Timing, Distribution and Predictors of Mortality Following a Road Traffic Injury in Northwest Ethiopia: A Hospital-Based Prospective Follow up Study

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Abstract

Background

Road traffic injury-related mortality continues to increase from time to time globally, but its burden is more than three times higher in low-income countries. This discrepancy is mainly due to poor trauma care system both at the pre-hospital and in-hospital. The analysis of injury patterns and time to mortality is crucial for the development and improvement of trauma care systems. This study aimed to identify patterns of RTI , and predictors of mortality following a RTI.

Methods

A prospective hospital-based follow up study was conducted among road traffic injury victims admitted to Gondar University Hospital between May 2019 and February 2020. The total follow-up time was 30 days. Injury severity was determined using revised trauma score (RTS). A Cox regression model was used to identify the time to death and predictors of mortality. Hazard ratios (HR), attributable risks (AR) and population attributable percent (PAR) were computed to estimate the effect size and public health impacts of road traffic injuries.

Results

A total of 454 victims were followed for 275,534 person-hours. There were 80 deaths with an overall incidence of 2.90 deaths per 10,000 person-hours of observation (95% CI: 2.77, 3.03). The significant predictors of time to death were being a driver (AHR=2.26; 95% CI: 1.09, 4.65, AR=14.8), accident at inter urban roads (AHR=1.98; 95% CI: 1.02, 3.82, AR=21%), hospital arrival time (AHR=0.41; 95% CI: .16, 0.63; AR= 3%), SBP on admission (AHR= 3.66; 95% CI: 2.14, 6.26; AR=57%), GCS of <8 (AHR= 7.39; 95% CI, 3.0819 17.74464;AR=75.7%), head injury with polytrauma (AHR= 2.32 (1.12774 4.79; AR=37%) and interaction of distance from hospital with pre-hospital care.

Conclusion

This study demonstrated that trauma deaths follow the classical tri-modal pattern in low resource settings. Interventions on pre hospital care, and advancing the hospital trauma care system is required to reduce preventable deaths caused by road traffic injuries. We recommend further study that assess capability of primary hospitals in the area in providing primary trauma care.

Background

Annually, nearly 6 million people die from injury, which is more than deaths caused by a combination of HIV, tuberculosis, and malaria (1). Besides, every fatal injury is responsible for 20–50 non-fatal injuries that influence productivity and consequently affect economic development (2, 3). Road traffic injuries are among the leading causes of injuries, having high economic implications as it mainly affects the economically active segment of the population (4). It impacts more than 3% of gross domestic product for most countries (5). It is roughly estimated that the cost of road crash injuries is about 1% of the gross national product in low-income countries, 1.5% in middle-income countries and 2% in high-income countries (6). Road traffic injury-related mortality continues to increase from time to time globally, but its burden is more than three times higher in low-income countries (7). This discrepancy is mainly due to poor trauma care system both at the pre-hospital and in-hospital settings (8–10).

Ethiopia is one of countries with a low economic development and has high burden of both communicable and non communicable diseases (11). Ethiopia has one of the highest road traffic injury related mortality in the sub-Saharan region (12). Despite the remarkable efforts made in training of key emergency personnel in the country, there is no well established and organized emergency medical system to provide pre hospital trauma care (13). The only available emergency service is the infrequent Ambulance transportation, which itself lacks health care professonal accoumpany at scene and on the way to hospital (14). These are the main factors explaining the higher crash fatality in Ethiopia (15, 16).

Among many factors affecting mortality following a trauma, time from injury to death have attracted the attention of several scholars since three decades ago (17–19). The trimodal distribution of mortality was first described by Trunkey in 1983 based upon the time interval from injury to death (17). According to Trunkey, there are three peaks of mortality following a trauma. The first peak is observed within minutes, usually at the scene of injury. Most deaths at the scene are from non-survivable injury to the brain and thorax (20). The second peak occurs within the first four hours of injury, in line with the concept of the "golden hour" (21). The most common causes of deaths during this time are severe cardiovascular injuries, severe pelvic and intra-abdominal injuries with consequence of heavy exsanguinations (22–24). Well organized pre hospital care and advanced trauma care at hospitals could avert these deaths (25). The third peak of death following trauma, called "late deaths", occur after the first week of injury (26). Such deaths are caused by late complications such as sepsis and multiple organ failure (27). The advance in trauma care system in most developed countries has significantly reduced late deaths. This has changed the classical trimodal pattern of mortality following trauma in to bimodal pattern (19, 25–27). However, studies from low-income countries regarding the timing distribution of mortality showed that mortality following trauma still follows the classical tri-modal pattern (28).

Delay in arrival to a hospital, among other various factors, has been mentioned to determine time to death following injury (29). In most areas of low and middle income countries, Ambulance service is not available to transfer victims from accident scene to a health care facility. If at all available, there is poor coordination between ambulance and hospital staff, which is one reason for delays in trauma care at the health care facility (30). In countries like Ethiopia where there is absence of pre hospital trauma care system and poor road infrastructure, delays in hospital arrival is expected. There is paucity of information on pattern of mortality following traumas in the study area. The few available studies are cross-sectional and document based which lacks information on important predictors and the studies only included deaths in the hospital ignoring late deaths at home. There is also methodological gap in analysis that ignores timing component of deaths.

There is also paucity of evidence on hospital arrival time, time to death and predictors of mortality following a road traffic injury in the study area. This study aimed to identify proportion of victims who got pre hospital care at the scene of injury, describe hospital arrival time, time to death and its predictors following a road traffic injuries. The analysis of trauma mortality and its temporal distribution is crucial for the development and improvement of trauma care systems.

Materials And Methods

Design

This is a prospective hospital-based cohort follow up study which was conducted at Gondar University comprehensive hospital from May 1, 2019 and February 30, 2020.

Study settings

The study hospital is one of the referral and teaching Hospitals in the country. With more than 500 bed capacity, it provides basic and advanced services at its different units, including a 24-hours emergency department receiving all emergency cases.

Musculoskeletal and head trauma care is provided by four orthopedic surgeons and one neurosurgeon. General surgeons and specialists in other fields such as thoracic, gastro-intestinal, genito - urinary and maxillofacial surgery are also assigned 24hr on call to manage trauma cases in their respective fields. The emergency department is managed by 29 nurses assigned on 24hr-rotation. Every day, five surgical Residents and one senior orthopedic surgeon are assigned to the emergency department for trauma management. All trauma cases are brought to the emergency department for initial evaluation and resuscitation. The maximum observation period in the emergency department is 24 hours after which the patient is either discharged, admitted to appropriate unit or referred.

The hospital provides operative services in two minor surgery facilities, one main theatre complex, an obstetric, fistula, dental and ophthalmic operative units. Major emergency operation is provided at the main theatre in three dedicated rooms 24 hours seven days. The hospital has a radiology department staffed with 5 senior radiologists and other supportive technicians. The available imaging services include conventional radiology, ultrasonography, magnetic resonance imaging and computerized tomography. Based on our pilot study, trauma constituted nearly 30% of emergency related admissions in the hospital. With regard to emergency response, the hospital provides 24 hours trauma services but there is no established out-of-hospital emergency care services.

Sampling and sample size

The sample size was calculated using the sample size calculation formula for survival analysis using STATA 14. Considering the following assumptions, $\alpha = 0.05$, $\beta = 0.2$, HR = 0.643, taken from a study conducted at Turkey indicating hazard of death among victims with low GCS was 0.64% (31), probability of event from pilot study = 0.28, (SD = 0.5), and amount of event/probability of an event. Therefore, event

= 121, n = amount of event/probability of event = 121/0.28 = 432, and considering 5% loss to follow up = 454.

Eligibility criteria

All road traffic injury victims who visited the hospital after sustaining a road traffic injury during the data collection period were included except those victims who were dead on arrival, comatose with no attendant and with unknown injury time.

Study variables

The primary outcome was time to death measured in hours between road traffic injury and the 30th day of injury. Accordingly, those victims who died between injury times to 30th days of injury were events and those who were still alive at the 30th day were considered as censored. Secondary outcomes were pre hospital first aid, length of hospital stay and hospital arrival time. The exposure variable was having any degree of injury by any vehicle. The independent variables were socio-demographic factors (age, sex, educational status, occupation and residence of the victims and the distance between accident location and hospital), accident-related factors (road user category, type of vehicle, time of the accident, day of the week, lighting condition), pre-hospital first aid, means of transport to the hospital, hospital arrival time, anatomic body region injured, vital signs, neurologic status, and injury severity score.

Operational definition

Trauma severity was computed using the "Revised Trauma Severity Score" which was based on three parameters. These parameters are the Glasgow coma scale (GCS), respiratory rate (RR), and systolic blood pressure (SBP) (32). According to the revised trauma score, these three parameters are coded and added (Table 1).

Table 1
parameters used to measure revised trauma score

GCS	Code	SBP	Code	RR	Code
13–15	4	›89	4	10–29	4
9–12	3	76–89	3	›29	3
6–8	2	50–75	2	6–9	2
4–5	1	1–49	1	1–5	1
3	0	0	0	0	0
RTS = 0.9368 x GCS_v + 0.7326 x SBP_v + 0.2908 x RR_v, where v is the value (0–4)					

Data collection/Data sources/ measurement

All road traffic injury victims who visited the hospital after sustaining a road traffic injury during the data collection period were included. Victims who arrived dead and who were comatose and with no attendant and unknown injury time were excluded from the study.

Data were collected by four trained data collectors who were assigned to the emergency department. A predesigned and tested checklist was used to collect information on basic epidemiological variables, crash characteristics such as day of injury, time of injury, and hospital arrival time. Additionally, information on road user category, availability of pre-hospital first aid, type of transportation used to transfer the victim to the hospital, clinical findings, the outcome in the emergency department, and decision after evaluation at the emergency department (whether discharged, admitted, referred or died) were collected. Information regarding the road traffic injury-related events and pre-hospital factors were collected from the victims when condition allowed, or the relatives accompanying the victim.

Interviewing a victim was done after securing the initial lifesaving management at an emergency department. For those victims who were critical and unable to communicate, relevant information was collected from the caregivers. Admitted victims were followed up on daily basis for the maximum of one month. Victims discharged before one month or those treated at the outpatient department were communicated by phone on the 30th day of injury to follow their outcome.

Cause of in-hospital mortality was collected from the victims' medical records based on the assessment of the physicians in charge of clinical care of the victims. These clinicians were not involved in the study. For late deaths that occurred after hospital discharge, verbal autopsy was collected from family members who had been attending the victims. The verbal autopsy was collected by phone by the principal investigator (33). Clinical presentations of victims during the last days of survival were asked to know the possible immediate causes of death.

Source Of Bias And Minimizing Strategy

Severity of injury is one possible source of bias in this study, because including victims with highest injury severity score will result in to over estimation of the outcome (death). To avoid selection bias, participants were enrolled regardless of an injury severity score. To minimize bias due to loss to follow up, we explained the importance of the study and the importance of remaining in the study for both the participants and the general population in the future. A repeated attempt was made to contact participants after discharge from the hospital to know their status on the 30th day of the enrollment. We also took multiple contact numbers to access the victims or proxy. The data collection tool was also piloted and standardized to avoid interviewer bias. Bias due to instrument error for clinical data (BP, PR, and O_2 saturation) was minimized by checking the reliability of the instruments by comparing the measures with other instruments every day. Bias due to differential selection was minimized by including all degrees of injury (mild and severe cases) at the design stage. At the analysis stage, bias due to confounding was minimized by conducting multivariable analysis and stratified analysis. We used a predefined and the prepared data management plan to avoid selective reporting bias.

Data analysis

Data were analyzed using STATA 14. Tables and graphs were used to summarize descriptive results. A Cox regression model was employed to identify factors that influence mortality. The Cox regression model is the most popular regression technique for survival analysis because it examines the impact of various predictors of the risk of death and also accounts for censoring in the data (34). Variables with a p-value < 0.25 in the univariate Cox regression analysis were included in the multivariate analysis. We estimated hazard ratios and their 95% confidence intervals. A cutoff value of $p < 0.05$ was used in the multivariate analysis as the threshold for statistical significance. Non parametric tests such as the Kaplan Meir estimate, life table and log rank tests were also employed as required.

Performing log-log survival curves based on Schohenfield residuals were used to assess the proportional hazard assumption. Both bivariable and multivariable analysis was performed. Interaction of covariates on the main outcome was examined as necessary. Multicollinearity was controlled. The article has been registered with UIN of researchregistry6556. The STROCSS Checklist was also addressed.

Results

Characteristics of the study subjects

Out of 11,960 trauma patients who visited the Emergency Department between May 6, 2019 and February 30, 2020, three thousand eighty four cases were trauma victims with 560 of the cases (18.2%) following road traffic injury. Four hundred fifty-four participants were enrolled and studied during the study period and 106 were excluded because of incomplete information. The study participants comprised of 327 (72%) men and 127 (28%) women, resulting in a male to female ratio of 2.6:1.

Majority of the participants were in the productive age group. The mean age was 29 ± 15.5 years with a range from 1 year to 82 years. The median age was 27 years (IQR: 19, 37 years). The majority of the road traffic injury victims, 233 (51.3%) were passengers followed by 167 (36.8%) pedestrians and 54 (11.9%) drivers. As to the educational status, only 130 (28.6%) of the victims completed secondary education while 144 (31.7%) are unable to read and write. The majority of the victims, 116 (25.5%) were farmers by occupation followed by 70 (15.4%) students. Two hundred sixty-four (58.1%) of the victims were urban while 190 (41.9%) were rural dwellers. Nearly 60% (240) of the victims were reported from urban area. The majority of accidents, 402 (88.5%) were sustained during daylight with the highest accident time in the afternoon (1:00 PM-6:00 PM). Tuesday and Friday were found to be the days with the highest frequency of accidents (Table 2).

Table 2
Characteristics of road traffic injury victims, May 2019-February 2020.

Variable	Category	Frequency	Percentage
Age	≤ 5 years	15	3.3%
	6–14	42	9.3%
	15–44	319	70.2%
	≥45	78	17.2%
Sex	Male	127	28%
	Female	327	72%
Road user category	Passengers	168	37%
	Pedestrian	232	51.1%
	Drivers	54	11.9%
Educational status	Can't read and write	144	31.7%
	Can read and write only Primary education Secondary education Tertiary education	44	9%
		85	18.7%
		131	29%
		50	11%
Occupational status	Farmers	116	25.6%
	Gov. employee	53	11.7%
	Merchant	23	5.1%
	Student	70	15.4%
	Self- employee	68	15.0%
	Drivers	60	13.2%
	Others	64	14.0%
Residence	Urban	264	58.1
	Rural	190	41.9
Lighting condition	Daylight	402	88.5%
	Night	52	11.5%

Variable	Category	Frequency	Percentage
Time of accident	6:00AM-12:59AM	165	36.3%
	1:00PM -6:59 PM	202	44.5%
	7:00PM-11:59PM	44	9%
	12:00PM-5:59AM	43	9%
Day of the week	Monday	63	13.9%
	Tuesday	76	16.7%
	Wednesday	71	15.6%
	Thursday	61	13.4%
	Friday	76	16.7%
	Saturday	66	14.5%
	Sunday	41	9%
Type of vehicle	Heavy truck loaders Peoples' transport	59	13%
	Cars	173	38.1%
	Three wheel vehicles	17	3.7%
	Others	196	43.2%
		9	2%

Pre-hospital circumstances, hospital arrival time, and means of transportation to hospital

The median distance from the place of accidents to the hospital was 40km, IQR (10km, 80km). Three hundred twelve (68.7%) of the accidents were within 60 km distance from the hospital, while the rest 142 (31.3%) were sustained within the distance range of 61 to 500km. Concerning hospital arrival time, 184 (40.5%) of the victims reported to the hospital within 1 hour of the accident, 176 (38.9%) arrived within 1–4 hours of accidents. The total pre-hospital time interval in this study was 364 minutes. The hospital arrival time for accidents sustained in the town was 144 minutes while it was 537 minutes for accidents in the rural areas.

None of the victims received pre-hospital care at the scene of injury by trained personnel but bleeding control with traditional means was provided to nine victims. From the total injured, 283 (62.3%), were directly transferred from the scene of injury while 171 (37.7%) were referred from primary hospitals. None of the victims who were transferred from the primary hospitals got surgical intervention at the primary hospitals except wound dressing, immobilization with local materials, and tetanus prophylaxis. About means of transportation to the hospital, the majority 311 (68.5%) were transferred by commercial vehicles. Only 93 (20.5%) were transferred by ambulance but none received pre-hospital care by trained ambulance crew. Ambulance service was not for free and the victims had to cover the cost of fuel ranging from 400–800 Ethiopian Birr (40–80 USD) (Table 3).

Table 3
Pre hospital circumstances, hospital arrival time, and means of transportation.

Variables	Category	Frequency	Percentage
Distance from Hospital	≤ 60km	312	68.7%
	> 60km	142	31.3%
Hospital arrival time	≤ 1 hour of injury	184	40.5%
	Within 1–4 hours of injury	176	38.8%
	4–24 hours of injury	69	15.2%
	> 24 hours of injury	25	5.5%
Who brought the victims to the hospital	Police man	29	6.8%
	Relative/family	378	82.6%
	Others	47	10.6%
Pre-hospital care	Yes	171	37.7%
	No	283	62.3%
Transport to hospital	Ambulance	93	20.5%
	Commercial vehicles	311	68.5%
	Others	50	11%

Injury patterns and characteristics

Extremities and the head were the most commonly injured body regions accounting for 194 (42.7%) and 113 (24.9%) of cases respectively. Multiple body region injuries accounted for 85 (18.7%), thoraco-abdominal body region accounted for 32 (7%), and other body regions including the face, teeth, and the like accounted for 30(6.6%).

We computed the injury severity score using the revised trauma score. Accordingly, the mean revised trauma score (RTS) was 6.5 ± 2.0. The injury severity score ranges from 0.29 to 7.55. According to our data, RTS of < 3 (non-survivable injury score) was observed in 41 (9%) and a score of less than 4 was recorded among 56 (12.3%).

Based on the Glasgow coma scale score, 64 (14.1%) had a severe head injury, 18 (4%) had a moderate head injury and 372 (81.9%) had mild head injuries. Moreover, the rate of mortality was 52 (65%) for severe, 8 (10%) for moderate, and 20 (25%) for mild head injuries. Out of the observed 454 road traffic accidents, fracture was sustained by 289 (63.7%) of victims. The most frequently involved bone was the lower extremity comprising 42% of all fractures followed by skull fracture (14.8%) (Fig. 1).

Management of outcomes of road traffic injury victims

Out of the total 454 victims that visited the hospital, 76 (16.8%) were evaluated and treated at an outpatient department while 378 (83.2%) were admitted to the hospital for further evaluation and treatment. Of the total admitted, surgical intervention was required for 162 (35.7%) cases. The most frequently performed major surgical procedure was craniotomy, 25 (15.4%) followed by intramedullary nailing (IMN) 15 (9%). From the minor procedures, wound debridement was the most frequently performed procedure, 64 (39.5%) followed by immobilization using plaster of Paris (POP) 42 (25.9%). The mean hospital stay was 6.2 ± 10 days, ranging from 1 day to 100 days. Reasons for discharge were on physician advice in 246 (65%) cases followed by death in 71 (18.7%), against medical advice in 38 (10%) and referred for better management to higher centers in 24 (6.3%) cases (Table 4).

Table 4
Management outcome of road traffic injury victims; May 6; 2019 to February 2020.

Variables	Category	Frequency	Percentage
Decision at OPD	Sent home same day	76	16.7%
	Admitted to hospital	378	83.3%
Reason for admission	Requires surgery or resuscitation	256	67.73%
	Requires Close observation	122	32.27%
Commonly performed procedure	Debridement	64	28.9%
	Craniotomy	25	11.3%
	POP	52	23.5%
	Wiring & pin traction	17	7.6%
	Wound repair	22	10%
	Chest tube	12	5.4%
	IMN	18	8%
	Laparotomy	4	1.8%
	Others	7	3.1%
Mean hospital stay	6.6 ± 9.8 days		
Reason for discharge	On medical advise	324	71.4%
	Died	71	15.6%
	Against medical advice	38	8.4%
	Referred	21	4.6%

Survival analysis

Four hundred fifty-four participants were followed for a total of 275,534 person-hours. There were 80 (17.60%) deaths and 15(3.30%) loss to follow up. We used the available case analysis technique as a missing data management option. From the total deaths, 13 (16.25%) occurred within the first hour of injury, 11 (13.75%) between the first and 4 hours of injury and 18 (22.50%) occurred between 4 and 24 hours of injury. Thirty-two (40%) of the deaths occurred after 24 hours up to the first 7 days while the rest six deaths occurred after a week of injury (Fig. 2).

The overall incidence rate of death was 2.90 deaths per 10,000 person-hours of observation (95%CI: 2.77, 3.03). Since more than 75% of participants survived beyond the study time, we couldn't compute the median survival. Instead, we computed the cumulative and mean survival times. The mean survival time was 607 hours or 25.30 days with a standard deviation 10 days.

The cumulative proportion of surviving at the end of the first hour of injury was 97.30% (95% CI: 95.39%, 8.49%). Similarly, it was 94.93% (95% CI: 92.47%, 96.60%), 90.95% (95% CI: 87.92%, 93.23%), 83.89% (95% CI: 80.17, 86.97%) and 82.34% (95% CI: 78.51%, 85.56%) at the end of fourth, 24th, 168th and 720th hours of injury respectively (Table 5).

Table 5
Overall life table of road traffic injury victims; May 2019-February 2020

Time in hours	Number at risk	Loss to follow up	Number of events	Proportion of events	Proportion Surviving	Cumulative Proportion Surviving
1	442	0	12	0.027	0.973	0.973
2	433	0	9	0.02	0.98	0.95
3	432	0	1	0.002	0.99	0.94
4	431	0	1	0.002	0.998	0.938
6	429	0	2	0.004	0.996	0.934
12	428	0	1	0.002	0.998	0.932
24	413	0	15	0.036	0.964	0.89
48	406	0	7	0.0172	0.982	0.87
72	399	0	7	0.0175	0.982	0.85
96	392	0	7	0.0178	0.982	0.83
120	388	0	4	0.010	0.99	0.82
144	386	0	2	0.0052	0.99	0.81
168	381	0	5	0.013	0.98	0.79
288	380	0	1	0.002	0.997	0.77
312	379	0	1	0.002	0.997	0.75
432	378	0	1	0.002	0.997	0.74
480	377	0	1	0.002	0.997	0.73
528	376	0	1	0.002	0.997	0.72
672	375	0	1	0.0026	0.99	0.71
720	359	15	1	0.0027	0.99	0.70

Condition of victims at the 30th day of injury

Assessment at the 30th day of injury revealed that 30 (6.60%) were still in bed with unremarkable improvement, 263 (57.90%) had a better condition, but not completely healed, 45 (9.90%) were healed with some limitation, 21 (4.60%) were completely healed and back to work, 15 (3.30%) were lost to follow-up and 80 (17.6%) died. Apart from those who died, 23 had functional losses (4 (0.88%) had lost teeth, 4 (0.88%), had an amputation of the limb, 3 (0.66%) had hearing loss, 3 (0.66%), had vision loss, 5 (1.10%), had impaired memory and 4 (0.88%) were paraplegic at 30th day of injury).

Immediate causes of deaths at a specific time interval

From the total of 17 deaths in the first hour of admission, 13 (76.5%) were due to non-survivable injury. The leading cause of death in the first four hours of admission to the hospital was hemorrhage (21.3%). Hemorrhage and secondary complications, mainly aspiration pneumonia were the major causes of death between the first 4 and 24 hours. According to our data, late deaths were mainly due to sepsis and multiple organ failure (Fig. 3). All deaths were confirmed by the clinician incharge of patient care.

Predictors of mortality following a road traffic injury

The significant predictors of time to death for road traffic injury victims were being a driver (AHR = 2.26; 95% CI: 1.09, 4.65, AR = 14.8), accident location at the rural residence (AHR = 1.98; 95% CI: 1.02, 3.82;AR = 21%), hospital arrival time (AHR = 0.41; 95% CI: 0.16, 0.63;AR = 3%), systolic blood pressure on admission (AHR = 3.66; 95% CI: 2.14, 6.26; AR = 57%), GCS of < 8 (AHR = 7.39 ; 95% CI, 3.0819 17.74464; AR = 75.5%), GCS between 9–13 (AHR = 8.1565 (3.36 19.82, AR = 39%), combined head injury with multiple body site (AHR = 2.33 (1.13, 4.80; AR = 37%) and interaction of long distance from hospital (AHR = 2.98 (1.46 4.39; AR = 5.5%) (Table 6).

Table 6
Predictors of mortality following a road traffic injury, May, 2019 to February 2020

Variables	Categories	Total	RTI deaths	CHR(95%CI)	AHR(95%CI)
Road user category	Pedestrian	168	22	1.00	1.00
	Passengers	234	43	1.47 (.88, 2.46)	1.97 (1.10, 3.52)*
	Drivers	54	15	2.36 (1.22 4.55)	2.61 (1.28 5.30)*
Residence	Urban	264	23	1.00	1.00
	Rural	194	57	3.90 (2.40 6.34)	1.98 (1.02 3.82)*
Hospital arrival time	Within < 1 hour	184	32	1.00	1.00
	Within 1-4hours	176	25	.32 (.45 1.30)	.41 (.16 .63)**
	Within 24 hours	69	20	1.74 (.99 3.05)	.42 (.18 .95)
	After 24 hours	25	3	.64 (.19 2.09)	.40 (.10 1.56)
Systolic BP	≤ 89	53	36	10.07 (6.45 15.71)	3.66 (2.14 6.26)
	> 89	401	44	1.00	1.00
GCS	≤ 8	64	52	32.44 (19.12 55.06)	7.39 (3.08 17.74)**
	9–12	18	8	9.97 (4.39 22.67)	8.15 (3.35 19.82)**
	13–15	372	20	1.00	1.00
Injury site	Non-head injury	262	14	1.00	1.00
	Isolated Head injury	105	33	7.05 (3.77 13.19)	2.28 (1.12 4.65)*
	Combined head injury	87	33	8.50 (4.54 15.89)	2.57 (1.26 5.24)**
Pre-hospital Care # distance	Yes#<60km	93	7	1.00	1.00
	Yes#>60km	79	11	1.74 (.87 3.48)	2.98 (1.46 4.39)*
	No#<60km	217	38	.688 (.25 1.89)	.60 (.28 1.25)
	No#>60km	65	24	3.69 (1.76 7.73)	.81 (.31 2.10)
Key * Significant at P < 0.05, **P < 0.001					

Discussion

The current study demonstrated that deaths following a trauma follow the classical tri-modal pattern in low resource countries and pre hospital care is rarely available for victims of road traffic injuries. Free ambulance transportation was in-available for trauma victims resulting in delay in hospital arrival for accidents sustained on rural roads. Being a driver, accident location at rural areas, low systolic blood pressure and low GCS on admission, injury site and interaction of providing pre hospital care and long distance were found to be predictors of time to death among road traffic injury victims.

The classical tri-modal distribution of trauma deaths was described by Trunkey in 1983 (35). Different previous studies had disproved this traditional distribution of mortalities due to the main reduction in the number of early and late hospital deaths (36). Our study demonstrated that road traffic injury mortality still followed the traditional tri-modal pattern. According to the current study, there were two peaks, one in the first 24 hours and the second at the end of the first week of the injury. Nearly half of the deaths occurred in the hospital after a week of admission. A similar finding was reported by a study conducted at Iran showing two peak times of trauma deaths (28). Poor operative services for severe head injury cases and lack of intensive care unit for severely injured victims could explain the reason for late deaths in our hospital (37). The surgical set up in our case is not optimum to perform surgical intervention for severely injured head injury victims. Besides, there is no well-equipped surgical ICU service to support victims with ventilatory failure. On the other side, the in-availability of pre-hospital basic life support care could have resulted in clinical deterioration of victims that could result in late complications (8).

In this study, none of the victims received pre-hospital care at the scene of injury. This is consistent with previous studies that showed pre-hospital emergency care is under-served or unavailable in most low and middle-income countries (38, 39). The finding is also consistent with a study conducted in Addis Ababa where none of the victims got pre-hospital care (15). The current study also indicated that full package Ambulance service was unavailable for all the victims and only 20% received transportation service without trained personnel accompanying the victims. Our finding is in line with a systematic review indicating Ambulance service was under served in many low and middle income countries (40) and a study conducted in Pakistan that reported majority of participants didn’t want to call Ambulance for emergency cases because the Ambulances didn’t function properly (41). On top of this the available ambulance service was not for free, and victims or the family have to cover cost for fuel and per Diem of drivers. Similar finding was reported from Cambodia (42).

The current study also showed that many trauma victims who were referred from primary hospitals would have been treated at those hospitals. This is in line with a study conducted at Southern India, which showed that trauma care was unnecessarily delayed and liable for unnecessary referrals due to poor resources for trauma case management (30) and another study demonstrated that there are many deficiencies in emergency care services ranging from in-availability of drugs and lack of trainings to provide the required emergency care (43).

According to our study, the overall incidence of road traffic injury deaths was 29 per 100,000 hours of observation. This finding is higher when compared with a study conducted at Tikur Anbessa Hospital, Addis Ababa, which was 10/100,000 hours of observation (15). The discrepancy could be explained by the fact that the Tikur Anbessa Hospital has a better trauma management setup including an intensive care unit (ICU). Hence the quality of care could explain the lesser death at the Tikur Anbessa Hospital (23). Other explanation could be due to the fact that follow up continued after discharge from hospital in the current study, while the mentioned study didn't follow victims after discharge that ignored deaths at home after discharge.

The study revealed that pedestrians are the most frequently affected road user categories as compared to passengers and drivers. This is in line with the federal police commission report (44) and studies conducted in the capital city, Addis Ababa, (45, 46) all showing pedestrians to be the road user categories most frequently affected by RTI. But severe and fatal injuries were more likely to occur among drivers and passengers in our study. This finding was consistent with previous study that indicated fatal injuries were more likely among drivers and passengers (47) but in contradiction to findings in a study that showed pedestrians are more likely to die from a vehicle accident (48).

Our study demonstrated that accidents that were sustained in rural areas were more likely to result in a fatal outcome than those at the urban location. Our finding is consistent with a study conducted by Craig Zwerling and colleagues that showed injury severity and fatality was more than three times higher at rural area than urban areas (49). This could be explained by the fact that most areas of the rural residence lack health care facility and transport access to reach the hospital timely resulting in mismanagement and delays of care. This will, in turn, result in bad outcomes (50). The other possible explanation for the increased mortality in rural residence could be the fact that vehicles are very speedy in the rural areas as a result of poor traffic control. Studies showed that accident intensity increases when a crash is caused by a speedy vehicle (51).

Low systolic blood pressure on admission was significantly associated with time to death among road traffic injury victims. This finding is in line with previous studies that showed victims with low blood pressure on admission were more likely to experience death than their counter parts (14, 52–53). This can be explained by the fact that acute blood loss is very likely in trauma patients that had brought the drop in systolic blood pressure (54). Low systolic blood pressure could increase mortality via poor organ perfusion and consequent organ failure (55). Besides, acidosis from poor perfusion and late complications as nosocomial infection and sepsis are also very likely to occur in patients with hemorrhagic shock (56, 57). These are the possible explanations for low systolic blood pressure and increased mortality.

The current study revealed that hospital arrival time is associated with 30 days of mortality following a road traffic injury. Accordingly, victims who arrived at the hospital between one to four hours were more likely to die than those who arrived within one hour of injury and beyond 4 hours of injury. This is contrary to the concept of the "Golden hour" of trauma that depicts the outcome of trauma was better when victims arrive within one hour of injury (58–59). This could be explained by the fact that victims who are seriously injured and have non-survivable injuries were more likely to be directly transferred to hospital immediately after injury than less severe injury cases, thus increasing the death rate among victims who arrived within 60 minutes of injury.

The study showed an interaction between long distance from the hospital and pre-hospital first aid to be significantly associated with 30 days mortality following a road traffic injury. The possible explanation for this finding could be due to delays in definitive care. Though essential trauma care is vital to treat time-sensitive issues such as airway compromise and severe bleeding, delayed patient transfer, and delays in definitive care also endanger the life of trauma victims (60). This is particularly the case in low resource countries like Ethiopia where the majority of primary hospitals are not in a position to provide essential trauma care (61).

Impact Of The Study

We have calculated the attributable risk for the predictors of mortality. Our study showed that accidents at inter-urban locations had an increased hazard of death when compared with those accidents in urban locations. The increased death in these locations is due to lack of timely care on-site and delays to hospital arrival, mainly due to poor transport access and long distance from the hospital. This finding implies that the establishment of emergency medical services and improved access to health care facilities could reduce such deaths by 21%.

Those victims who had a systolic blood pressure of less than 90 mmHg on admission had a risk of death by more than 3-fold when compared with their counterparts. This implies that maintaining the hemodynamics of victims as early as possible can reduce deaths following an injury by 57%. With this regard, the role of emergency medical response at the scene of the injury and early transfer of victims to definitive care units will have a vital role in reducing reversible causes of mortality.

The study demonstrated that those victims who had head injury had a higher risk of death when compared with non-head injury cases. Accordingly, victims with an isolated head injury and multiple injuries including head injury had more than twice the risk of death when compared with injury to other body regions. Hence, the use of protective materials such as helmet could potentially reduce mortality following a road traffic injury by 26–32%.

Limitation Of The Study

As our participants were only those victims who visited the hospital during the data collection period, deaths at the scene of the injury and minor cases who didn't come to the hospital were excluded. Such exclusion might underestimate the actual injury and mortality from a road traffic injury. Besides, the exclusion of minor cases might introduce selection bias. The time interval between injury and hospital arrival was determined based on self-report or family report. We expect a recall bias in such a stress full situation. The direct cause of death was assessed using verbal autopsy for those deaths that occurred at home after discharge. This may not be precise without autopsy and physician judgment.

Because many of the drivers escape or were arrested after the accidents, we couldn't assess driver-related risk factors such as speed, presence of drunk driving, age, and experience of driving which could be a source of variability for the outcome of the injury.

Conclusion And Recommendations

This study demonstrated that, the classical tri-modal pattern of mortality is still occurring in low resource settings. The study showed that there is a gap in both pre-hospital trauma care and primary trauma care at district hospitals in the study area. Being a driver, accidents at the inter-urban roads, low systolic blood pressure and low GCS on admission and presence of head injuries were predictors of time to death following road traffic injuries.

The regional and zonal health sectors need to revise the pre-hospital trauma care service implementation including Ambulance access and package. The hospital needs to improve trauma care services, especially surgical and supportive interventions such as mechanical ventilatory support for severely injured victims. Future studies should be conducted to assess the capability of primary hospitals in the area in providing essential trauma care, and barriers to establishing emergency medical service in the country at large and study area in particular.

Abbreviations

AHR	Adjusted Hazard Ratio
AR	Attributable Risk
BP	Blood Pressure
CI	Confidence Interval
GCS	Glasgow Comma Scale
HIV	Human Immuno Virus
HR	Heart Rate
ICU	Intensive Care Unit
IMN	Intra Medullary Nailing
IQR	Inter quartile Range
O_2	Oxygen
POP	Plaster of Paris
PR	Pulse Rate
RTI	Road Traffic Injuries
RTS	Revised Trauma Score
RR	Respirator Rate
SBP	Systolic Blood Pressure
SD	Standard Deviation

Declarations

Ethical Approval and Consent for participation

Ethical clearance was obtained from the University of Gondar Ethical review board, and permission letter was obtained from Gondar University Comprehensive Specialized Hospital. Informed written consent was obtained from participants, care givers or proxy as appropriate. The purpose of the study was explained to every victim or an appropriate proxy. On arrival at the emergency department, only hospital arrival time was registered and other information was collected after all the necessary medical care was secured. During our observation, any abnormal finding or complaint such as pain was communicated to the appropriate medical care team for intervention. For those victims who were discharged against medical advice, we continued our follow up by phone and some of them changed their mind and returned back and continued their medical follow up.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Authors' contribution

ZD designed the study, analyzed the data and drafted the manuscript. MY, TA, GB and KG involved in the design of the study, analysis and critically evaluated the manuscript for intellectual content. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interest

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Figures

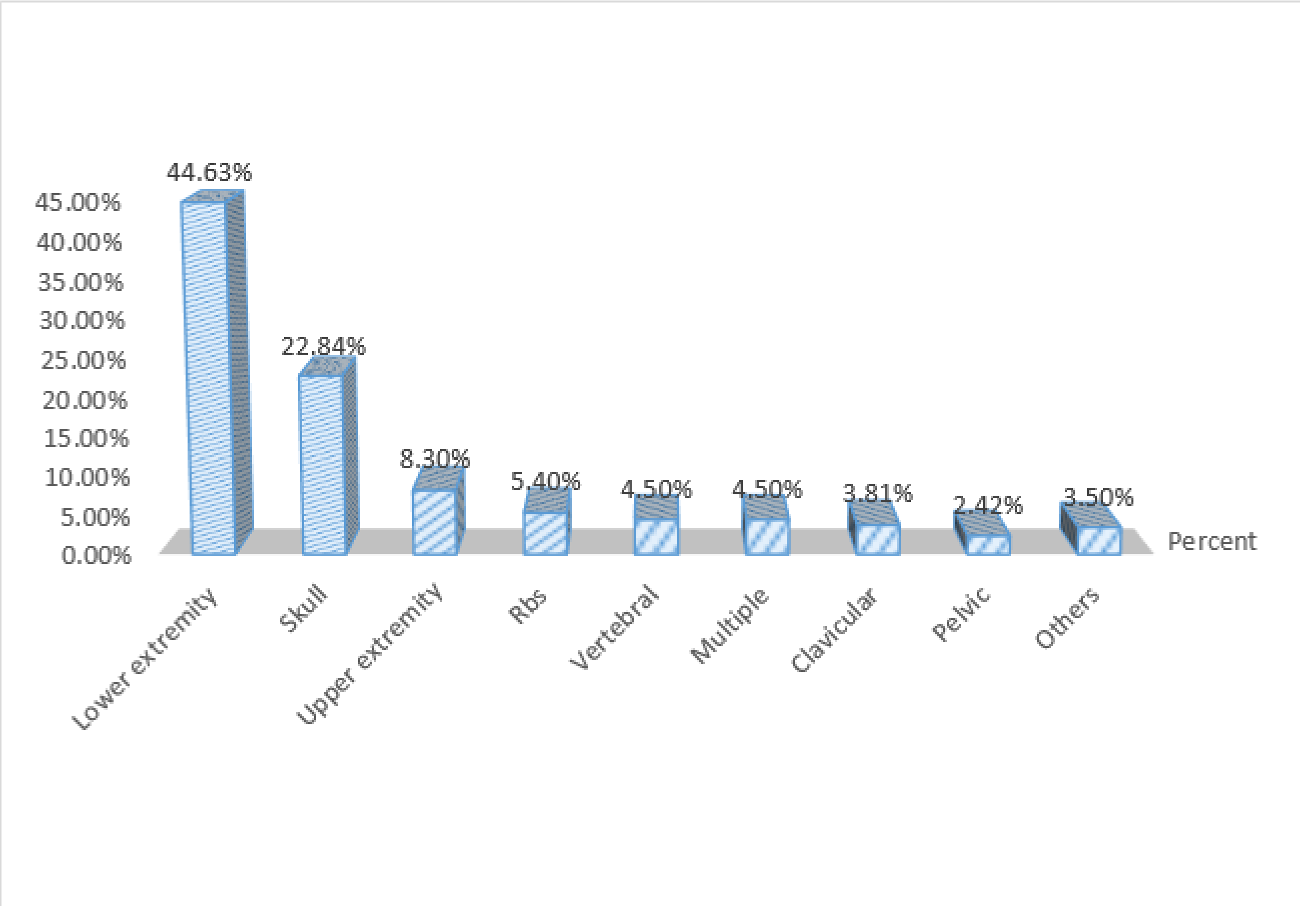

Figure 1

Commonly sustained fractures among RTI victims, Hospital, Ethiopia

Figure 2

Timing distribution of mortality following road traffic injuries, May 6; 2019 to February 30, 2020

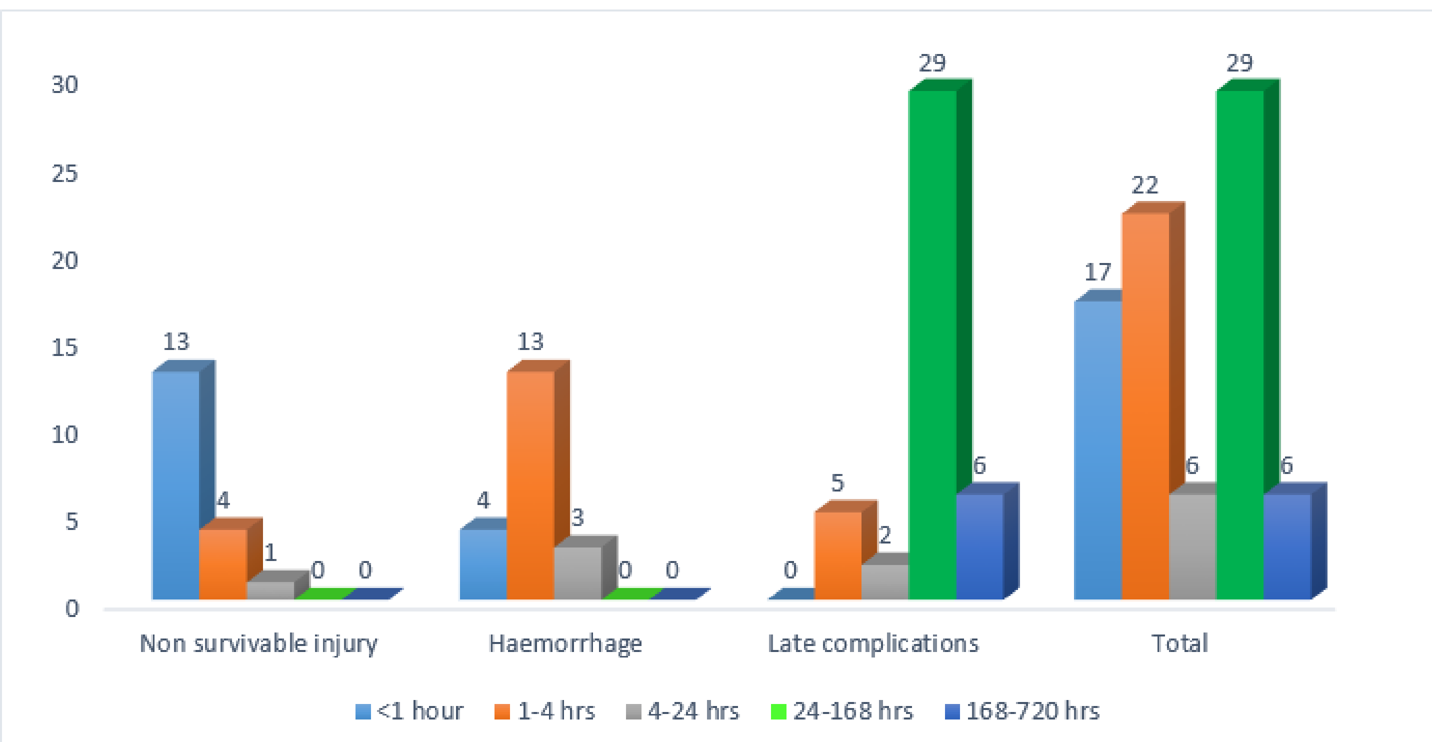

Figure 3

Immediate causes of deaths following a road traffic injury at a specific time interval, May 2019 –February 2020.

Supplementary Files

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- STROBEStatement.docx