Original Research

Adult pedestrian and cyclist injuries in Lilongwe, Malawi: a cross-sectional study

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Abstract

Background

Pedestrian and cyclist injuries are a major concern globally, but especially in low-income countries. Locally conducted research is needed to measure the size of the problem and advise policy on road safety interventions. We wanted to investigate the precise circumstances of these injuries in Lilongwe, Malawi and to identify risk factors for severe injuries.

Methods

Cross-sectional study of all adult pedestrian and cyclist injuries presenting to a large central hospital. This was a sub-study of a larger study with all types of road users included. All patients provided detailed information about the incidents leading to injury and were tested for alcohol.

Results

There were 222 pedestrians, 183 bicycle riders and 42 bicycle passengers among the 1259 adult road traffic injury victims that were treated at Kamuzu Central Hospital during a 90-day period in 2019. Of these injuries, 60.2% occurred while the victim was walking/cycling along the road and 22.3% when the victim was trying to cross the road. The majority of the victims were men (89.1%). Helmet use for bicyclists was almost non-existent. Only 1 patient had used reflective devices when injured in the dark, despite 44.7% of these injuries occurring in reduced light conditions. There was an increased risk for serious and fatal injuries for pedestrians compared with bicyclists, and also compared with all types of road users. Patients injured in rural areas and those hit by lorries were more severely injured. Consuming alcohol before being injured was associated with more severe injuries in bicyclists. Being injured while crossing the road at painted zebra crossings was associated with an increased risk of serious and potentially fatal injuries.

Conclusion

This study identified important risk factors for severe injuries in pedestrians and cyclists. Implications for preventive measures are presented in a Haddon Matrix.

Key Words; Injuries, road traffic collisions, pedestrians, bicycling, Malawi, risk factors

Introduction

Road traffic injuries (RTIs) constitute a growing but neglected global health crisis. Every year, about 1.35 million people lose their lives on the roads and another 20–50 million people sustain non-fatal injuries due to road traffic crashes. Africa has the highest RTI death rate of all WHO regions (26.6 per 100,000 population)[1]. Pedestrians and cyclists represent 26% of all road traffic related deaths globally. In Africa these two groups are estimated by the WHO to make up 44% of the deaths, and in Malawi 66%[1].These road users are particularly vulnerable due to exposure to traffic with no protective equipment, compared with the car and truck drivers with whom they share the road, and are often referred to as "vulnerable road users" together with motorcyclists.

Pedestrian and cyclist injuries in a low-income setting have been studied most extensively in Ghana, where they found that 70% of pedestrian deaths happened when the victims were trying to cross the road[2] and that 98% of pedestrian injuries happened away from pedestrian crossings[3]. Pedestrian crossings were rare and not easily accessible, and observation of pedestrians at crossings showed risky behavior. In one study, pedestrians had an adjusted odds ratio (AOR) of a fatal injury of 7.4 compared to a driver/rider of a motorized vehicle, while an injury on a bicycle had an AOR of 3.6[4].

Malawi has one of the world's highest rates of traffic-related fatalities with an estimated rate of road traffic deaths of 31 per 100000 inhabitants annually[1]. In a hospital-based study in Lilongwe, Malawi, it was reported that pedestrians sustained 32% of the injuries and 49% of the deaths, while cyclists had 28% of the injuries and 17% of the deaths[5]. Schlottman and co-workers studied Malawian police records of road traffic injuries from 2008 to 2012, and found that pedestrians had the highest on-scene mortality of all road users, at 42%, while cyclists had a 37% on-scene mortality[6]. Injuries occurring at night, and in rural areas were more likely to be fatal.

There is an urgent need for efforts to prevent these injuries. Measures that are effective in one country are not necessarily the best solution in another country, where vehicle fleet composition, road user demography, road user behaviour,

https://dx.doi.org/10.4314/mmj.v32i4.4

road design and built environment characteristics are different. To implement effective preventive measures in the Malawian context, it is therefore necessary to have a clear picture of the injuries happening to Malawian cyclists and pedestrians, for these efforts to be effective. This study therefore aimed to provide knowledge of the circumstances around injuries sustained by pedestrians and bicycle riders and passengers, and to identify risk factors for contracting more severe injuries.

Methods

This was a cross sectional study of injured pedestrians and bicycle riders and passengers 18 years and older that presented to the casualty department at Kamuzu Central Hospital (KCH) during 3 months, from 25 May 2019 to 22 August 2019. KCH is located in the Malawian capital, Lilongwe. It is the referral hospital for the Central Region of Malawi and has approximately 900 beds. This study is a sub-study of a larger cross-sectional study where all types of road users with road traffic injuries over 18 were included[7]. Only patients with a possible need for in-hospital treatment are normally evaluated in the casualty department, and injuries that are obviously minor are treated in the outpatient department. Many patients attended to in the casualty department are not admitted but sent home after evaluation and treatment.

All patients provided written consent, either in the casualty department (i.e. emergency room), if they could cooperate, or at a later stage. Data were collected at presentation, often with information from accompanying persons. If consent was not obtained at a later stage, the information was deleted. Exclusion criteria were persons under 18 years old, patients brought in dead, patients with injuries from other causes, or patients who opted out (lack of consent).

Data collection was done by two medical doctors fully employed by the project, working shifts to cover the whole week at all hours. They were not involved in the treatment of the patients. An electronic tablet with FileMaker Pro software (Apple Inc, Cupertina, CA, USA) was used for data collection and storage. The geographical position of the injury site was registered using Google maps software on the electronic tablet. The severity of the injuries was evaluated by the recording doctors at admission and classified into five different groups corresponding to their expected outcome: expected full recovery, expected minor long-term disability, expected moderate disability, expected major disability or likely fatal injury. This is an internally developed classification system, with more detailed descriptions attached to optimize inter- and intra-observer reliability. All information about the mechanism leading to injury, the surrounding circumstances and physical environment were given by the patients or accompanying persons, and no investigations were done to verify this information.

Alcohol testing was done on all patients. Cooperative patients were tested by a breathalyser (Dräger Alcotest 5820, Drägerwerk AG & Co., Lübeck, Germany), and patients who were unable to use a breathalyser were tested with a saliva test (QED A150, Orasure Technologies, Inc., Bethlehem, PA, USA). The overall results of the alcohol testing have been described in a different article[7].

Analysis

Injuries where the prognosis was expected to be a moderate disability, major disability or likely fatal injury, were classified as serious injuries. Patients expected to fully recover or have a minor disability were classified as a mild injury. Patients were classified as alcohol positive if they either tested positive for alcohol when arriving at KCH or admitted use just before the injury. Patients were classified as having a traumatic brain injury (TBI) if a neurological injury was recorded and the Glasgow Coma Scale (GCS) was 13 or less. Bicycle riders and passengers were both classified as "bicyclists" and analysed together.

A logistic regression analysis was done to identify risk factors for a serious injury. Both an unadjusted and adjusted analysis was done, the latter correcting for sex, age, alcohol status, referral status and road user type. Imputation of the mean value for age was done for eight patients in one analysis. Prevalence ratios were used to compare risks for serious injury with the other road user types in the larger study with 1259 road traffic injuries. Differences in proportions were analysed by Pearson's chi-square test. A significance level of 5% (generated P-value less than 0.05) was used together with the 95% confidence intervals (CIs) for the interpretation of the results.

Data analysis was done using STATA (Version 15, STATA Corp., College Station, TX, USA). The manuscript was prepared adhering to the principles of the STROBE-statement[8].

Ethical issues

The study was approved by the Malawian National Health Sciences Research Committee (approval 1962/2018). The Data Protection Officers of Diakonhjemmet Hospital and the Norwegian Institute of Public Health approved of the data handling, according to EU regulations. We consulted The Norwegian Regional Health Research Committee, who concluded that a formal application to them was not necessary according to the Norwegian Health Research Act.

Results

Overview

During the 3-month inclusion period, 1347 road traffic injury patients of all road user types fulfilled the inclusion criteria, but in 88 patients (6.5%) consent was not obtained. This left 1259 patients included, and of these there were 222 pedestrians, 183 bicycle riders and 42 bicycle passengers.

For these pedestrians and bicyclists there were missing data on alcohol status for 6 patients, age for 9 patients and sex for 8 patients. Speed limit at the injury location was unknown in 53 cases and missing in 19 cases. Three patients had missing information about injury severity. Activity when injured was missing in 20 cases.

Table 1 shows baseline characteristics of the patients included in the study, stratified by road user type. There were 391 men (89.1%) and 48 (10.9%) women. Of the injuries, 60.2% occurred while the victim was walking or cycling along the road, and 22.3% while trying to cross the road. In the two groups combined, 29.9% had used alcohol before the injury. Table 2 shows further characterizations of the injuries stratified by road user type, showing among other things that alcohol use before the injury was more frequent in pedestrians (P= 0.000). Use of helmets and reflective devices was almost non-existent.

Table 1. Baseline characteristics of the patients

	Pedestrians (%)	Bicyclists (%)
Number of patients	222	225
Age groups		
18–24	51 (22.8)	54 (25.2)
25–34	76 (33.9)	76 (35.5)
35–44	46 (20.5)	48 (22.4)
45–54	29 (13.0)	20 (9.4)
55–64	13 (5.8)	9 (4.2)
65+	9 (4.0)	7 (3.3)
% Males	85.8	92.3
Education		
No formal education	13 (6.1)	10 (4.5)
Primary education	99 (46.3)	123 (54.9)
Secondary education	76 (35.2)	77 (34.4)
College/university	26 (12.2)	14 (6.3)
Purpose of travel		
Business trip	16 (7.2)	50 (22.2)
To/from work	53 (23.9)	103 (47.8)
To/from school	4 (1.8)	3 (1.3)
To/from market/ town for errands	105 (47.3)	59 (26.2)
Other/missing	44 (19.8)	10 (4.4)

Eleven (2.5%) patients were brought to the hospital by ambulance, and 4 (0.9%) by the police. There were 155 (34.8%) patients who were transported with the vehicles involved in the accident, and 121 (27.1%) of the patients were transported by bystanders.

Figure 1 shows the time of injury, showing a markedly increased incidence in the morning rush hour, but especially in the evening hours from 16.00 to 20.00.

Predictors of injury severity

Tables 3 and 4 show different risk factors associated with serious injuries. Pedestrians had a higher risk of serious injuries compared with bicyclists; the same was found when comparing with the all other road user types that had data for both severity and vehicle type. In 220 pedestrians there were 46 serious injuries, while 1015 non-pedestrians had 78 serious injuries, giving a prevalence ratio of 2.72 (95% CI 1.95–3.78). When only considering likely fatal injuries, this prevalence ratio was even more increased, at 5.19 (95% CI 2.69–10.02).

The bicyclists did not have a significantly different risk of sustaining a serious or likely fatal injury when compared with the other road users. Patients injured in rural areas and those hit by lorries and unknown vehicles had a higher proportion of serious injuries. In bicyclists, alcohol use was associated with more serious injuries, with an AOR of 3.93 (95% CI 1.28–12.06), but this association was not present in pedestrians, where the AOR for a serious injury was 1.03 (95% CI 0.48–2.24).

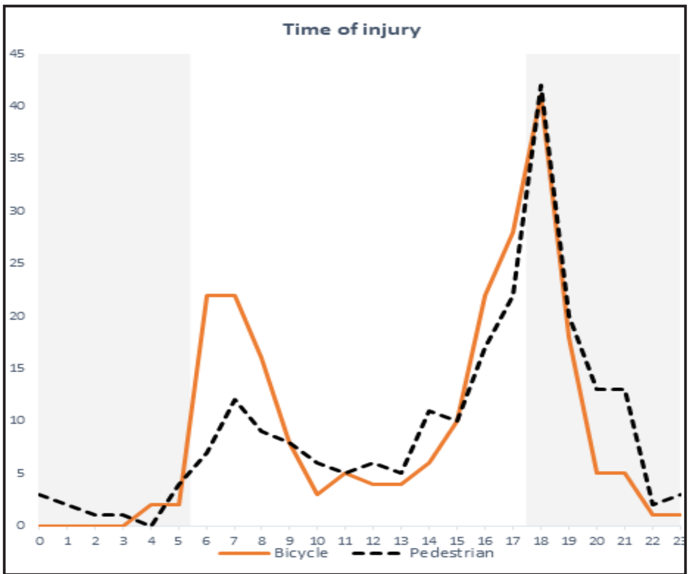

Figure 1. Time of injury, separate lines for bicyclist and pedestrians. Grey background depicts hours of reduced light conditions or darkness

Table 2. Further characteristics, risk factors and outcomes

	Pedestrians (%)	Bicyclists (%)
Activity when injured		
Crossing the road	64 (30.2)	31 (14.4)
Standing or moving in the vicinity of the road	25 (11.8)	8 (3.7)
Walking/cycling on the shoulder or edge of the road	92 (43.8)	165 (76.7)
Other	31 (14.6)	11 (5.1)
Alcohol use before injury[a]	92 (42.6)	40 (17.8)
Self-reported cannabis use	4 (1.8)	3 (1.4)
Use of reflective device at night	0	1 (2.1)
Helmet use	-	2 (0.9)
Severity		
Likely to fully recover	151 (68.6)	177 (79.0)
Minor deformities or disability	23 (10.4)	28 (12.5)
Moderate deformity or disability	20 (9.09)	13 (5.8)
Major disability	8 (3.6)	3 (1.3)
Fatal injury expected	18 (8.2)	3 (1.3)
Glasgow coma scale		
14–15	188 (85.1)	215 (96.0)
8–13	11 (5.0)	2 (0.9)
3–8	22 (9.9)	7 (3.1)

https://dx.doi.org/10.4314/mmj.v32i4.4

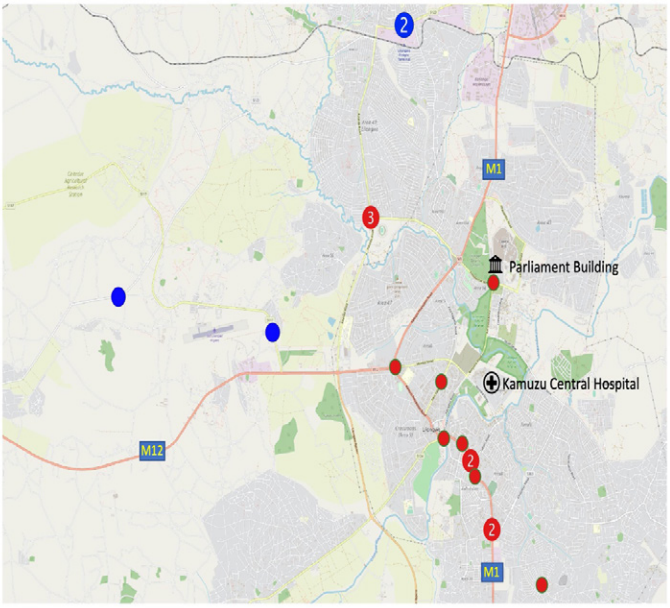

Figure 2. Map of Lilongwe city showing sites where injuries were reported to have happened at zebra crossings. Injuries considered to have a likely fatal outcome on admittance are shown in blue.

Modalities of crossing the road

There were 95 injuries that resulted from patients trying to cross the road, 22.3% of the injuries where the activity when injured was registered. As presented in Table 3, this was associated with an increased risk of a serious injury compared with other activities at the time of injury, though not statistically significant in the AOR analysis. We also found differences in risk associated with the different modes of crossing the road: crossing on a painted zebra crossing (21 patients, 8 serious injuries, 4 likely fatal) had a crude OR of 2.84 (0.98–8.24, not significant) for a serious injury, compared with the 70 patients who were crossing the road without a zebra crossing (13 serious injuries, 3 likely fatal) and 3 patients who were crossing on an elevated zebra crossing (no serious injuries). When adjusting for age, sex, patient type and alcohol status, the OR for serious injury was 3.9 (1.15–13.12). The risk of a likely fatal injury when crossing on a painted pedestrian crossing was even higher, with a crude odds ratio of 5.49 (1.12-26.87). Because of the small numbers, an adjusted analysis could not be performed. Figure 2 shows the geographical locations of the injuries that happened at zebra crossings in Lilongwe city.

Table 3. Risk factor analysis for serious injuries.

	N (%)[a]	Mild injury (%)	Serious injury (%)	OR (95% CI)	AOR(95% CI)[b]
Sex					
Female	48 (10.9)	43 (89.6)	5 (10.4)	1	1
Male	391 (89.1)	329 (84.8)	59 (15.2)	1.54 (0.58–4.05)	1.42 (0.50–4.04)
Age				1.02 (1.00–1.04)*	1.03(1.00–1.05)*
Referral status					
Directly to KCH	367 (82.1)	323 (88.5)	42 (11.5)	1	1
Referral patients	80 (17.9)	56 (70.9)	23 (29.1)	3.16 (1.76–5.65)*	4.34 (2.28–8.27)*
Type of road user					
Bicyclist	225 (50.3)	205 (91.5)	19 (8.5)	1	1
Pedestrian	222 (49.7)	174 (79.1)	46 (20.9)	2.85 (1.61–5.05)*	2.51 (1.30–4.85)*
Activity when injured					
Other	42 (9.8)	39 (92.9)	3 (7.1)	1	1
Crossing the road	95 (22.3)	73 (77.7)	21 (22.3)	3.74 (1.04–13.32)*	3.04 (0.79–11.76)
Standing or moving close to the road	33 (7.7)	29 (87.9)	4 (12.1)	1.79 (0.37–8.64)	1.26 (0.22–7.11)
Walking/cycling on the edge of the road	257 (60.2)	225 (88.2)	30 (11.8)	1.73 (0.50–5.96)	1.82 (0.49–6.76)

[a]Three patients have missing severity, so columns do not add up.

[b]Adjusted for sex, age, alcohol status, referral status and road user type.

*P<0.05.

AOR, adjusted odds ratio; CI, confidence interval; KCH, Kamuzu Central Hospital; OR, odds ratio.

Traumatic brain injuries

There were 53 patients who were recorded with a neurological injury. Of these, 37 had a GCS of 13 or below, and were classified as having a TBI. This was more common in pedestrians, where 13.1% had a TBI, whereas 3.6% of the bicyclists had a TBI (P=0.000). TBI was also more common in patients who had consumed alcohol before the injury (12.1%) than in those who had not consumed alcohol (5.2%, P=0.01). Patients hit by lorries had the highest incidence of

Table 4. Risk factor analysis for serious injuries

	N (%)[a]	Mild injury (%)	Serious injury (%)	OR (95% CI)	AOR(95% CI)[b]
Type of site					
Urban	365 (82.8)	328 (90.4)	35 (9.6)	1	1
Rural	76 (17.2)	48 (64.0)	27 (36.0)	5.27 (2.93–9.47)*	4.92 (2.42–10.02)*
Speed limit					
50–60 km/h	361 (84.4)	308 (86.0)	50 (14.0)	1	1
100 km/h	14 (3.3)	8 (57.1)	6 (42.9)	4.62 (1.54–13.88)*	3.13 (0.76–12.96)
Unknown	53 (12.4)	47 (88.7)	6 (11.3)	0.79 (0.32–1.94)	0.55 (0.19–1.59)
Alcohol status					
No alcohol use when injured	309 (70.1)	274 (89.0)	34 (11.0)	1	1
Alcohol use when injured	132 (29.9)	104 (80.0)	26 (20.0)	2.01 (1.15–3.52)*	1.61 (0.83–3.09)
Light conditions					
Daylight (05.31–17.29)	245 (55.3)	215 (88.1)	29 (11.9)	1	1
Light-reduced (17.30-5.30)	198 (44.7)	162 (82.7)	34 (17.4)	1.56 (0.91–2.66)	1.15 (0.60–2.20)
Vehicle involved					
Car/pickup	212 (47.4)	189 (89.2)	23 (10.8)	1	1
Bicycle	17 (3.8)	16 (94.1)	1 (5.9)	0.51 (0.07–4.05)	0.59 (0.07–5.24)
Lorry	33 (7.38)	21 (65.6)	11 (34.4)	4.30 (1.84–10.05)*	3.84 (1.45–10.21)*
Minibus	49 (11.0)	41 (83.7)	8 (16.3)	1.60 (0.67–3.83)	1.69 (0.64–4.47)
Motorcycle	43 (9.6)	35 (85.4)	6 (14.6)	1.41 (0.53–3.71)	1.11 (0.38–3.23)
No other vehicle	50 (11.2)	44 (88.0)	6 (12.0)	1.12 (0.43–2.92)	1.70 (0.56–5.12)
Other	17 (3.8)	16 (94.1)	1 (5.9)	0.51 (0.07–4.05)	0.74 (0.09–6.38)
Unknown	26 (5.8)	17 (65.4)	9 (34.6)	4.35 (1.73–10.88)*	4.54 (1.65–12.47)*

TBI at 27.3%, followed by those hit by unknown vehicles at 23.1%.

Discussion

This study found that pedestrian road traffic injury victims in Lilongwe had an increased risk of serious and fatal injuries compared with bicycle riders and passengers, and when compared with all other traffic users. Pedestrians also had an increased risk of TBIs. Many injuries occurred after drinking alcohol, especially among pedestrians, and in bicyclists this was associated with higher injury severity. The use of reflective devices in the dark, and helmets for cyclists was almost non-existent.

Accident victims hit by lorries had an increased risk of a serious injury, as did those hit by unknown vehicle types. The latter is not surprising, as TBIs were frequent in this category, and amnesia for the episode might have been one of the reasons why the vehicle was unknown. Patients from rural areas had a higher risk of a serious injury, possibly because of higher vehicle speed in this setting. More severe injuries in rural/village areas have also been reported in studies from Ethiopia[9] and Ghana[2].

Zebra crossings

Only 21 of the injuries happened at painted zebra crossings, perhaps reflecting that these are quite rare in Malawi and that they are generally not considered to be a safe place to cross the road. An observational study from Botswana[10] showed that even if 85.8% of drivers were not distracted, 80.4% did not yield to pedestrians at pedestrian crossings. Though the magnitude of this problem has not been measured in Malawi, the authors know from experience that the situation is similar in Malawi, and it is an interesting finding that injury severity seems to be higher when a person is injured on these crossings. One explanation for this might be that the pedestrians at a zebra crossing might mistakenly think that a vehicle is going to respect their right of way, thereby exposing them to more kinetic energy than they would have otherwise. Painted zebra crossings are not proved to provide any safety for pedestrians, but there is evidence that rebuilding a painted crossing to an elevated crossing, or a crossing with a refuge mid-way, will reduce the incidence of injuries[11]. Speed bumps ahead of the crossings reduce the speed of vehicles at the crossing and are also likely to reduce the incidence and severity of injuries.

Implications for prevention

Based on the above findings, we have constructed a Haddon matrix[12] with implications for prevention (Table 5). Printed in italics in the matrix are the findings from this study that we believe are relevant and have implications for prevention. Suggested measures are printed in bold. Measures presented with references in the matrix have been shown to be effective, or cost-effective, in other studies.

There is good evidence from other low-income countries that building speed bumps and speed tables at relevant sites reduces injuries and deaths[13-15]. Reducing vehicle speed is crucial both for primary and secondary prevention of

https://dx.doi.org/10.4314/mmj.v32i4.4

Table 5. Haddon Matrix with findings printed in italics, and suggested preventive measures printed in bold. Measures that have documented effect are referenced

	Host	Vector	Physical environment	Social environment
Pre-crash	*Alcohol use in pedestrians and cyclists* **Media campaigns promoting safe alcohol use.[19,20] Physical environment modifications minimizing risk of reckless behavior[13-15].** *No reflective devices used* **Media campaigns and distribution of reflective devices**.	*Alcohol use in drivers[7]* **Better enforcement of alcohol legislation[19]. Media campaigns on drunk driving[20]**	*Many injuries while crossing the road* **Provide safe pedestrians crossings[11].** *Many injuries while walking along the road.* **Provide separation between vehicles and pedestrians/ cyclists. Cost-effectiveness studies needed.**	*No respect for zebra crossings among drivers?* *Insufficient legislation on drink driving, poor enforcement?* **Media campaigns and improved legislation and enforcement on alcohol use[19] and observance of traffic rules[22].** **Better training of drivers. Local observational studies needed.**
Crash	*Reckless behaviour when crossing?* **Studies needed to evaluate behaviour of pedestrians.** *No helmet use among cyclists* **Increase the rate of helmet use for bicyclists[23].**	*Worse injuries in high speed* **Construct speed bumps and speed tables[13-15].** **Enforcement of speeding regulations[22].** *More severe injuries from lorries* **Focus on lorries when enforcing alcohol legislation, driver training and licencing, and technical standard of vehicles.**	*More severe injuries in rural areas* **Provide speed lowering measures in rural areas[14].** *More severe injuries on painted zebra crossings* **Replace painted zebra crossings with elevated crossings or crossings with a refuge[11]; add speed bumps before crossings.**	*Errant behaviour and attitudes of drivers?* **Increased law enforcement[22].**
Post crash		-	*Insufficient data registration and analysis of injury hotspots.* **Provide better statistics and hotspot analysis. Improve and institutionalise trauma registries in hospitals. Improve police data collection and quality.**	*Very few transported by ambulances* **Improve prehospital services.** **Improve trauma services in hospitals.**

road traffic injuries, and an Australian study calculated that if drivers obeyed the speed limits, there would be a 13% decrease in pedestrian fatalities. If all drivers were driving 10 km/h slower, a 48% reduction in pedestrian deaths could be expected[16].

We found that most injuries occurred while the victims were walking along the road, and providing sidewalks or pavements separated from the road by a kerb or a separation strip is a standard recommendation[17], although cost-effectiveness studies seem to be lacking, at least in low-income countries. Providing safe infrastructure for cyclists is also important, although evidence for effectiveness when it comes to preventing injuries is conflicting due to the fact that providing safer infrastructure also increases the volume of cycling, leading to more injuries especially at intersections[18].

In another study from this same cohort we found that 23.8% of car drivers had been drinking alcohol before the injury[7]. Drink-driving is a major cause of road traffic injuries for pedestrians and cyclists, and there is evidence for reducing this by both random and selective alcohol testing, and by mass media campaigns[19,20], although a later review has questioned the effectiveness of the latter[21]. Law enforcement is a key element in road traffic injury prevention, both aimed at reducing speed, drink-driving and the general adherence to traffic rules, and the up-scaling of traffic enforcement has been shown to be very cost-effective in a similar setting in Uganda[22].

Limitations and possible bias

All the information is this study is collected from the patients or persons accompanying them. Some questions might be difficult to answer, and there might be mistakes recorded and even systematic recall biases. Due to the in-hospital collection of data, immediately fatal injuries were not included in the study. According to police data from the period 2008–2012[6], 40.7% of injured pedestrians and cyclists died on the scene. Patients suffering fatal injuries might have had a different risk factor profile than those surviving their injuries, and our results might therefore not be generalisable to fatal injuries. We did not receive consent from 6.5% of the patients, and this may produce some bias, for example if they refuse to participate to conceal their use of alcohol before the injury. Some of these patients were most likely not able to consent because of a severe injury, and this implies a selection bias to the study. There are also other hospitals in the area admitting and treating road traffic injuries, so we do not present a complete picture of the pedestrian and cyclist injuries in this period. It is unclear if this produced any bias to the results, except for the information presented in Figure 2, where the geographical distribution of zebra crossing injuries might have been influenced by patients being admitted to other hospitals. There is also a likely bias involved in that this is a tertiary hospital that admits referral patients from other hospitals. This may especially involve patients from rural areas and patients injured on highways with a 100 km/h speed limit, as only the more severely injured patients are referred to the central hospital. We have corrected for this in the adjusted analysis, but some patients might have been be transported directly from a distant scene of injury to the central hospital without stopping at a health centre or a district hospital, and therefore were not categorized as referral patients.

Conclusion

This study demonstrated an increased risk of serious injury for pedestrians, compared with both injured bicyclists and all injured road users. The most common activity when injured was walking or cycling along the road. The use of bicycle helmets or reflective devices in the dark was practically non-existent. Use of alcohol before their injury was found in 29.9% of the patients had, and this was associated with more severe injuries in bicyclists. Being injured while crossing at zebra crossings was associated with an increased risk of both serious injuries and potentially fatal injuries. These findings have important implications for the planning and implementation of preventive measures against road traffic injury in Malawi.

Funding

This study was supported by a grant from the World Bank Group. Financial support was also received from the International Council on Alcohol Drugs and Traffic Safety and the Norwegian Council for Road Safety (Trygg Trafikk).

Acknowledgements

The study was made possible by the administrative and technical support from Elin H. Wyller at the Norwegian Institute of Public Health and Håvard Furuhaugen at Oslo University Hospital, and the recruitment work was done by Lovemore Kamange and Noel Yotamu at Kamuzu Central Hospital. Statistical advice was given by Joseph Sexton at Diakonhjemmet Hospital.

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