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Review of a large trauma registry in Addis Ababa, Ethiopia: insights into prehospital care and provider training for trauma quality improvement

Nichole Starr ,[1] Mengistu Ayehu,[2] Alex Zhuang,[3] Habtamu Tamiru Minalu,[2] Genet Kifle Alemu,[2] Samuel Fisseha,[2] Sisay Chekol,[2] Aklile Habtemariam,[2] Makida Hadis,[2] Biruh Alemtsehay,[2] Minale Mengiste,[2] Ashenafi Kefeni Bori[2]

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[1]University of California San Francisco, San Francisco, California, USA
[2]ALERT Trauma Center, Addis Ababa, Ethiopia
[3]Boston University School of Medicine, Boston, Massachusetts, USA

Correspondence to
Dr Nichole Starr; Nichole.Starr@ucsf.edu

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ABSTRACT

Background Injury is a major cause of death and disability in Ethiopia. ALERT Hospital, one of only three designated trauma centers in the country, has employed a basic trauma registry since its inception in 2016; however, these data had not been used. In joint efforts with the Federal Ministry of Health, we aimed to understand patient injury characteristics and predictors of mortality, to inform priorities in resource and training investments.

Methods Data from 12 816 consecutive patients in the first 3 years of the trauma registry were reviewed retrospectively. Modified Early Warning Score was used at triage to indicate injury severity (red=critically injured, green=minor injury). No physiologic data for calculating Injury Severity Scores or in-hospital intervention data were available. Triage groups were compared and multivariate logistic regression conducted to determine predictors of in-emergency department (ED) mortality.

Results Most patients presented with minor injuries with 64.7% triaged as 'yellow' and 16.4% triaged as 'green', and most (75.9%) referred from another facility. Of those who were critically injured, only 31.0% arrived by ambulance. Most injuries were soft tissue (51.1%) and fractures (23.0%); when stratified by triage category, most critical ('red') patients had sustained head injuries (52.7%). Arrival by ambulance (OR 2.20, p=0.017) and head injury (OR 3.11, p<0.001) were independent predictors of death in the ED.

Conclusion This study of injured patients presenting to an Ethiopian trauma center is one of the largest to date, highlighting the need for more accessible and streamlined prehospital trauma care. Opportunities for improvement include staff training in initial trauma management and implementation of a more comprehensive trauma registry containing physiologic, intervention, and outcomes data to support a robust quality improvement program. Efforts by the Federal Ministry of Health are ongoing to support these improvements in care.

Level of Evidence Level 3, observational study

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Injury is a major cause of death and disability in LMICs including Ethiopia, however trauma quality improvement programs are not well established.

WHAT THIS STUDY ADDS

⇒ This largest trauma registry-based study to date from Ethiopia describes the demographics, transport and referral patterns of a population of trauma patients presenting to a trauma center in an LMIC, highlighting potential areas for improvement.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Investment from local hospitals and Ministries of Health in LMICs into comprehensive trauma registries with quality improvement programs, emergency dispatch systems and provider training in basic and advanced trauma care may improve system efficiency and patient outcomes in the future.

INTRODUCTION

In 2009, the WHO and several international surgical societies published a collection of guidelines for improving the quality and efficacy of trauma care around the world. This joint effort was made in response to the more than 5 million people who lose their lives to injury-related deaths each year, 90% of which occur in low-income and middle-income countries (LMICs).[1] Among the recommendations, the report emphasized the importance of assessing the quality of trauma care in hospitals with tools such as a trauma registry.[2] Trauma registries are an important component of programs to improve trauma care and reduce mortality in both high-income and low-income environments.[3] Although trauma registries are common in high-resource settings, their use is varied in countries with constrained resources and less developed trauma systems. Despite this, many registries have been implemented in low-income settings, including in sub-Saharan Africa, in an effort to improve trauma care.[4–7] Many of these programs use trauma registries to identify and review preventable deaths from trauma and address gaps in specific trauma care processes.[8]

Injury remains a prevalent cause of death and disability in Ethiopia.[9] Although several studies have characterized the volume and types of injury seen at hospitals across Ethiopia,[10–13] particularly noting the high volume of road traffic crashes contributing to trauma volumes,[14] established, permanent trauma

registries outside of short-term studies remain rare.[15] The Ethiopian Ministry of Health has implemented a basic standardized trauma registry throughout major hospitals in Ethiopia. ALERT Hospital Trauma Center is currently one of only three designated trauma centers in the country and has been maintaining this basic trauma registry on patients presenting to the trauma unit since 2016.

Although this trauma registry has been in existence for several years, its data have never been analyzed or used to guide any future priority setting. The aim of this study was to examine the previous 3 years of trauma registry data to describe the patterns of injury and the demographics of patients presenting to the ALERT Trauma Center, identify priority areas for local trauma system improvement, and inform future implementation of a more comprehensive, standardized, and accessible registry.

METHODS

Study setting

ALERT Hospital is a tertiary care hospital in Addis Ababa, the capital city of Ethiopia. It serves a population of approximately 3.5 million and has 20 emergency department (ED) beds, 38 inpatient trauma ward beds, and 10 critical care beds. The hospital has 10 operating rooms, 3 of which are exclusively dedicated to trauma care.

ALERT Hospital Trauma Center was inaugurated in 2015 as one of three dedicated trauma centers in the country. The hospital began a basic trauma registry in 2016 by entering all patients who presented to the trauma ED, a separate building from the medical ED, in a ledger. Data were then later transcribed into the hospital's electronic database (online supplemental appendix 1).

Study design

This was a retrospective cohort review of a previously existing basic trauma registry at one trauma center in Addis Ababa, Ethiopia. The database was maintained by hospital personnel in Microsoft Excel and was deidentified prior to analysis for study purposes. After ethical approval was obtained by the hospital Institutional Review Board, the deidentified database was delivered to study personnel for cleaning and analysis. All entries in the database for the continuous 3 years since its inception were included in the original dataset. The registry was developed by the Ministry of Health and contains information on patient demographics, course of care (mode of arrival, referral status, triage category, time to triage, disposition after triage), diagnostic information (mechanism of injury, diagnosis), and ED outcomes (length of ED stay, disposition status from ED). No information after ED departure was included in the registry, and aside from the initial triage category, which accounts both for mechanism of injury and initial vital signs, no other physiologic or intervention data were included.

Missing data and excluded variables

The Excel format of the registry had additional duplicate or redundant variables (17 total) that were excluded and an additional 5 variables with such little data were also excluded from the analysis, leaving the database with a total of 27 variables in the final analysis (figure 1). The vast majority of patients (12 776, 99.7%) with missing information on the mechanism of injury were ultimately excluded from analysis. Although 2364 patients were recorded to have sustained a road traffic crash, only 12.1% (287) of them contained any information on the type of vehicle involved. All patient records, including those with missing data, were included in this available-case analysis, which captured missing data in respective 'unknown' categories. Missing data numbers are not listed in tables for brevity, but percentages are calculated from total n in each respective category, including missing data.

Data cleaning and analysis

All patients recorded in the trauma registry between September 2016 and March 2019 were included in this study. The dataset was cleaned using Excel V.16.39. Data cleaning involved converting dates from the Ethiopian to Gregorian calendar as well as correcting errors and typos in initial data entry. In the event of an unclear entry, data

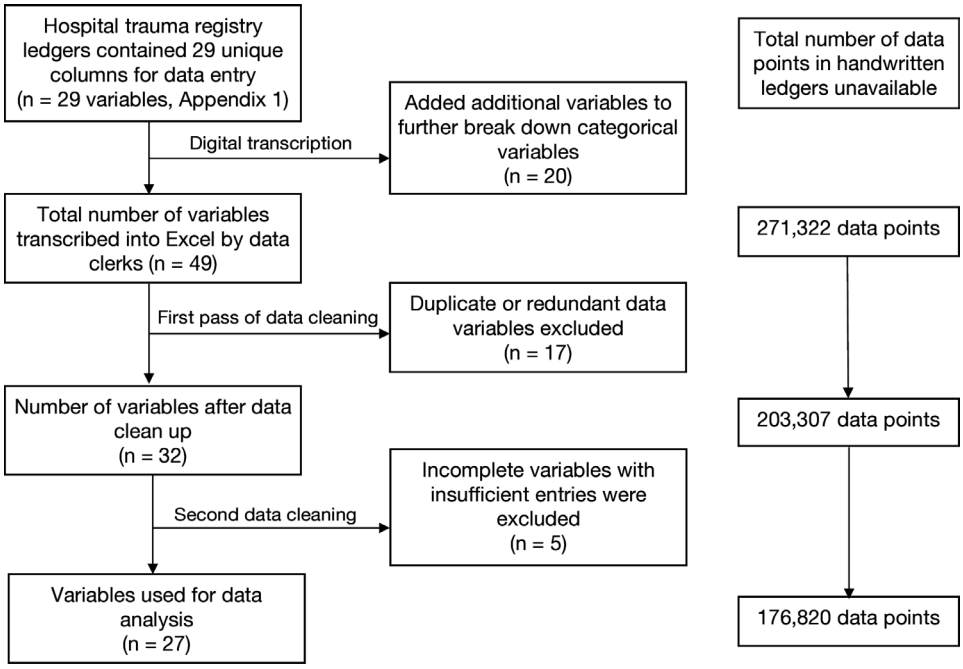

Figure 1 ALERT trauma registry data flow.

Table 1 Modified Early Warning Score (MEWS)

Score	0	1	2	3
Mobility	Walking	With help	Stretcher	
Heart rate	51–100	41–50 or 101–110	≤40 or 111–129	>130
Respiratory rate	9–14	15–20	≤8 or 21–29	>30
Oxygen saturation	≥94%	90–94%	≤90%*	
Temperature	35.1–37.2	37.3–37.9	≤35.0 or ≥38.5	
CNS/AVPU	Alert	Respond to voice	Respond to pain or confused	Unresponsive
Systolic blood pressure	101–199	81–100	71–80 or ≥200	≤70
Trauma	No	Yes		
Pain score	No pain	1–3 of 10	4–7 of 10	≥7 of 10
Red	**Orange**	**Yellow**	**Green**	**Black**
MEWS ≥7	MEWS 5–6	MEWS 3–4	MEWS 3–4	Dead on arrival
OR	OR	AND	OR	
Chest pain		Hgb <8	Hgb <10	
Current seizure	Post-seizure	Previous bleeding		
Hypoglycemia <45		Hematemesis		
Aggressive	Aggressive	Hemoptysis		

*Not for CO poisoning.
AVPU, alert, verbal, pain, unresponsive; CNS, central nervous system; CO, carbon monoxide; Hgb, hemoglobin; MEWS, Modified Early Warning Score.

clerks and hospital staff were consulted, and uninterpretable entries were discarded. Data were analyzed using Stata V.16.1.

Patients were stratified by injury severity based on their vital signs and diagnosis upon triage. Patients are first assigned a numerical score according to the Modified Early Warning Score—a scoring system intended to identify patients at increased risk of clinical deterioration and death, which has been validated in medical and surgical patients.[16 17] Triage categories were organized by color, with 'red' as the most critical category, followed by 'orange', 'yellow', and 'green' in descending order of severity and urgency; 'black' signified patients who were dead on arrival (tables 1 and 2).

Table 2 Overall characteristics (N=12 816)

Age, median (IQR)	27 (21–36)	Triage category	
Sex		Red	480 (3.7%)
Male	9568 (74.7%)	Orange	1481 (11.6%)
Female	3201 (25.0%)	Yellow	8293 (64.7%)
Patient residence		Green	2099 (16.4%)
Addis Ababa	9388 (73.3%)	Black	41 (0.3%)
Amhara	475 (3.7%)	Disposition after triage	
Harar	14 (0.1%)	Resuscitation area	4291 (33.5%)
Oromia	1322 (10.3%)	Operating room/procedure room	2188 (17.1%)
SNNPR	274 (2.1%)	ED examination room	759 (5.9%)
Tigray	38 (0.3%)	Waiting area	4187 (32.7%)
Mode of arrival to hospital		Dead on arrival	21 (0.2%)
Ambulance	1329 (10.4%)	Injury location by AIS body region	
Taxi	3299 (25.7%)	Head	1381 (10.8%)
Self-presentation (walk up)	4039 (31.5%)	Face	264 (2.1%)
Interfacility referral	2878 (22.5%)	Thorax	339 (2.6%)
Private vehicle	727 (5.7%)	Abdomen	101 (0.8%)
Police	35 (0.3%)	Spine	188 (1.5%)
Assisted	113 (0.9%)	Upper extremity	994 (7.8%)
Road traffic crash	2364 (18.4%)	Lower extremity	926 (7.2%)
Road traffic crash type		Patient disposition from ED	
Pedestrian	1861 (78.7%)	Stabilized and discharged from ED	8332 (65.0%)
Motorcyclist	74 (3.1%)	Admitted	1567 (12.2%)
Vehicle occupant	429 (18.1%)	Direct to OR	156 (1.2%)
Referral from other facilities	9725 (75.9%)	Referred out	215 (1.7%)
Referral location		Died in ED	57 (0.4%)
Health center	4675 (48.1%)		
Different hospital	1561 (16.1%)		

AIS, Abbreviated Injury Score; ED, emergency department; OR, operating room; SNNPR, Southern Nations, Nationalities and Peoples' Region.

Each diagnosis entry was assigned a standardized Abbreviated Injury Score body region code. These were further sorted into injury categories within specific body regions, including head, face, thorax, abdomen, spine, upper extremity, lower extremity, and body region not otherwise specified.

Descriptive and summary statistic tables were generated using patient demographic, injury, and hospital course information. Comparative analysis included using X^2 or Kruskal-Wallis tests of significance as appropriate to analyze differences between groups. Univariate and multivariate analyses were also conducted to determine predictors of in-ED mortality.

RESULTS

A total of 12 816 records from the trauma registry were identified and reviewed for this study. Of the 12 816 patients included, median age was 27 (SD 15) years and 9568 (74.7%) were male (table 2). Most patients lived in Addis Ababa (9388, 73.3%); the second most common region of residence was Oromia (1322, 10.3%), which surrounds Addis Ababa. Most patients self-presented to the ED (n=4039, 31.5%); 25.7% (3299) arrived by taxi, whereas only 10.4% (1329) arrived by ambulance. Most patients were referred to ALERT from an outside center (n=9725, 75.9%). Approximately half of patients were referred from a health center (n=4675, 48.1%), whereas others were either referred from a secondary or tertiary hospital (n=1561, 16.1%).

Triage category, injuries and disposition after triage

Most patients were triaged in the 'yellow' triage category (n=8293, 64.7%), whereas 480 (3.7%) were 'red' (table 2). After initial triage, about one-third of patients were transferred to the resuscitation area (n=4291, 33.5%), and another one-third went back to the waiting area (n=4187, 32.7%). The rest of patients either went directly to the operating/procedure room (n=2188, 17.1%) or an unmonitored ED examination room (n=759, 5.9%). 18% (n=2364) of patients were involved in a road traffic crash; of these, the majority (1861, 78.7%) were pedestrians. Most (65.0%) patients were stabilized and discharged from the ED; 12.2% (1567) were admitted to the hospital, and few (57, 0.4%) patients died in the ED.

Demographics, injuries and outcomes by triage category

Of the most severely injured 'red' patients (480), 31.0% (149) presented by ambulance, compared with 4.2% (87) of 'green' patients (table 3). 19% of red patients (90) and 45.1% (946) of green patients presented by themselves without vehicular assistance. 32% of red patients (155) were sent to the operating/procedure room after triage, whereas 24.9% (119) returned to the waiting area and 19.8% (95) were sent to the resuscitation area. These proportions are reflected similarly in the breakdown of orange patients' disposition after triage, with 34.8% (515) going to the operating/procedure room, 25.1% (371) to the waiting area, and 21.3% (316) to the resuscitation area.

Soft tissue injuries (5584, 43.6%) and fractures/dislocations (2489, 19.4%) were the most common injuries (table 4). 'Red' patients were most likely to present with head injuries (253, 52.7%) such as traumatic brain injuries and intracranial bleeds, whereas green patients were most likely to present with soft tissue injuries (1310, 62.4%) (table 3). The vast majority of upper (82.8%) and lower extremity injuries (88.3%) consisted of fractures/dislocations, most of which were assigned a yellow triage category. Although many of the differences between variables by triage category reached statistical significance, it was beyond the scope of the article to explore detailed statistical differences between individual triage category groups.

Most green patients (1665, 79.3%) were stabilized and discharged from the ED, 4.2% (89) were admitted, and 0.6% (12) died in the ED (table 3). Meanwhile, 29.2% of red patients (140) were stabilized and discharged, 31.5% (151) were admitted, and 4.6% (22) died in the ED. The ED length of stay was not reliably recorded in the registry and therefore not included in this analysis.

Predictors of ED mortality

A multivariate logistic regression analysis was performed to examine predictors of mortality in the ED. When controlling for age, gender, and triage severity category, residence in Addis Ababa (OR=0.52, p=0.049) and interfacility transfer (OR=0.17, p=0.001) predicted lower likelihood of in-ED mortality (table 5). Patients who arrived by ambulance (OR=2.20, p=0.017) and had sustained head injury (OR=3.11, p<0.001) had increased odds of death in the ED.

DISCUSSION

This study represents the largest population of injured patients studied in Ethiopia to date. Analysis of the first 3 years of the ALERT Trauma Center trauma registry reveals several important issues in the functioning of the trauma center as well as the trauma response system in Addis Ababa and may be used to highlight areas of potential improvement.

Prehospital care and initial patient triage

The small proportion of critically injured patients arriving by ambulance highlights gaps in the prehospital care system and elucidates opportunities for more robust ambulance services and communication networks to expedite patient transport. A recent large-scale study from Malawi noted similar problems in long transport times for patients with serious injuries and highlighted the importance of improved emergency medical services.[18] Similarly in Nigeria, a high proportion of patients were transported to trauma centers by laypersons with long transport times.[19] The pattern of a high proportion of road traffic accidents and intracranial injuries among those seriously injured was also seen in a recent study in Tanzania using data from the WHO model trauma registry.[20] In cases of seriously injured patients with head injury, rapid transport to a trauma center with highest level of care provides the best opportunity for survival. In this setting, a potential opportunity for improvement could be greater access to ambulance services for critically injured patients to receive immediate care during transport and reach the trauma center as rapidly as possible.

Although critically injured patients should be prioritized to receive ambulance transport to trauma centers, conversely, low-acuity patients can safely be treated at lower levels of care. The high number of soft tissue injuries and low-acuity patients treated at ALERT creates difficulties in patient flow, rapid triage, and treatment at one of the few designated trauma centers in Ethiopia. Many of these minor injuries could likely be treated at lower levels of care, freeing space at the trauma center to manage more complex injuries but need to be managed through an improved prehospital triage process to ensure the correct mix of patients is optimized at each level of care. Currently, the Federal Ministry of Health is developing a centralized ambulance dispatch call center for Addis Ababa and constructing ambulance 'hubs' distributed throughout the city for more coordinated and timely prehospital response. The Ministry of Transport has also

Table 3 Demographics and injury by triage category

Factor	Red	Orange	Yellow	Green	P value
N	480	1481	8293	2099	
Age, median (IQR)	28 (23–38)	28 (22–38)	27 (21–35)	27 (20–35)	<0.001
Sex					<0.001
Male	389 (81.2%)	1199 (81.1%)	6173 (74.5%)	1484 (70.9%)	
Female	90 (18.8%)	280 (18.9%)	2108 (25.5%)	609 (29.1%)	
Patient residence					<0.001
Inside Addis Ababa	253 (52.7%)	968 (65.4%)	6193 (74.7%)	1674 (79.6%)	
Outside Addis Ababa	130 (27.0%)	321 (21.7%)	1342 (16.2%)	270 (12.9%)	
Mode of arrival to hospital					<0.001
Ambulance	149 (31.0%)	308 (20.8%)	772 (9.3%)	87 (4.2%)	
Taxi	69 (14.4%)	250 (16.9%)	2404 (29.0%)	546 (26.0%)	
Self-presentation (walk up)	90 (18.6%)	344 (23.2%)	2545 (30.7%)	946 (45.1%)	
Interfacility referral	139 (29.0%)	452 (30.5%)	1839 (22.2%)	345 (16.4%)	
Private vehicle	21 (4.4%)	84 (5.7%)	504 (6.1%)	112 (5.3%)	
Police	0 (0.0%)	8 (0.5%)	18 (0.2%)	7 (0.3%)	
Assisted	2 (0.4%)	9 (0.6%)	84 (1.0%)	13 (0.6%)	
Referral from other facilities	399 (83.1%)	1173 (79.2%)	6482 (78.2%)	1493 (71.1%)	<0.001
Referral location					<0.001
Health center	141 (29.4%)	502 (33.9%)	3189 (38.5%)	767 (36.5%)	
Other hospitals	163 (34.0%)	323 (21.8%)	926 (11.2%)	113 (5.4%)	
Disposition after triage					<0.001
Resuscitation area	95 (19.8%)	316 (21.3%)	2865 (34.5%)	895 (42.6%)	
Operating room/procedure room	155 (32.3%)	515 (34.8%)	1320 (15.9%)	154 (7.3%)	
ED examination room	26 (5.4%)	78 (5.3%)	579 (7.0%)	67 (3.2%)	
Waiting area	119 (24.8%)	371 (25.1%)	2812 (33.9%)	840 (40.0%)	
Road traffic crash	143 (29.8%)	361 (24.4%)	1531 (18.5%)	294 (14.0%)	<0.001
Road traffic crash type					0.057
Pedestrian	121 (84.6%)	295 (81.7%)	1195 (78.1%)	220 (74.8%)	
Motorcyclist	3 (2.1%)	17 (4.7%)	45 (2.9%)	8 (2.7%)	
Vehicle occupant	19 (13.3%)	49 (13.6%)	291 (19.0%)	66 (22.4%)	
Patient disposition from ED					<0.001
Stabilized and discharged from ED	140 (29.2%)	595 (40.2%)	5765 (69.5%)	1665 (79.3%)	
Admitted	151 (31.5%)	484 (32.7%)	805 (9.7%)	89 (4.2%)	
Direct to OR	30 (6.3%)	46 (3.1%)	72 (0.9%)	5 (0.2%)	
Referred out	20 (4.2%)	41 (2.8%)	119 (1.4%)	31 (1.5%)	
Died in ED	22 (4.6%)	5 (0.3%)	15 (0.2%)	12 (0.6%)	

ED, emergency department; OR, operating room.

supported several training events for drivers to receive basic first responder training for road traffic accidents. The results from this study provide convincing support for this service expansion.

ED triage and resuscitation

Overall, in the ED, mortality was low at 0.5%. However, 12 (0.6%) of patients triaged as 'green' died in the ED. This would suggest that either a serious injury was missed, or these patients may have been triaged inappropriately. In such circumstances, a death audit could be performed to identify the exact details related to these patient presentations and a preventable death review by the trauma quality improvement committee. Furthermore, the disposition after triage also points to potential inefficiencies in workflow, with nearly half of 'green' patients being sent to the resuscitation area, which is typically intended for more critically injured patients. Conversely, about one-third of critically ill patients were sent to the waiting room after triage, emphasizing the need for staff trauma training and restructuring of triage systems so that patients are immediately allocated to the appropriate level of care on arrival. These findings could serve as a basis for incentivizing the establishment of trauma quality improvement programs to conduct routine preventable death reviews and identify opportunities for improvement, which do not currently exist in any robust form in Ethiopia.

Health center referrals

The large number of referrals from health centers is also related to the organization of prehospital transport and referral structures. Rather than being referred to receive clinical care, as most of the referrals were for patients with low triage acuity, anecdotally, many of these patients were referred to have medicolegal documentation completed, which can only be performed by physicians. Although data regarding reason for referral were not specifically documented in the registry, the frequent patient presentation from health centers for medicolegal documentation is well-known among Ethiopian physicians. The burden of this documentation being transferred to treating physicians at trauma centers can distract from the time dedicated to clinical service provision for more severely injured

Table 4 Injury types overall and by triage category

Factor	Total	Red	Orange	Yellow	Green	P value
N	12 816	480	1481	8293	2099	
Injury by AIS head	1381 (10.8%)	253 (52.7%)	345 (23.3%)	687 (8.3%)	75 (3.6%)	<0.001
Head injury NOS	15 (1.1%)	2 (0.8%)	3 (0.9%)	8 (1.2%)	2 (2.7%)	
Skull fracture	208 (15.1%)	9 (3.6%)	40 (11.6%)	138 (20.1%)	18 (24.0%)	
Mild TBI	571 (41.3%)	42 (16.6%)	145 (42.0%)	350 (50.9%)	30 (40.0%)	
Moderate TBI	291 (21.1%)	79 (31.2%)	97 (28.1%)	93 (13.5%)	17 (22.7%)	
Severe TBI	112 (8.1%)	92 (36.4%)	12 (3.5%)	4 (0.6%)	1 (1.3%)	
Intracranial bleed	163 (11.8%)	29 (11.5%)	45 (13.0%)	79 (11.5%)	4 (5.3%)	
Scalp laceration	21 (1.5%)	–	3 (0.9%)	15 (2.2%)	3 (4.0%)	
Injury by AIS face	264 (2.1%)	2 (0.4%)	31 (2.1%)	181 (2.2%)	44 (2.1%)	0.52
Ophthalmic injury	18 (6.8%)	–	–	16 (8.8%)	2 (4.5%)	
Oral/dental injury	41 (15.5%)	–	4 (12.9%)	30 (16.6%)	7 (15.9%)	
Facial laceration	51 (19.3%)	–	5 (16.1%)	33 (18.2%)	10 (22.7%)	
Facial fracture	154 (58.3%)	2 (100.0%)	22 (71.0%)	102 (56.4%)	25 (56.8%)	
Injury by AIS thorax	339 (2.6%)	14 (2.9%)	42 (2.8%)	247 (3.0%)	29 (1.4%)	<0.001
Thoracic trauma NOS	4 (1.2%)	1 (7.1%)	1 (2.4%)	2 (0.8%)	–	
Blunt thoracic trauma	79 (23.3%)	3 (21.4%)	6 (14.3%)	60 (24.3%)	9 (31.0%)	
Penetrating thoracic trauma	22 (6.5%)	2 (14.3%)	6 (14.3%)	13 (5.3%)	1 (3.4%)	
Hemothorax	35 (10.3%)	3 (21.4%)	12 (28.6%)	18 (7.3%)	2 (6.9%)	
Rib fracture	96 (28.3%)	5 (35.7%)	10 (23.8%)	71 (28.7%)	5 (17.2%)	
Clavicle fracture	91 (26.8%)	–	4 (9.5%)	75 (30.4%)	11 (37.9%)	
Scapular fracture	12 (3.5%)	–	3 (7.1%)	8 (3.2%)	1 (3.4%)	
Injury by AIS abdomen	101 (0.8%)	10 (2.1%)	22 (1.5%)	57 (0.7%)	11 (0.5%)	0.12
Abdominal trauma NOS	9 (8.9%)	1 (10.0%)	3 (13.6%)	3 (5.3%)	2 (18.2%)	
Blunt abdominal trauma	68 (67.3%)	6 (60.0%)	9 (40.9%)	44 (77.2%)	8 (72.7%)	
Penetrating abdominal trauma	24 (23.8%)	3 (30.0%)	10 (45.5%)	10 (17.5%)	1 (9.1%)	
Injury by AIS spine	188 (1.5%)	8 (1.7%)	59 (4.0%)	109 (1.3%)	8 (0.4%)	<0.001
Lumbar spine fracture	16 (8.5%)	–	6 (10.2%)	8 (7.3%)	2 (25.0%)	
Thoracic spine fracture	1 (0.5%)	–	–	–	–	
Cervical spine fracture	36 (19.1%)	3 (37.5%)	8 (13.6%)	24 (22.0%)	–	
Spinal cord injury	135 (71.8%)	5 (62.5%)	45 (76.3%)	77 (70.6%)	6 (75.0%)	
Injury by AIS upper extremity	994 (7.8%)	8 (1.7%)	62 (4.2%)	764 (9.2%)	148 (7.1%)	0.087
Injury NOS	103 (10.4%)	4 (50.0%)	8 (12.9%)	76 (9.9%)	15 (10.1%)	
Fracture/dislocation	823 (82.8%)	4 (50.0%)	50 (80.6%)	632 (82.7%)	125 (84.5%)	
Soft tissue injury/infection	46 (4.6%)	–	3 (4.8%)	36 (4.7%)	7 (4.7%)	
Amputation	22 (2.2%)	–	1 (1.6%)	20 (2.6%)	1 (0.7%)	
Injury by AIS lower extremity	926 (7.2%)	21 (4.4%)	181 (12.2%)	655 (7.9%)	61 (2.9%)	<0.001
Injury NOS	11 (1.2%)	0 (0.0%)	2 (1.1%)	8 (1.2%)	1 (1.6%)	
Fracture/dislocation	818 (88.3%)	16 (76.2%)	158 (87.3%)	583 (89.0%)	53 (86.9%)	
Soft tissue injury/infection	7 (0.8%)	–	–	5 (0.8%)	2 (3.3%)	
Amputation	1 (0.1%)	1 (4.8%)	–	–	–	
Sprain	18 (1.9%)	–	1 (0.6%)	15 (2.3%)	2 (3.3%)	
Pelvic trauma NOS	1 (0.1%)	–	–	1 (0.2%)	–	
Pelvic fracture	67 (7.2%)	4 (19.0%)	20 (11.0%)	40 (6.1%)	3 (4.9%)	
Genital trauma	3 (0.3%)	–	–	3 (0.5%)	–	
Injury by body region NOS	6612 (51.6%)	86 (17.9%)	449 (30.3%)	4491 (54.2%)	1472 (70.1%)	<0.001
Soft tissue injury	5584 (84.5%)	42 (48.8%)	323 (71.9%)	3812 (84.9%)	1310 (89.0%)	
Burn	219 (3.3%)	10 (11.6%)	28 (6.2%)	129 (2.9%)	46 (3.1%)	

AIS, Abbreviated Injury Score; NOS, not otherwise specified; TBI, traumatic brain injury.

patients. Further study on the reasons for trauma center referral and medicolegal documentation process may help identify possible opportunities for improvement. Although the ambulance dispatch system may help to address some of these inappropriate referrals, education is needed at the health center level, as well as consideration of appointing more general physicians at health centers to alleviate the burden of injury documentation being performed at the trauma center. A more widely implemented trauma intake form that can serve as a medicolegal document nationwide would be another potential solution.

Expansion of trauma registry data

To fully use data on injured patients to inform improvement efforts at the facility level and beyond, an integrated and comprehensive trauma registry is necessary. However, this has been difficult to implement and maintain at the

Table 5 Univariate and multivariate predictors of death in ED

	Univariate logistic regression			Multivariate logistic regression		
	OR	95% CI	P value	OR	95% CI	P value
Age (years)	1.01	0.99 to 1.03	0.206			
Male gender	0.71	0.37 to 1.37	0.310			
Triage category						
Red	18.83	10.89 to 32.54	<0.001			
Orange	0.76	0.30 to 1.92	0.568			
Yellow	0.19	0.10 to 0.34	<0.001			
Green	1.29	0.68 to 2.45	0.434			
Referred from hospital	1.75	0.86 to 3.56	0.125			
Patient resides in Addis Ababa	0.43	0.23 to 0.81	0.008	0.52	0.27 to 1.00	0.049
Arrival by:						
Ambulance	3.12	1.70 to 5.72	<0.001	2.20	1.15 to 4.19	0.017
Taxi	1.20	0.66 to 2.17	0.548			
Self	0.59	0.32 to 1.08	0.087			
Interfacility	0.21	0.08 to 0.59	0.003	0.17	0.06 to 0.48	**0.001**
Primary injury location						
Head	5.17	3.01 to 8.89	<0.001	3.11	1.73 to 5.59	<0.001
Face	1.76	0.43 to 7.26	0.435			
Thorax	1.00					
Abdomen	1.00					
Spine	2.84	0.68 to 11.75	0.151			
Upper extremity	0.46	0.11 to 1.88	0.279			
Lower extremity	0.50	0.12 to 2.06	0.338			
Soft tissue NOS	0.58	0.34 to 0.98	0.043	0.82	0.47 to 1.43	0.485

ED, emergency department; NOS, not otherwise specified.

hospital level thus far. A study of injured patients at Yekatit 12 and Black Lion Hospitals in Addis Ababa demonstrated a high prevalence of trauma and poor outcomes for severely injured trauma patients and called for the implementation of trauma registries to better track patient care and outcomes in trauma,[21] which was subsequently implemented with higher-quality data.[22] Similarly, in Mekele, Ethiopia, a retrospective study found a high prevalence of traumatic injuries in EDs, primarily from interpersonal violence, falls, and road traffic accidents, and also called for the implementation of a trauma registry for higher-quality data.[23] One study including patients from two referral hospitals in Addis Ababa found a higher than expected mortality rate by Injury Severity Score,[21] highlighting the importance of not only cataloging injury data with comprehensive registries, but identifying opportunities for trauma quality and outcome improvement initiatives as well. As a next step at ALERT Trauma Center, a more detailed trauma registry with information on physiologic data and interventions will be implemented, and staff will be trained to improve data completeness. This registry, using the WHO trauma intake form and standardized WHO trauma registry, will allow for injury scoring and more details on ED and hospital interventions, as well as inpatient complications and discharge outcomes, all of which are essential for understanding current practices and identifying improvements at the hospital level. This more comprehensive registry will inform a facility-based quality improvement program as part of a national initiative to strengthen trauma care in Ethiopia. A similar process has been undertaken in Tanzania, lessons from which may pave the way for implementation in Ethiopia.[24]

Limitations

Data incompleteness posed a significant limitation in the evaluation of this trauma registry. The retrospective nature of this study made real-time improvement of data quality impossible, and as data clerks recorded entries by hand, this method produced a significant number of errors and missing information in the registry. Although the clerks were trained in data collection protocols, they were not able to consistently capture pertinent information. For example, date and time entry formats were not standardized, and many words were incorrectly transcribed from the ledger into the electronic database. These errors in data transcription and entry further support the notion of an electronic data capture mechanism. Also, the available-case approach to analyzing datasets with missing entries can introduce bias; however, in our analysis, the likelihood of such bias was minimal because the causes of missing data were unlikely to have been systematic or associated with outcomes.

Furthermore, physiologic data necessary to calculate Injury Severity Scores and interventions performed in the ED were not included in this registry. Additionally, in-hospital interventions and outcomes, including those routinely included in most trauma registries such as hospital length of stay, prevalence and cause of overall mortality, and intensive care unit outcomes are not available in this registry. Individual chart review was deemed to be too difficult and costly for the scope of this project as paper charts must be individually collected from the record room and many paper records are incomplete. It is difficult to target and prioritize areas for improvement without this more granular understanding of care provided at the patient level. Additionally, causes and timing of patient deaths were not available in the registry; therefore, it is difficult to infer detailed interventions

that may have had the highest impact for these patients. This registry has been modified and at present, a more comprehensive trauma registry is being used at ALERT Hospital following the WHO trauma intake format.

Studies on trauma registry implementation in LMICs demonstrate an enormous range of form completion rates, ranging from 21% to 90%.[25–27] One study in Ethiopia at Tikur Anbessa Hospital characterized the successes and challenges of standardized trauma registry form implementation, noting that data capture rate was low, and that lack of training and supervision was a key challenge to form completion.[28] Furthermore, it is difficult to evaluate the types and quality of in-hospital services provided as the registry did not contain such information. Patient charts also commonly do not document all ED interventions or procedures. A more comprehensive registry is needed and currently beginning implementation to capture more information regarding in-hospital trauma care. Ideally, this would be integrated with the medical record to avoid duplication of data collection and overburdening the staff with clerical tasks of registry data collection.

CONCLUSION

Many sub-Saharan nations have underdeveloped trauma systems,[29] including Ethiopia which is currently pursuing nationwide efforts to improve the care of injured patients. This pilot trauma registry study offers important insights into the volume and type of trauma seen at one of the three major trauma centers in Ethiopia, as well as to the necessary changes in coordination of trauma care services, prehospital transport, triage, and resuscitation practices. Findings from this study highlight the need for more robust and high-quality trauma data in Ethiopia, as well as the establishment of trauma quality improvement programs to identify opportunities for change and implement measures to improve patient care. As part of a collaboration with the Federal Ministry of Health and the WHO, a more comprehensive trauma registry is being implemented at seven newly designated trauma hospitals in Ethiopia. Prehospital services are also being scaled and training of prehospital providers enhanced in Addis Ababa. Through the dedicated efforts of clinicians and public health practitioners in Ethiopia, the key learning from this study and others will help inform improvements to the care of injured patients nationwide.

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ORCID iD

Nichole Starr http://orcid.org/0000-0003-0714-5512

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