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ORIGINAL SCIENTIFIC REPORT

Trauma Surveillance and Registry Development in Mozambique: Results of a 1-Year Study and the First Phase of National Implementation

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Abstract

Background Mozambique has had no policy-driven trauma system and no hospital-based trauma registries, and injury was not a public health priority. In other low-income countries, trauma system implementation and trauma registries have helped to reduce mortality from injury by up to 35%. In 2014, we introduced a trauma registry in four hospitals in Maputo serving 18,000 patients yearly. The project has since expanded nationally. This study summarizes the challenges, results, and lessons learned from this large national undertaking.

Methods Between October 2014–September 2015, we implemented a trauma registry at four hospitals in Maputo. In October 2015, the project began to be expanded nationally. Physicians and allied health professionals at each hospital were trained to implement the registry, and each identified and trained data collectors. We conducted semi-structured interviews with the key stakeholders of this project to identify the challenges, results, and creative solutions implemented for the success of this project.

Results Most participants identified the importance of having a trauma registry and its usefulness in identifying gaps in trauma care. The registry identified that less than 5% of injured patients arrived by ambulance, which served as evidence for the need for a prehospital system, which the Ministry of Health had already begun implementing. Participants also highlighted how the registry has allowed for a structured clinical approach to patients, ensuring that severely injured patients are identified early. Challenges reported included the high rates of missing data, the difficulty in establishing a streamlined flow of trauma patients within each hospital, and the bureaucratic challenges faced when attempting to improve capacity for trauma care at each hospital by introducing a trauma bay and new technologies. Participants identified the need to improve data completeness, to disseminate the results of the project nationally and internationally, to improve inter-divisional cooperation, and to continue educating health providers on the importance of registries. Participants also identified political instabilities in the region as a potential source of challenge in expanding the project nationally; they also identified the lack of uniform resource allocation and low personnel in many areas, especially rural, as a major burden that would need to be overcome.

Conclusion Introduction of a trauma registry system in Mozambique is feasible and necessary. Initial findings provide insight into the nature of traumas seen in Maputo hospitals, but also underscore future challenges, especially in minimizing missing data, utilizing data to develop evidence-based trauma prevention policies, and ensuring the sustainability of these efforts by ensuring continued governmental support, education, and resource allocation. Many of these measures are being undertaken.

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Introduction

Injuries are a leading cause of global morbidity and mortality [1] and have a larger social, economic, and health impact than the world's most common infectious diseases [2]. The burden of injury is often greater in low- and middle-income countries (LMICs) than in higher-income countries [1–3]. Lack of sufficient human and material resources, the absence of organized trauma systems, and inadequate injury surveillance compound this problem.

Of all global injury-related mortality, about 90% occur in LMICs. Injury is expected to contribute 20% of global mortality by the year 2020 [4]. Most LMICs lack a robust post-injury rehabilitation or support infrastructure, which has a socioeconomic impact estimated at $500 billion yearly [5]. Despite the massive scale of the problem, and several calls from leading global health institutions, it is only recently that the global public health community has embraced the need for a concerted, global effort to tackle injury. The gap in injury care is most pronounced when it comes to injury surveillance in LMICs, which highlights the importance of monitoring in guiding effective strategies in global health [6–8]. It is only with better knowledge of injury-related epidemiology that a systematic, cost-effective approach to tackle this challenge will be feasible.

Mozambique, a low-income country according to the World Bank, has had no active injury surveillance and monitoring to date. About 69% of the country's 26.5 million residents live in rural areas, 31% in urban areas, and there is an increasing urbanization rate at 3% annually [9–11]. Consequently, there has been a rise in motorization, population density, and an increase in urban injury patterns, including motor vehicle collisions [12, 13]. These developments have put further strain on an already stretched health system.

Given the above considerations, a trauma registry was implemented in Mozambique in October 2014. This study's purpose is to show that the collection of hospital-based minimal trauma data sets is a feasible project in LMIC settings and can identify gaps in the trauma system to address in a targeted fashion.

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Methods

Partnership and planning phase

In 2013, the Center for Global Surgery at the McGill University Health Centre, an academic institution focussed on developing global partnerships to improve trauma and emergency surgical capacity through research and training, was invited to partner with several Mozambican stakeholders for the development of a robust injury surveillance capacity in Mozambican hospitals. Partners included the Ministry of Health (MOH), the Central Maputo Hospital (CMH), the National Institute of Health (NIH), and the Eduardo Mondlane Faculty of Medicine.

Ethics approval

Ethics approval was obtained from both the Institutional Review Board of the McGill University Faculty of Medicine and the Eduardo Mondlane Faculty of Medicine and National Institute of Health Ethics Boards.

Setting

The trauma registry (TR) was implemented in four Maputo hospitals (Table 1) which together serve approximately 19,000 injured patients annually after the successful implementation of a pilot study [12]. Selected healthcare professionals were trained in the use of the registry at the research hospitals. We report on data collected between August 2014 and September 2015.

Registry and data entry

The data in the TR are levied on an official Ministry of Health paper form in Portuguese, and the data are transcribed to an electronic record, iTRAUMA^{TM}, designed to run as a native, HTML-based application on the iOS operating system. The paper registry form became a formal component of the official patient record.

The TR contains the following sections: Patient Identifier Number; Demographic Information; Details of Injury; Injury Mechanism; Road Traffic Incident Details; Clinical Assessment of Patient and Injuries including Injury Severity and Anatomic Descriptors; and Outcomes. A time stamp and signature by the physician would complete the form.

The clinical assessment component incorporated the Kampala Trauma Score 2 [14]. The KTS2 has been shown to perform as well as more comprehensive scoring systems to calculate a probability of survival (Ps). An integral part of the trauma registry is the collection of physical vital

Table 1 Number of patients assessed per month in the four enrolled hospitals between August 2014 and September 2015

Date (year-month)	Central Maputo Hospital	Jose Macamo Hospital	Mavalene Hospital	Matola Hospital	Grand total
2014-Aug	418	298	265	176	1157
2014-Sep	429	236	261	187	1113
2014-Oct	441	223	240	191	1095
2014-Nov	446	312	185	145	1088
2014-Dec	413	245	202	155	1015
2015-Jan	489	232	195	159	1075
2015-Feb	488	202	197	198	1085
2015-Mar	423	221	161	152	957
2015-Apr	557	301	204	171	1233
2015-May	517	215	199	156	1087
2015-Jun	525	221	178	167	1091
2015-Jul	448	278	198	179	1103
2015-Aug	370	241	177	147	935
2015-Sep	507	213	178	171	1059
Grand total	6471	3438	2840	2354	15103

signs of injured patients such as blood pressure, pulse, and respiratory rate. In addition to identifying the sickest patients who would need immediate intervention (often including surgery), these parameters make it possible to calculate a trauma score for each patient and allow a standardized assessment of injuries for both planning and research purposes [15–17]. These scores are also essential for quality assurance and improvement in trauma care delivery and allow for stratified and baseline comparison between different sites. Our registry utilized the Kampala Trauma Score 2 that is adapted to environments such as Mozambique [14]. This score has been validated in several low- and middle-income settings as performing on par with more advanced scoring tools such as the Injury Severity Score or the Revised Trauma Score [18].

Data analysis

Standard descriptive and summary statistics were generated for the demographic, personal, injury, and physical assessment characteristics of the cohort. The primary analysis used means and standard deviations (SD), medians and interquartile ranges (IQR), and proportions to provide an overview of patient descriptors, injury mechanism, physical examination results, and outcomes.

Comparative proportional analyses were conducted to assess for temporal data completeness patterns, with missing cells and categories marked as "Other" considered to be missing. The registry should not have empty cells as the classes are comprehensive.

We cross-tabulated patient descriptors, injury mechanisms, physical examination results, and outcomes across the different hospitals and for the overall cohort.

Results

Patient demographics

Data were collected on 15,103 patients in the four participating hospitals (See Table 1). The largest number of injured patients was treated at Central Maputo Hospital (6471/15103, 44%), followed by Jose Macamo Hospital (3438/15103, 24%), Mavalene General Hospital (2840/15103, 18%), and Matola Hospital (2354/15103, 14%). A majority (6745/15103, 62%) of the population were men, and the mean age was 26.5 (±16.7). Just over a third had at least a secondary school education level (5286/15103, 35%), followed by (4229/15103) 28% with a primary school level. The majority of patients were adults above the age of 18 (9666/15103, 64%), (2114/15103) 14% were marked as children (ages 1–18), and the rest were missing age information. The majority of adult patients were employed (6343/15103, 42%), most commonly as manual laborers (2869/15103, 19%). The majority of injured patients arrived at the ED by private vehicles (5588/15103, 37%), followed by (4228/15103, 28%) on foot and (755/15103, 5%) by a medical vehicle such as ambulance or hospital transport car. However, the mode of transport varied substantially across hospitals (Table 2).

Table 2 Patient demographics and mode of patient arrival to the four enrolled hospitals between August 2014 and September 2015

Characteristics	Central Maputo	Jose Macamo	Mavalene	Matola	Grand total
Sex					
Male (%)	3106 (49.2)	1140 (41.5)	1415 (67.2)	1084 (64.9)	6745 (44.6)
Female (%)	2007 (31.7)	1662 (58.5)	697 (32.8)	585 (35.1)	4951 (32.7)
Missing data (%)	750 (22.2)	1430 (42)	409 (12.8)	818 (23)	3407 (22.5)
					15103
Mode of arrival					
Ambulance (%)	560 (88)	37 (5.8)	8 (1.2)	28 (4.4)	633 (5.2)
Foot (%)	386 (6.9)	672 (33.1)	1562 (62)	725 (39.3)	3345 (27.9)
Other (%)	1962 (35.1)	385 (19)	314 (17)	255 (10.1)	2916 (24.3)
Police (%)	124 (2.2)	38 (1.9)	48 (1.9)	66 (3.6)	276 (2.3)
Private vehicle (%)	2352 (53.6)	853 (1.9)	568 (12.9)	612 (13.9)	4385 (36.6)
Unknown (%)	206	46	79	102	433 (3.6)
Grand total	5590	2031	2579	1788	11988
Kampala trauma score (SD)	3.7 (3.6)	7.3 (4.3)	7.2 (3.9)	4.3 (4.2)	5.12 (2.63)

Injury mechanism and characteristics

Falls constituted the most common mechanism of injury at (4530/15103, 30%) followed by motor vehicle collisions at (2870/15103, 19%). The vehicles implicated in road traffic collisions were primarily cars (11025/15103, 73%) and motorbikes (756/15103, 5%). Assaults (intentional injuries) accounted for (2719/151034) 18% injuries, whereas (11328/15103) 75% of injuries were unintentional. The remaining (1057/15103, 7%) were missing. Only (302/15104) 2% of injuries were self-inflicted. Most injuries occurred at home (5890/15103, 39%), during transportation (1963/15103, 13%), and at work (1510/15103, 10%). For (2870/15103) 19% of patients, the mechanism was marked as "Other" without further delineation, and (7249/15104) 48% of this category was missing.

Injury severity

Complete trauma scoring requires all variables of the KTS2 to be measured (Table 2). Age was recorded in over (12082/15103) 80% of patients, whereas respiratory rate and blood pressure were each recorded for less than (3776/15103) 25% of patients. For patients with a complete recording of all variables (2004 patients, 13.2%), the mean KTS was 5.12.

Injury patterns, outcomes, and follow-up

The most common injury patterns were the presence of wounds and any fracture, followed by injuries to the head, neck, chest, and abdomen (see Fig. 1). 95% (14348/15103) of patients were treated and sent home, whereas 5% (755/15103) were admitted (Table 3). Injury pattern information was completed for 15.9% (2401/15103) of patients, whereas 84.1% (12701/15103) was missing. The most common injury pattern was the presence of any fracture at 5.26% (794/151034), and the lowest was spine injury with paralysis at 0.33% (50/15103). At 2-week follow-up, 6% (906/15103) of patients admitted had remained in hospital, 78% (11780/15103) were sent home, and 14.3% (2160/15103) were transferred to another hospital. 1.67% (252/15103) of patients in the database had the clinical outcome (i.e., admitted, operated, or sent home) at 2 weeks completed.

Data completeness

Data completeness was calculated as the proportion of valid values to the total number of data fields in the registry. Missing cells and categories marked as "Other" or "Unknown" were considered missing data. The overall completeness rate was 62% (9364/15103). There were high levels of missing data in the collection of physical, vital signs on patients, limiting the calculation of the Kampala Trauma Score to only 13.2% (1993/15103) of the cohort. For most variables, the data completeness rate improved over time, but for some, the rate dropped. Outcomes from the emergency department (i.e., admitted or discharged) and outcomes at 2 weeks were missing at high levels, 69.9% (10557/15103), and 98.33% (14850/15103), respectively.

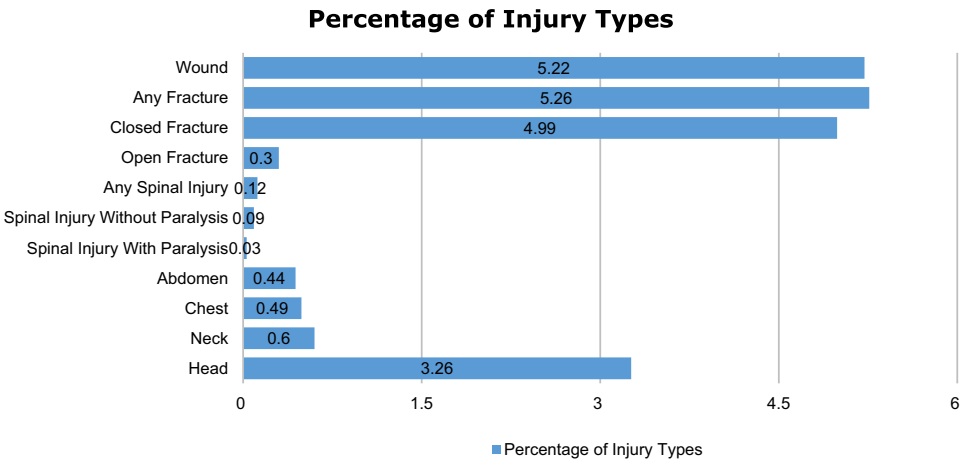

Fig. 1 Injury pattern types in the cohort

Table 3 Patient outcomes in the four enrolled hospitals between August 2014 and September 2015

Outcomes	Central Maputo	Jose Macamo	Mavalene	Matola	Grand total
Dead ED (%)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.0)	1 (0.0)
Referred to another hospital	1	40	94	80	215
Treated and sent home	1139	1113	1011	1022	4285
Missing (%)	6196 (84.4)	2680 (70.6)	1300 (56.5)	642 (38.5)	10818 (75.6)
Grand total	7335	3793	2311	1664	15103

Discussion

Trauma registry data drives performance improvement

Introducing injury surveillance and monitoring capacity in LMICs is a challenging endeavor. In high-income countries, the development of organized trauma systems has led to a decrease in trauma-related mortality of up to 35–50% [19–21]. The development of sustainable trauma registries that allow for continuous monitoring of injury rates, mechanisms, patient access, and healthcare system performance was essential to this success [22]. Since 2004, the WHO began a joint call to all member states, especially LMICs, to introduce trauma monitoring capacities at all hospitals serving injured patients [23].

To date, most of the global data around the burden of injury in LMICs have come from short-term monitoring projects, vital statistics, and from the Global Burden of Diseases and Injuries effort. While these data have been instrumental in creating awareness to the significance of the injury pandemic, there must now be a drive toward collecting hospital-based injury-related statistics to better target gaps at multiple levels, including the prehospital and hospital settings. This project is the largest such concerted effort to take place at a system's level in a LMIC to date. The key achievements of this work have shown that implementation of a trauma registry in a low-resource setting is feasible and that the data collected can identify gaps in trauma performance, inform the organization of trauma care, and highlight possible targets for injury prevention.

Registry monitoring identifies gaps in several areas of trauma performance

The introduction and use of the described registry have led to several improvements in the quality of data collection and have helped to streamline the trauma care given to patients.

Clinical care provision The collected data revealed gaps in the delivery of timely care for injured patients. In fact, only 13.2% (1994/15103) of patients received a complete clinical trauma score, whereby the norm is that every patient receives one. Given that the score consists of vital signs, neurologic status, and age, many trauma patients did not have these findings recorded. A potential reason for this gap was a lack of blood pressure machines; however, pulse, respiratory rate, and neurologic status were also often not recorded. Other reasons are likely to have contributed to

this finding: While termed "a vital sign," the collection of such information is not the standard of care in the often clinically overworked emergency setting, which will require a culture shift before it becomes the standard. It is likely that very sick patients were triaged to definitive care before the full range of clinical variables was collected. Although the KTS has its limitations, it is by far the most validated score in low-resource settings. We selected KTS because it has been validated in resource-limited settings [14].

An organized approach to trauma patients The gaps identified led to the elaboration of a precise sequence of care delivered to each injured patient who arrives at the hospital: assessment in the trauma bay followed by real-location to an orthopedic room or a multi-trauma room depending on the nature of injuries. The application encourages an organized and consistent approach to the management of all trauma patients with the goal of improving outcomes.

Prehospital system The demographic and injury data collected on patients identified patterns of injury in Maputo. Analysis of the registry revealed that fewer than 5% (755/15103) of injured patients arrived at the hospital by ambulance or received any prehospital care, with most patients arriving by foot or by private vehicles not equipped to deliver essential care. Through the auspices and support of the Ministry of Health in Mozambique six physicians were sent to Portugal to train in Emergency Medical Preparedness and prehospital system design. Also, in response to the low rate of ambulance transport, reflecting the need to augment the prehospital system, the MOH has purchased 41 ambulances equipped with advanced life support capabilities to support the identified gap (Personal Communication—Ministry of Health, Mozambique). The ongoing data collection can now serve as a useful monitoring tool for the impact of the prehospital system.

Injury prevention Data in the registry also revealed a low rate of compliance with seat belt and helmet protection (more than 60% (9062/15103) of patients involved in MVCs did not wear a seat belt or helmet). These are specific targets that should now be the focus of injury prevention interventions. The highest burden of injury comes from falls, with MVCs being second, a finding that differed from that projected by the Global Burden of Diseases Study, and a significant difference to delineate in the design of injury prevention policies [4, 7, 24].

Registry quality improvement Continued monitoring of registry performance is crucial to the attainment of relevant variables that form the basis of successful policies and intervention strategies. For example, upon identification that many of the operators categorized a significant number of inputs as "Other," that option was removed to promote more accurate data collection. Having "Other" as an item often resulted in its use as a default selection, making it difficult to analyze injury-specific data. The option "Other" was removed, and this led to more informative data collection in the registry. Additionally, more frequent training and site visits have been initiated to provide further improvement in data collection capacity.

Limitations

The overall objectives of this project were accomplished and represent an immensely positive development for tackling the burden of trauma in Mozambique, sub-Saharan Africa, and LMICs in general. Due to their anticipated cost and complexity, trauma registries have been largely absent in low-resource settings [25]. Importantly, this work is a proof of concept element and is the first time such a registry has been introduced at this scale and in this setting. It is expected, therefore, that one would encounter major limitations after just 1 year of implementation. In Mozambique, we encountered the following challenges that, in turn, resulted in several limitations of the study:

Data completeness is an area that needs improvement, and which likely introduced several biases into the analysis. The study PIs responded in a targeted fashion to this challenge by eliminating the category "Other" in the registry and by intensifying data entry training. It is exceedingly rare that the circumstances of an injury cannot be described with the standard itemized lists provided in the registry, and such a structural adjustment will engage the data entry operator to identify a valid descriptor. Although high rates of missing data are a significant limitation, it is well in keeping with the experiences of more developed trauma systems in several international locales [19]. The missing variables were due mostly to the novelty of the experience especially in physiological measurements such as BP and RR, a problem compounded by the lack of material resources such as the availability of blood pressure cuffs. The purchase of blood pressure machines helped and so did the continued focus on training around registry use and clinical care provision. More site visits by the PI and project coordinators also helped reinforce the change. It is also important to note that even in the high-income context such as North America and Europe, registry implementation also faced data completeness issues that required time and continued training to improve.

Another serious limitation with the introduction of the registry results from the lack of a denominator to calculate incidence rates. As in any surveillance system, the registry provides information on the incidence of injuries and not on the population from which the traumas emerge. Census, registration, and population assessment information are lacking in Mozambique, and such data would have to be

available before accurate population rates can be calculated.

The next step will be to build upon education paradigms by implementing further training in structured clinical trauma training using templates adapted for low-resource settings, such as the Trauma Team Training© course developed by the Canadian Network for International Surgeons. Such a course will provide specialized training in the team approach to injured patients and should significantly improve the clinical data collected by engraining the importance of vital sign collection and the structured, organized approach to the injured patient.

Furthermore, the registry has been scaled up by both the Ministry of Health and the Governmental Hospitals as the official trauma registry and is now budgeted for by the Ministry of Health itself. The analytical component of the data will be managed by the National Institute of Health in Mozambique, the national research body for health in partnership with the Center for Global Surgery. To ensure sustainability, all data collection was carried out by local Mozambican health workers.

This study represents the first time a successful injury surveillance program has been implemented in a very low resource context. The development of the iTRAUMA™ platform and its ease of use, without the need for active internet in the hospital setting, provided the right technology for the right environment. The data collected presents a rich pool of modifiable descriptors and causes of injury, the flow of clinical care provided, and gaps at all levels of trauma care that can be addressed through targeted interventions. As data collection quality improves, more preventative policies, such as development of awareness campaigns around seat belt and helmet use, can be developed. The cultural shift will take time, but this work represents an important milestone in continued improvement in trauma care in a low-resource setting.

Summary and conclusion

This is the first report of the implementation of a successful trauma registry in sub-Saharan Africa. Our evaluation of over 15,000 patients presenting to four Maputo based hospitals identifies significant areas for the further development of the trauma system in the region. Also, this report identifies the key approaches and important realities in the implementation of trauma registries in limited resource settings. This is the essential foundation necessary for regional and eventual national injury surveillance strategies to address a leading cause of morbidity and mortality so that national leadership can provide safer environments in which its population can thrive.

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