuries Prevention Intervention Measures in Bamenda

The effectiveness of road safety initiatives in Bamenda was determined at the outcome level, focusing on the impact of various intervention measures, as illustrated in Figure 5. Findings reveal that road safety education stands out as the most effective intervention, achieving an impressive success rate of 86.5%. This indicates that educational programs aimed at raising awareness about safe driving practices significantly contribute to reducing the occurrence of accidents and injuries. Additionally, capacity-building training sessions, primarily coordinated by the Ministry of Transport through its Department of Road Safety, demonstrated a notable success rate of 79.4%. These trainings equip participants including drivers and community members with essential knowledge and skills to combat road accidents effectively. Furthermore, sensitization programs organized by municipal council authorities have also yielded positive outcomes, with a success rate of 62.8%. These initiatives serve to engage the community in discussions about road safety, thereby fostering a collective responsibility for safer road behaviors.

Other interventions, such as community task force partnerships, achieved a positive impact rate of 55.1%, highlighting the importance of collaborative efforts between local organizations and residents in promoting road safety. Meanwhile, enforcement actions carried out by road safety police showed a success rate of 50.6%, emphasizing the vital role of law enforcement in ensuring compliance with traffic regulations.

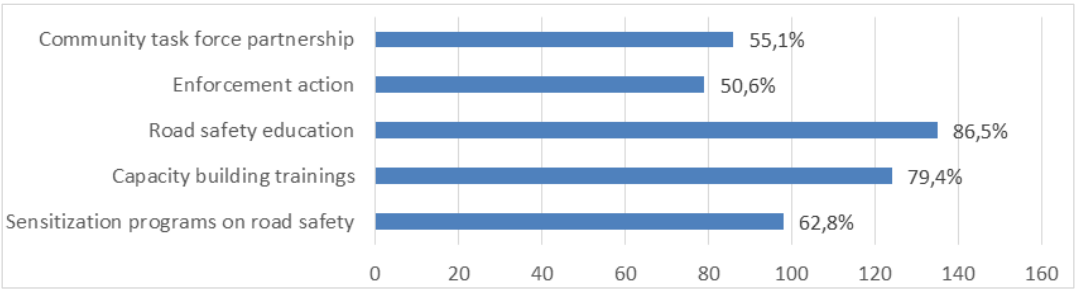
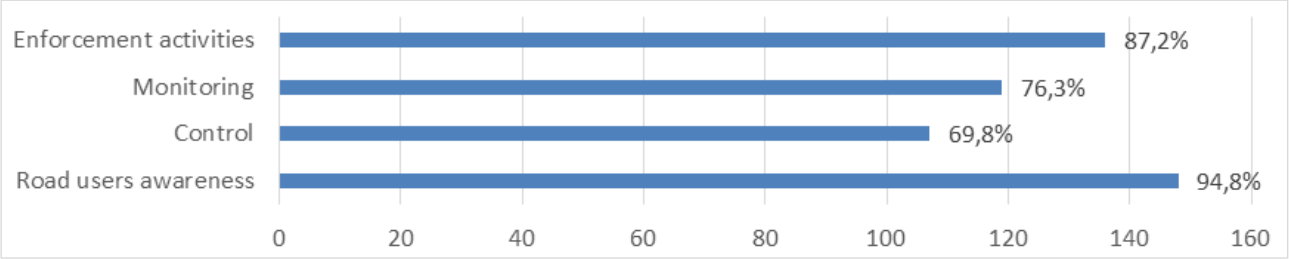


Figure 5. Accident/Injury Prevention intervention measures.

4.3.2. Perception of Accident/Injury Prevention by Road Users

The perception of accident/injury prevention measures among road users in Bamenda reveals a generally positive outlook, particularly among those who actively participate in related initiatives and programs. As depicted in Figure 6, an impressive 94.8% of road users express awareness of these

prevention strategies. This high level of awareness suggests that educational campaigns and community outreach efforts are effectively reaching their target audience, fostering a culture of safety and vigilance on the roads. In addition to awareness, the perception of enforcement activities is also noteworthy, with a participation rate of 87.2%. This indicates that road users recognize the importance of law enforcement in maintaining road safety. The acknowledgment of enforcement efforts suggests that when users perceive a strong police presence and active monitoring of traffic laws, they are more likely to adhere to safety regulations themselves. The levels of monitoring and control, reported at 76.3% and 69.8% respectively, shows the importance of consistent oversight in ensuring the effectiveness of safety measures. These figures indicate that road users value ongoing monitoring as a means of sustaining road safety initiatives. Implementing regular assessments and controls not only reinforces the legitimacy of the interventions but also encourages road users to remain engaged in safer practices.



Source: Fieldwork, 2025

Figure 6. *Perception of accident/injury prevention by road users in Bamenda.*

4.4. The Road Safety Management Matrix for Road Accident/Injury Factor

The Haddon Matrix, as illustrated in Table 4, categorizes road safety management into three distinct phases: pre-event, event, and post-event. In the pre-event phase, the primary objective is to prevent road traffic collisions. Stakeholders in Bamenda have implemented road safety programs such as education campaigns to foster safe driving behaviors among motorists. Additionally, stringent enforcement of traffic regulations has been crucial in mitigating risks associated with reckless driving. During the event phase, which encompasses the occurrence of a crash, the activation of emergency response units is critical. Hospitals in Bamenda have established protocols and emergency units to address injuries resulting from road traffic incidents. Regular vehicle inspections at key locations such as Mile 5 and Up-Station, ensures that vehicles adhere to safety standards. Moreover, expert teams from the municipal councils are actively engaged in on-the-ground initiatives that promote the consistent use of seatbelts and helmets among drivers and motorcyclists, reinforcing the importance of personal protective measures during transit. In the post-event phase, there is a significant focus on sustaining lives and improving outcomes for crash victims. The Municipal Councils and Trade unions have taken the initiative to organize workshops on road safety, which serve as platforms for education and awareness. Concurrently, the collection of data on the immediate causes of road traffic injuries forms a critical component of this phase. This data is essential for informing future prevention strategies and enhancing the overall efficacy of road safety interventions.

Table 4. *Road safety management matrix for identifying road accident/injury factors.*

Basic road safety elements		Road users (hosts)	Environment	vehicle
Pre-crash	Crash prevention	Education training, license, impairment, behavior	Road design signs, markings maintenance	Roadworthiness, system (lights, brakes,)
Crash	Accident/Injury prevention	Use of restraints (seatbelts) impairment	Protection (barrier) pedestrians crossing	Restraints crashworthiness, maintenance
Post-crash	Life sustaining	First aid skill, access to medics	Rescue facilities, congestion	Ease of access, fire risk
Pre-crash	Crash prevention	Education, training,	Road design, signs, markings,	Roadworthiness, system

Basic road safety elements	Road users (hosts)	Environment	vehicle
	impairment, behavior	maintenance	(lights, brakes,)

Source: Author's conception, 2025

The Road Safety Management Matrix also categorizes basic road safety elements into three components: road users, the environment, and vehicles. In the pre-crash segment, there is implementation of efforts directed toward crash prevention through education, training, and behavior modification of road users. The environment made used of optimal road design, appropriate signage, and rigorous maintenance. To maintain vehicle safety, stakeholders frequently undertake regular assessments of roadworthiness including the functionality of critical systems such as lights and brakes. During crashes, road users are emphasis to use restraints like seatbelts, protective measures for pedestrians, and vehicle crashworthiness. Finally, in the post-crash phase, life-sustaining efforts hinge on first aid training, access to medical services, efficient rescue operations, and addressing potential hazards like congestion and fire risks. This structured approach provides a comprehensive overview of the intricate factors influencing road safety.

4.4.1. Implications of the Haddon Matrix to Stakeholders

While this study provides important insights into accidents/injuries interventions to the scientific community, it also provides contribution to city authorities and road users in Bamenda and Cameroon as a whole. The first primary concern is that the imitative is life saving and prevent injuries among individuals who are most at risk of road traffic accidents. By raising awareness about the importance of road safety, promoting safe behaviors, and improving infrastructure and enforcement measures, the above interventions has help reduce the incidence of crashes and their associated human and economic costs.

This work is very helpful to local residents of Bamenda to take ownership of road safety initiatives in their own neighborhoods. By involving community members in the planning and implementation of interventions, a sense of ownership and responsibility for the success of these programs is inevitable. The study can help build partnerships and collaborations between different stakeholders involved in road safety efforts in Bamenda. Government agencies, community organizations, and non-governmental organizations, the coming together of these agencies can help foster coordinated and comprehensive approach to addressing road safety challenges. Resources can be used efficiently, efforts synergistic, and these makes the interventions to be more sustainable in the long term.

4.4.2. Implication for Policy

The results of this paper have proven that community-based road safety interventions are effective in reducing road traffic injuries among road users. Policymakers may consider allocating more resources and funding towards community-based programs that focus on improving road safety and reducing accidents. The study suggests that road safety education and awareness campaigns were very effective in changing the behavior of road users and reducing injuries in Bamenda. Policymakers may consider investing in public education campaigns that promote road safety and responsible behavior among road users.

Community task force partnership with local stakeholders also highlighted significant importance of working with local stakeholders, such as community leaders and organizations, in designing and implementing injury prevention interventions. Policymakers can use this information to encourage collaboration and partnerships with local entities to address road safety issues in Bamenda.

Policymakers can use information from this work to establish monitoring and evaluation mechanisms to track the impact of their interventions and make necessary adjustments to improve outcomes. Finding from the study indicates that road user groups, such as pedestrians, taxi drivers, and bike riders need serious intervention. Policymakers can use this information to design targeted interventions that address the unique needs and challenges of each of these groups.

5. Discussion of Findings

The alarming statistics surrounding road traffic accidents emphasize the urgent need for effective interventions, especially in low- and middle-income countries (LMICs). The WHO's estimate of 1.19 million deaths due to road accidents annually (WHO, 2023), this highlights a global public health crisis, particularly acute in regions like sub-Saharan Africa where underreporting skews the actual figures (Bhalla et al., 2011). In Bamenda, the trends from 2015 to 2023 echo this narrative. The peak in injuries and fatalities in 2016 coincided with socio-political instability and inadequate infrastructure, aligning with findings by Assailly (2017) that attribute a significant portion of accidents to human behavioral factors. The subsequent decline in fatalities, especially during the pandemic, underscores the potential impact of reduced traffic and public safety interventions as suggested by Dragutinovic & Twisk (2006). Reckless driving emerged as the predominant cause of crashes, with 97.4% of respondents

identifying it as a critical factor. This finding resonates with literature attributing the majority of road traffic incidents to human error, reiterating the arguments of Choudhary et al. (2020) regarding distracted driving. Additionally, environmental factors such as poor road conditions and infrastructure, which Nelson et al. (2018) emphasize, significantly contribute to the unsafe driving environment in Bamenda. The study's identification of specific crash hosts taxis, motorbikes, and private vehicles reveals a nuanced understanding of how different types of vehicles face distinct challenges. The high incidence of unsafe driving among taxis (96.2%) and motorbikes (88.4%) suggests a culture of risk-taking, likely driven by economic pressures and market demands as indicated by El-Gabri et al., (2020) on risky road user behavior as a pervasive issue in Africa. The marked contrast in over-speeding behavior between taxis and private vehicles, with taxis at 75% and private vehicles at 40.4%, highlights the need for targeted interventions that prioritize the safety of public transport drivers and passengers, as suggested by Katopola et al. (2022). Addressing these issues requires a comprehensive approach that includes community engagement, improved infrastructure, and stricter enforcement of traffic regulations to foster a safer driving environment in Bamenda and similar contexts.

6. Recommendations

To address the traffic injury crisis in Bamenda, following recommendations framed within the Haddon Matrix model to ensure a comprehensive approach to prevention can guide stakeholders in the city:

Firstly, intensification of driver education and awareness programs is crucial, though there are already initiatives in this domain, frequent training sessions for drivers, particularly those operating taxis and motorbikes, can promote a sustainable safer driving behaviors. These programs should address the dangers of reckless driving, the importance of adhering to speed limits, and the risks associated with alcohol consumption. Community workshops that involve local stakeholders can further reinforce safe driving practices and create a culture of accountability among road users.

Secondly, improving road infrastructure is essential to reduce the risk of accidents. In Bamenda, the state of the urban roads are in a deplorable condition and requires total repair, installation of traffic signals, and creating designated pedestrian zones to separate foot traffic from vehicle routes. Infrastructure improvements should also focus on enhancing visibility and signage, particularly in high-traffic areas and near schools. Addressing these environmental factors, can drastically reduce road accidents in Bamenda city.

Thirdly, strengthening law enforcement is vital for ensuring compliance with traffic regulations. Increasing police presence at certain roads axis, particularly during peak hours, can deter reckless behaviors such as speeding and driving under the influence. Implementing stricter penalties for traffic violations, coupled with regular checkpoints to check for compliance with safety regulations, can help instill a greater sense of responsibility among drivers.

Engaging the community in traffic safety initiatives is vital as this can bring a sustainable change. Establishing partnerships with local organizations, schools, and community groups can enhance the effectiveness of road safety campaigns. Encouraging community members to participate in monitoring road safety conditions and report infractions can empower individuals and foster a sense of collective responsibility for road safety.

Lastly, promoting public transportation alternatives can alleviate road congestion and reduce the number of vehicles on the road. By investing in reliable and safe public transport systems, there is subsequent reduction in the use of private vehicles, particularly among economically disadvantaged groups, can be minimized. This shift not only improves overall traffic flow but also decreases the potential for accidents, creating a safer environment for all road users in Bamenda.

7. Conclusion

The application of the Haddon Matrix model for traffic injury prevention in Bamenda underlines the complex interplay of human behavior, environmental factors, and policy implications in addressing road safety challenges in Cameroon. The findings reveal that reckless driving, unsafe behaviors, and inadequate infrastructure significantly contribute to the high incidence of traffic accidents in the city. By categorizing these factors into the Haddon Matrix framework, encompassing pre-event, event, and post-event phases, stakeholders can identify specific intervention points that target the root causes of injuries. This structured approach facilitates a comprehensive understanding of the factors at play and allows for tailored strategies that enhance both driver behavior and road safety infrastructure. Furthermore, the insights gleaned from Bamenda emphasize the necessity for a collaborative effort involving government authorities, community organizations, and local residents to implement effective road safety measures. Recognizing that many of the identified risk factors stem from economic pressures and insufficient enforcement of traffic laws, interventions must prioritize community engagement and education, alongside infrastructural improvements. By leveraging the Haddon Matrix, stakeholders can develop targeted initiatives such as awareness campaigns, stricter enforcement of regulations, and enhancements to road conditions that address the unique challenges faced in Bamenda. This holistic approach not only aims to reduce traffic injuries but also fosters a culture of safety and responsibility among all road users, ultimately paving the way for safer urban mobility in Cameroon’s cities.

Abbreviations

BCC	Bamenda City Council
CADVA	Cameroon Association for the Defense of Victims of Accident
DRS	Department of Road Safety
LMICs	Low- and Middle Income Countries
NIS	National Institute of Statistics
RDT	Regional Delegation of Transport
RTI	Road Traffic Injuries

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Assailly, J. P. (2017). Road safety education: What works? Patient Education and Counseling, 100, S24–S29. https://doi.org/10.1016/j.pec.2015.10.017

[2] Bhalla, K., Shahraz, S., Abraham, J., Bartels, D., and Yeh, P. H., (2011). Road injuries in 18 countries, Department of Global Heath and Population, Harvard School of Public Health, Boston, MA, USA. Available from: https://roadinjuries.globalburdenofinjuries.org

[3] Björnberg, K. E., Belin, M. A, Hansson, S. O. & Tingvall, C. (Eds; 2022). The Vision Zero Handbook. Theory, Technology and Management for a Zero Casualty Policy. Sweden.

[4] Chee, P., Irwin, J., Bennett, J. M., & Carrigan, A. J. (2021). The mere presence of a mobile phone: Does it influence driving performance? Accident Analysis & Prevention, 159, 106226. https://doi.org/10.1016/j.aap.2021.106226

[5] Choudhary, P., Pawar, N. M., Velaga, N. R., & Pawar, D. S. (2020). Overall performance impairment and crash risk due to distracted driving: A comprehensive analysis using structural equation modelling. Transportation Research Part F: Traffic Psychology and Behaviour, 74, 120–138. https://doi.org/10.1016/j.trf.2020.08.018

[6] Christoffel T. and Gallagher S. S., (2006). Injury prevention and public health: practical knowledge, skills, and strategies: Jones & Bartlett Learning. [Google Scholar].

[7] Dotse J., Nicolson R., and Rowe R., (2019). Behavioral influences on driver crash risks in Ghana: a qualitative study of commercial passenger drivers. Traffic injury prevention, 2019. 20(2): p. 134–139. https://doi.org/10.1080/15389588.2018.1556792

[8] Dragutinovic, N., & Twisk, D. (2006). The effectiveness of road safety education: A literature review. SWOV Institute for Road Safety Research.

[9] El-Gabri D, Barcenas LK, Meier B, Mvungi M, Haglund M, Gerardo CJ, et al. (2020) Injury patients' perceptions of drink-driving: A qualitative assessment of drink-driving behavior in Moshi, Tanzania. PLoS ONE 15(5): e0230662. https://doi.org/10.1371/journal.pone.0230662

[10] Fosdick, T., Campsall, D., Kamran, M., & Scott, S. (2024). Creating a Cultural Maturity Model to Assess Safe System Readiness Within Road Safety Organizations. Journal of Road Safety, 35(1), 52–64, https://doi.org/10.33492/JRS-D-24-1-2125507

[11] Haldane V, Chuah FLH, Srivastava A, Singh SR, Koh GCH, Seng CK, et al. (2019). Community participation in health services development, implementation, and evaluation: A systematic review of empowerment, health, community, and process outcomes. PLoS ONE 14(5): e0216112. https://doi.org/10.1371/journal.pone.0216112

[12] Howat, P., Cross, D., Hall, M., Stevenson, M., Gibbs, S., Officer, J., Dillon, J., (2001). Community Participation in Road Safety: Barriers and Enablers. Journal of Community Health 26, 257–270. https://doi.org/10.1023/A:1010304511244

[13] Katopola D., Mashili F., and Hasselberg M., (2022). Pedestrians' Perception of Pedestrian Bridges—A Qualitative Study in Dar es Salaam. International journal of environmental research and public health, 19(3): p. 1238. https://doi.org/10.3390/ijerph19031238

[14] Mabunda MM, Swart L-A, Seedat M. (2008). Magnitude and categories of pedestrian fatalities in South Africa. Accid Anal Prev. 40(2): 586–593. https://doi.org/10.1016/j.aap.2007.08.019

[15] Mads, S., Chifundo, K., Gift, M., Stig, T. B., Carlos, V., Sven, Y., Asbjørg S. C., & Hallvard, G., (2020). Prevalence of alcohol use among road traffic crash victims presenting to a Malawian Central Hospital: A cross-sectional study, Traffic Injury Prevention, 21: 8, 527-532, https://doi.org/10.1080/15389588.2020.1819990

[16] Mooren, L., & Shuey, R. (2024). Systems Thinking in Road Safety Management. Journal of Road Safety, 35(2), 63–73. https://doi.org/10.33492/JRS-D-24-2-2109985

[17] Morgan L. M., (2001). Community participation in health: perpetual allure, persistent challenge. Health policy and planning, Vol. 16(3): p. 221–230. https://doi.org/10.1093/heapol/16.3.221

[18] Nelson E.-U. E., Okokon O. U., Nsidibe F. E., & Aniekan S. B., (2018). Commercial tricycle riders' perceptions of psychoactive drug use and the risk of road traffic accidents in Uyo, Nigeria. African journal of drug and alcohol studies, 2018. 17(2): p. 105–118.

[19] Nicol A, Knowlton LM, Schuurman N, Matzopoulos R, Zargaran E, Cinnamon J, Fawcett V, Taulu T, Hameed SM. (2014). Trauma surveillance in Cape Town, South Africa: An analysis of 9236 consecutive trauma center admissions. JAMA Surg. 149(6): 549–556. https://doi.org/10.1001/jamasurg.2013.5267

[20] Raynor N. J. and Mirzoev T., (2014). Understanding road safety in Kenya: views of matatu drivers. International health, Vol. 6(3): p. 242–248. https://doi.org/10.1093/inthealth/ihu034

[21] Staton C, Vissoci J, Gong E, Toomey N, Wafula R, Abdelgadir J, et al. (2016) Road Traffic Injury Prevention Initiatives: A Systematic Review and Metasummary of Effectiveness in Low and Middle Income Countries. PLoS ONE 11(1): e0144971. https://doi.org/10.1371/journal.pone.0144971

[22] Stewart K, Silcock D, Wegman F. 2012. Reducing drink driving in low and middle-income countries: Challenges and opportunities. Traffic Inj Prev. 13(2): 93–95. https://doi.org/10.1080/15389588.2011.634

[23] Teye-Kwadjo E., (2017). Risk factors for road transport–related injury among pedestrians in rural Ghana: implications for road safety education. Health Education Journal, 2017. 76(7): p. 880–890.

[24] Turner, B., (2013). Implementing The Safe System Approach to Road Safety: Some Examples Of Infrastructure Related Approaches. 16th Road Safety on Four Continents Conference Beijing, China, Australian Road Research Board (ARRB), pp 1-12, file:///C:/Users/user/Desktop/AUSTRALIA%20SUBMIT/Road%20Safety/

[25] Vissers L, Houwing S, Wegman F. (2017). Alcohol-related road casualties in official crash statistics. Paris, France: OECD International transport Forum. https://www.itf-oecd.org/sites/default/files/docs/alcohol-

[26] WHO (2004). World Report on Road Traffic Injury Prevention. WHO, Geneva.

[27] WHO, (2018). Global status report on road safety. Geneva, Switzerland: World Health Organization. https://www.who.int/violence_injury_prevention/road_safety_status/2018/n/

[28] WHO, (2019). Decade of Action for Road Safety 2021-2030. https://www.who.int/teams/social-determinants-of-health/safety-and-mobility/decade-of-action-for-road-safety-2021-2030

[29] WHO, (2021). Road traffic injuries fact sheet. https://www.who.int/en/news-room/fact-sheets/detail/road-traffic-injuries

[30] WHO, (2023). Global status report on road safety. *Safety and Mobility (SAM), Social Determinants of Health (SDH), pp, 1-81, https://www.who.int/publications/i/item/9789240086517*