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SURGERY IN LOW AND MIDDLE INCOME COUNTRIES

Police Transportation Following Vehicular Trauma and Risk of Mortality in a Resource-Limited Setting

Laura N. Purcell[1] · Gift Mulima[2] · Emily Nip[3] · Avital Yohan[1] · Jared Gallaher[1] · Anthony Charles[1,2,4]

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Abstract

Background In resource-limited settings, prehospital trauma care and transportation from the scene to a hospital is not well developed. Critically injured patients present to the hospital via privately owned vehicles (PV), public transportation, or the police. We aimed to determine the mortality following road traffic injury based on the mode of transportation to our trauma center.

Methods We performed a retrospective analysis of the Kamuzu Central Hospital (KCH) Trauma Registry from January 2011 to May 2018. Patients with road traffic injuries, presenting from the scene, were included. Those brought in dead or discharged from casualty were excluded. Bivariate analysis was performed over mortality. A Poisson multivariate regression determined the relative risk of mortality by prehospital transportation.

Results 2853 patients were included; 7.8% ($n = 223$) died. Patients were transported by PV ($n = 1963$, 68.8%), minibus ($n = 497$, 17.4%), and police (268, 9.4%). No patients were transported by ambulance. Patients transported by police (1 h, IQR 0–2) and PV (1 h, IQR 0–2), arrived earlier than those transported by minibus (2 h, IQR 0–27), $p < 0.001$. There was no difference in injury severity between the transportation cohorts. Compared to PV, patients transported by police (RR 1.56, 95% CI 1.13–2.17, $p = 0.008$) have an increased risk of mortality after controlling for injury severity. There was no difference in mortality in patients presenting by minibus (RR 0.83, 95% CI 0.55–1.24, $p = 0.4$).

Conclusion Patients transported to KCH via police have a higher risk of mortality than those transported via private vehicle after controlling for injury severity. Training police in basic life support may be an initial target of intervention in reducing trauma mortality. Overall, the creation of a functional prehospital ambulance system with a cadre of paramedics is necessary for both trauma and non-trauma patients alike. This can only be achieved by training all stakeholders, the police, public transport drivers, and the public at large.

✉ Anthony Charles
anthchar@med.unc.edu

1 Department of Surgery, University of North Carolina at Chapel Hill, Chapel Hill, USA

2 Kamuzu Central Hospital, Lilongwe, Malawi

3 University of North Carolina Project, Lilongwe, Malawi

4 UNC School of Medicine, 4008 Burnett Womack Building, CB 7228, Chapel Hill, USA

Introduction

In low and middle-income countries (LMIC), prehospital emergency medical services are underdeveloped and virtually non-existent, particularly in sub-Saharan Africa [1, 2]. Furthermore, the absence of emergency medical transport is a common barrier to timely care. This may be attributable to several factors, including the lack of ambulances, the inadequacy of road networks, and the inability to pay for transportation services. Hence, in timesensitive disease processes, such as traumatic injury, the consequences of a lack of transport can be grave.

Injury remains among the leading causes of morbidity and mortality worldwide, particularly in LMIC. According to the WHO, five million people die from injury every year, and this accounts for 9% of the world's death and 90% of trauma-related deaths occur in LMIC [3, 4]. Each year, 1.35 million people die around the world following motor vehicle collisions (MVC) [5]. These numbers are projected to rise substantially with increasing motorization in LMIC [6]. Although Africa has just 2% of the world's vehicles, it accounts for 16% of global road traffic deaths [7]. The estimated annual African MVC fatality rate (26 per 100,000 population) is twice and three times greater than the United States and Europe, respectively [5]. Also, an overwhelming proportion of these deaths occur before patients even reach the hospital [8].

Little is known about the prehospital experience of trauma patients in LMIC, including how the injured are treated and transported to healthcare facilities. We, therefore, sought to evaluate the relative risk of mortality in a cohort of trauma patients following road traffic injury based on the mode of transportation to our trauma center.

Methods

A retrospective analysis of the prospectively collected Kamuzu Central Hospital (KCH) Trauma Surveillance Registry was performed from Jan 1, 2008, to May 31, 2018. The registry contains demographic and injury characteristics of all patients who present to the KCH's casualty department with a traumatic injury. Data clerks follow patients admitted throughout their hospital admission to collect surgical and outcomes data.

Patients were included in this study if they presented to KCH from the scene of the injury and were admitted for their injuries. Patients excluded were transferred from an outside hospital, brought in dead or treated and discharged, or missing outcomes data. Patients who were discharged from the casualty were excluded as their injury severity would be minimal and hence discharged. Patients who were discharged from the casualty would have survived regardless of the mode of transportation to the hospital. Our intent with the inclusion/exclusion criteria was to assess the cohort of patients that had significant enough injuries to be admitted and may have benefitted from possible prehospital and in-hospital intervention. We also only included those patients arriving directly from the scene of injury for uniformity as we cannot control for treatment received at other hospitals before presentation to our center. Brought in dead patients were deliberately excluded as we could not differentiate patients that died at the scene from the patients that died en route to the hospital. Furthermore, patients that die at the scene will be predisposed to police transport and this may skew our findings further.

KCH is a 900-bed tertiary hospital located in Lilongwe, the capital of Malawi. It is the referral center for the district hospital located in Malawi's central region with a catchment of six million persons. During the study, trauma care was provided by casualty department clinical officers, general interns, and surgical registrars supervised by general surgery consultants. Clinical officer anesthetists provide anesthesia care.

The evaluation of data distribution and missing data was performed using univariate analysis. Bivariate analysis was performed over survived versus died and by transport mode. Means with standard deviations (SD) and medians with interquartile ranges (IQR) for normally distributed and non-normally distributed variables were used to describe central tendency, respectively. χ^2 for categorical variables, Student's *T*-Test for normally distributed continuous variables, and Kruskal–Wallis for non-normally distributed continuous variables were performed to compare demographic and outcomes distribution in the bivariate analysis.

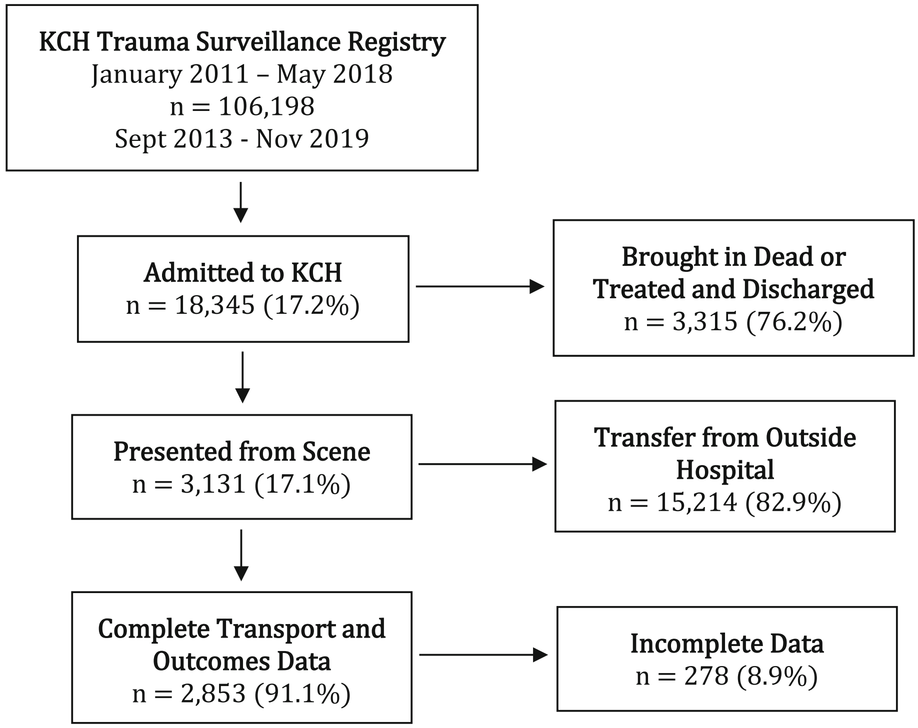
To determine the relative risk of mortality by mode of transport to the hospital, we performed a Poisson multivariate regression. Time to presentation was defined as the time from injury to presentation to our center (KCH). The Malawi Trauma Score (MTS), a validated trauma score, which includes age, sex, injury location, AVPU, and presence or absence of a radial pulse as a proxy for shock, as included in the model a priori [9]. Based on a significant p-value (< 0.05), the injury mechanism and injury type should be included in the model. Injury type was excluded due to collinearity with injury location. A backward elimination approach was used to reduce the model. As all covariates were significant, none were removed.

This analysis was performed using StataCorp v16.0, College Station, Texas. Confidence intervals are reported at 95%, and alpha was set at 0.05 for this study. The Malawi National Health Science Research Committee and the Institutional Review Boards approved this study.

Results

During the study period, 106,198 patients were included in the KCH Trauma Surveillance Registry. Of these, 18,345 were admitted, and 3131 were brought in from the scene. Of these, 2853 (91.1%) had complete modes of transport and outcomes data, Fig. 1. In the overall cohort, there was a mean age of 31.6 years (SD 15.9) and a male predominance (n = 2285, 80.2%). Patients were primarily transported via private vehicle (n = 1963, 68.8%) and injured in

Fig. 1 Inclusions and exclusion criteria flow diagram



motor vehicle collisions (*n* = 996, 37.4%). Primary injuries were fractures (*n* = 995, 34.9%) and head injuries (*n* = 717, 25.1%), Table 1.

Overall, mortality was 7.8% (*n* = 223). Patients who died were older (34.9 years, SD 15.5 versus 31.3 years, 15.9, $p = 0.001$). Both the died and survived cohorts were transported primarily by private vehicle (*n* = 143, 64.1% versus *n* = 1820, 69.2%, $p < 0.001$) with patients who died arriving before those who survived (0 h, IQR 0–1 versus 1 h, IQR 0–3, $p < 0.001$, respectively). Patients who died were more likely injured via pedestrian versus motor vehicle (*n* = 94, 45.4%) and those that survived were more likely injured via vehicle versus vehicle (*n* = 937, 38.2%). Head injury (*n* = 131, 58.7%) and fractures (*n* = 948, 36.1%) were the leading injury type for those who died and survived, respectively, Table 1.

Private vehicle, minibus, and police transported 68.8% (*n* = 1963), 17.4% (*n* = 497), and 9.4% (*n* = 268) of the overall cohort, respectively. The primary injury location was extremities for patients transported by minibus (*n* = 238, 47.9%) and head or cervical spine for both private vehicle (*n* = 960, 49.0%) and police (*n* = 147, 54.9%), $p = 0.004$. Patients who were transported by private vehicle (1 h, IQR 0–2) and police (1 h, IQR 0–2) arrived at the hospital sooner than those transported by minibus (2 h, IQR 0–27), $p < 0.001$). The mortality was higher for patients transported via police (*n* = 43, 16.0%) compared to private vehicle (*n* = 143, 7.3%) and minibus (*n* = 27, 5.4%), $p < 0.001$, Table 2.

The Poisson multivariate regression to determine the relative risk of mortality by mode of transport showed that police transportation resulted in a higher relative risk of mortality when compared to patients transported via private vehicle (RR 1.56, 95% CI 1.13–2.17, $p = 0.008$), when controlling for time to presentation, MTS, and injury mechanism. There was no difference in the risk of mortality being transported by minibus when compared to a private vehicle (Table 3).

Discussion

In this study, we show the variety of ways that trauma patients are transported to our trauma center following road traffic injuries, with the majority presenting via private vehicle and nearly 10% by the police. We show that there is a 56% increase in relative risk of mortality if presenting via police transportation to our trauma center after controlling for pertinent covariates, including injury severity and time to presentation. Interestingly, our data also show that the majority of patients were brought to our center by private vehicles. Furthermore, these patients arrived within one hour of the injury. This suggests that laypersons in Malawi can recognize higher acuity injuries and critically ill patients.

Table 1 Patient demographics and characteristics

	Overall (n = 2853)	Alive (n = 2630, 92.2%)	Died (n = 223, 7.8%)	p value
Age (years): mean (SD)	31.6 (15.9)	31.3 (15.9)	34.9 (15.5)	0.001
Male sex: n (%)	2285 (80.2)	2104 (80.1)	181 (81.5)	0.6
Alcohol use: n (%)	243 (8.5)	228 (8.7)	15 (6.9)	0.4
Transport: n (%)				< 0.001
Minibus	497 (17.4)	470 (17.9)	27 (12.1)	
Private vehicle	1963 (68.8)	1820 (69.2)	143 (64.1)	
Police	268 (9.4)	225 (8.6)	43 (19.3)	
Other	125 (4.4)	115 (4.4)	10 (4.5)	
Time to presentation (hours): median (IQR)	1 (0–3)	1 (0–3)	0 (0–1)	< 0.001
Injury mechanism: n (%)				0.003
Pedestrian versus motor vehicle	933 (35.0)	839 (34.2)	94 (45.4)	
Motor vehicle collision	996 (37.4)	937 (38.2)	59 (28.5)	
Bike collision	633 (23.8)	583 (23.7)	50 (24.2)	
Other	101 (3.8)	97 (4.0)	4 (1.9)	
Injury type: n (%)				< 0.001
Contusion	365 (12.8)	380 (13.7)	5 (2.2)	
Laceration	258 (12.6)	340 (12.9)	18 (8.1)	
Abrasion	180 (6.3)	174 (6.6)	6 (2.7)	
Fracture	995 (34.9)	948 (36.1)	47 (21.1)	
Penetrating wound	32 (1.1)	30 (1.1)	2 (0.9)	
Dislocation	66 (2.3)	66 (2.5)	0 (0.0)	
Internal injury	81 (2.8)	70 (2.7)	11 (4.9)	
Head injury	717 (25.1)	586 (22.3)	131 (58.7)	
Spine injury	15 (0.5)	14 (0.5)	1 (0.5)	
Traumatic amputation	18 (0.6)	16 (0.6)	2 (0.9)	
Other	25 (0.9)	28 (1.0)	0 (0.0)	
Injury location: n (%)				< 0.001
Head/C-spine	1363 (47.8)	1205 (45.9)	158 (70.9)	
Chest	100 (3.5)	92 (3.5)	8 (3.6)	
Abdomen/pelvis	257 (9.0)	240 (9.1)	17 (7.6)	
Extremities	1131 (39.7)	1091 (41.5)	40 (17.9)	
Malawi trauma score: median (IQR)	8 (5–9)	7 (5–9)	13 (8–19)	< 0.001
Admission disposition: n (%)				< 0.001
Admission to ward	2561 (89.8)	2518 (95.7)	43 (19.3)	
Admission to HDU	93 (3.3)	80 (3.0)	13 (5.8)	
Admitted to ICU	77 (2.7)	32 (1.2)	45 (20.2)	
Died in casualty	122 (4.3)	0 (0.0)	122 (54.7)	

These findings are significant as it lends itself to targeted injury prevention interventions that may potentially reduce trauma-related mortality in a resource-limited setting. In a South African study by Moller et al. with a cohort of 574 trauma patients, in-hospital mortality was not significantly affected by the transport method, unlike in our study [10]. Unlike Malawi, South Africa has an established emergency medical service and prehospital care system, and measuring mortality differences based on transportation mode may be more difficult to establish in a mature pre-hospital system [11]. In high-income countries, prehospital systems have been shown to reduce mortality following trauma [12]. The survival benefits of a prehospital system have also been shown to hold in LMIC [13, 14].

The mode of arrival to the emergency department in our study following road traffic injury in Malawi is

Table 2 Patient demographic and characteristics by transportation type

	Minibus (n = 497, 17.4%)	Private vehicle (n = 1963, 68.8%)	Police (n = 268, 9.4%)	Other (n = 125, 4.4%)	p value
Age (years): mean (SD)	29.2 (18.6)	31.8 (15.4)	32.3 (12.4)	35.5 (17.3)	< 0.001
Male sex: n (%)	387 (77.9)	1570 (80.1)	232 (86.9)	96 (76.8)	0.02
Injury location: n (%)					0.004
Head/cervical Spine	204 (41.1)	960 (49.0)	147 (54.9)	52 (41.6)	
Chest	13 (2.6)	74 (3.8)	9 (3.4)	4 (3.2)	
Abdomen/pelvis	42 (8.5)	179 (9.1)	23 (8.6)	13 (10.4)	
Extremities	238 (47.9)	748 (38.1)	89 (33.2)	56 (44.8)	
Malawi trauma score: median (IQR)	6 (5–9)	8 (5–9)	8 (5–9)	7 (5–9)	0.01
Injury mechanism: n (%)					< 0.001
Pedestrian versus motor vehicle	134 (29.2)	663 (36.1)	103 (41.7)	33 (27.3)	
Motor vehicle collision	134 (29.2)	703 (38.3)	101 (40.9)	58 (47.9)	
Bike collision	155 (33.8)	415 (22.6)	37 (15.0)	26 (21.5)	
Other	36 (7.8)	55 (3.0)	6 (2.4)	4 (3.3)	
Time to presentation (hours): median (IQR)	2 (0–27)	1 (0–2)	1 (0–2)	1 (0–4)	< 0.001
Died: n (%)	27 (5.4)	143 (7.3)	43 (16.0)	10 (8.0)	< 0.001

Table 3 Poisson multivariate regression for mortality

	Relative risk	95% confidence interval	p value
Mode of transport			
Private transport	Ref	–	–
Minibus	0.83	0.55–1.24	0.4
Police	1.56	1.13–2.17	0.008
Other	1.32	0.78–2.24	0.3
Time to presentation (days)	0.99	0.98–1.00	0.04
Malawi trauma score	1.18	1.16–1.20	< 0.001
Injury mechanism			
Pedestrian versus motor vehicle	Ref	–	–
Motor vehicle collision	0.71	0.53–0.96	0.02
Bike collision	1.02	0.74–1.39	0.9
Other	0.73	0.30–1.77	0.5

overwhelmingly by private vehicle, with 69% of all patients presenting this way. In a study conducted in Addis Ababa by Abebe et al., the mode of arrival to the casualty following RTI was by private vehicle and ambulance were 38 and 59%, respectively, which is a reflection of the maturity of the prehospital system in Ethiopia compared to Malawi [15]. Similar to our finding, Mowafi et al. in Uganda showed that the majority of trauma victims presenting to the emergency department arrived by private vehicle (53.4%) or public transport (37.7%), and only 5.9% were transported by public ambulance [16].

Police officers have been shown to arrive at the crash scene first, becoming, in effect, the first responders to RTI victims and almost always with a vehicle or the ability to obtain a vehicle expeditiously. Despite a higher frequency of police transportation (> 55%) following RTI, Boniface et al. from Tanzania show increased mortality following police transportation, similar to our study [17]. In Malawi, the police are not trained on essential trauma care, especially for the management of severely injured patients during transport. The increased risk of mortality in our trauma cohort presenting via police transportation may be attributable to a lack of knowledge and training.

In a recent qualitative study of police officers from Tanzania, the police expressed their roles after RTI were primarily rescuing victims and facilitating transport to a health care facility [18] However, they also expressed being overwhelmed while working with limited resources and support. These findings suggest police officers have no knowledge, skills, equipment, or supplies to provide care to RTI victims at the scene before rushing them to the appropriate hospital for definitive care. Our findings predispose the police as an initial target for an injury prevention intervention. Models of training currently exist to improve prehospital trauma care rendered to RTI victims in low-income countries. Emphasis during training should be placed on the airway (assessment, airway protection, and aspiration prevention), breathing, and circulation (hemorrhage control) management, followed by expeditious transport to the appropriate health facility [19, 20, 21].

This study has the inherent limitation of its retrospective methodology, including presentation bias and recall bias regarding time from injury to presentation. The full picture of prehospital deaths is unknown. Patients were excluded from this analysis if they were brought in dead as police are more likely to be called if an MVC victim is already dead at the scene, and therefore biasing police transport and resulting in a higher relative risk of mortality by police transport. Therefore, by excluding the brought in dead patients, we are biasing our results toward the null hypothesis.

Conclusion

We show that in a cohort of RTI patients, mode of arrival to the casualty via police transport resulted in a 56% increase in relative risk of mortality when compared with private vehicles. Our findings predispose police officers as targets of injury prevention strategies. The development of a functional prehospital system tailored to a resource-limited setting may lead to reduced trauma-related mortality. This can only be achieved by training all stakeholders, the police, public transport drivers, and the public at large.

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