ORIGINAL ARTICLE

Trauma burden, patient demographics and care-process in major hospitals in Tanzania: A needs assessment for improving healthcare resource management

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ARTICLE INFO

Keywords:
Injuries
Emergency
Surgery
Prehospital
Global health
Quality of care

ABSTRACT

Background: Appropriate referrals of injured patients could improve clinical outcomes and management of healthcare resources. To gain insights for system development, we interrogated the current situation by assessing burden, patient demography, causes of injury, trauma mortality and the care-process.

Methods: We used an observational, cross-sectional study design and convenience sampling to review patient charts from 3 major hospitals and the death registry in Tanzania.

Results: Injury constitutes 9–13% of the Emergency Centre census. Inpatient trauma-deaths were 8%; however, the trauma death registry figures exceeded the ‘inpatient deaths’ and recorded up to 16%. Most patients arrive through a hospital referral system (82%) and use a hospital transport network (76%). Only 8% of the trauma admissions possessed National Health Insurance. Road traffic collision (RTC) (69%), assault (20%) and falls (9%) were the leading causes of injury. The care process revealed a normal primary-survey rate of 73–90%. Deficiencies in recording were in the assessment of: Airway and breathing (67%), circulation (40%) and disability (80%). Most patients had non-operative management (42–57%) or surgery for wound care or skeletal injuries (43%). Laparotomies were performed in 26%, while craniotomy and chest drain-insertion were each performed in 10%.

Conclusion: The burden of trauma is high, and the leading causes are: RTC, assault, and falls. Deaths recorded in the death registries outweigh in-hospital deaths for up to twofold. There are challenges in the care process, funding and recording. We found a functional hospital referral-network, transport system, and death registry.
The current trauma-care guidelines recommend pre-hospital care, standardized treatment protocols, material and infrastructure-resource mobilization, provision of skilled personnel, quality improvement programs, monitoring, surveillance and rehabilitation services [1,2,4–9]. Unfortunately, these recommendations are not yet commonly utilized; specialized training is limited, financing systems and quality of care initiatives are lacking, and skills lag behind the acceptable level in most LMICs [10,12].

Commonly, the standard initial trauma care is based on Advanced Trauma and Life Support (ATLS) principles [6,13], and the advanced trauma care guidelines are provided by trauma-surgery related authorities [1,4–8,13]. To improve the quality of care, trauma-care algorithms and performance indicators were applied in HICs and in some LMICs [14–16], and trauma system models have been proposed specifically for LMICs [1,17].

Tanzania is a country on the Eastern part of equatorial Africa, with a population of 59 million people, with increasing urbanization and increased access to modern transportation means. Roads, however are often poorly maintained and drivers are therefore at risk of crashes, along with the reliance on public transport by most of the population [18].

In Tanzania, like other LMICs, there is a high rate of trauma. Road Traffic Crashes are the lead cause in most of Africa [19,20]. Emergency medicine training programs have been initiated in Tanzania and there is a good progress of emergency care in the main hospitals [21], however organized trauma system models are not yet in place, trauma care training in medical curricula is deficient, and trauma-surgery specialization among health professionals is yet to start [22,23]. Resources for trauma care along with all other healthcare services compete for a meagre 32% of the National Health Insurance Fund (NHIF) coverage, and prehospital emergency services are currently not included in this public health funding (NHIF) system [24,25].

To improve the outcome for the severely injured, the quality of trauma care must be maintained beyond the Emergency Centres (ECs) and this involves other cadres such as trauma surgery and rehabilitation services. This study aims to evaluate the existing trauma-care practices to identify critical areas for improvement by adapting the context-based trauma system. Studying injury patterns and their care process offers an opportunity to assess the pre-existing standards and consequently allows for appropriate planning for improvement. This is important in LMICs where resources are limited, therefore the proposed trauma system adaptation should be cost effective and based on existing structures to avoid HICs trauma systems importation which are not feasible in LMICs [1,7].

The objective of this research was to assess: the in-hospital trauma-burden, major injury processes of care; and the trauma death burden. Findings will be important in improving the outcome of trauma care, guiding specific trauma-care skills development, and to advocate for trauma-care funding by the NHIF; and for future monitoring and evaluation.

Methods

Study design: This is observational and cross-sectional study including consecutive patients in alternative months in 2018 to include high and low peak injury incidents periods [26,27].

Tanzania is a LMIC in the Eastern part of Africa with a population around 59 million people [18]. The country’s health care systems are organized from lower level dispensaries, health centers, district and regional hospitals to central referral hospitals. The public health system has an inter-hospital transport network of vehicles staffed by non-trained drivers. Referral letters are required prior to transfer to a higher hierarchy hospital, and additionally trauma patients need a special police form number 3 (PF3) to attend to any hospital [18,28]. There are 4 major referral hospitals country-wide: Muhimbili National hospital (MNH) has several emergency physicians and is a training facility, Mbeya zonal referral hospital and Kilimanjaro Christian Medical Centre (KCMC) both have ECs headed by emergency medicine specialists. All hospitals serve as medical and health professions training facilities with surgical rotations. If patients arrive at higher level hospitals without the formal referral systems, these are considered ‘self-referrals’ as opposed to ‘hospital referrals’. Additionally, local regulations in Tanzania require all deaths to be registered in the registry maintained by the Registration, Insolvency and Trusteeship Agency (RITA), hence this is a ready source of trauma death data that was drawn from RITA offices in: Moshi, Muhimbili and Mbeya [29].

We screened EC patient registries in hospitals to identify trauma patients who were treated in 2018. We included patient records from 3 hospitals: Kilimanjaro Christian Medical Centre (KCMC), Mbeya zonal referral hospital, and Muhimbili national hospital surgery wards.

We included patients who suffered major penetrating and blunt injuries from physical mechanisms, falls, road traffic accidents, or weapons. We excluded fragility fractures and injuries not primarily addressed by most trauma systems models, namely: burns, drowning, hanging, poisoning, chemical and radiation exposures.

Demographical variables included age and sex distribution; patient transport, type of referring hospital, financing options; process of care variables (initial emergency care of airway, breathing, circulation; or specific surgical treatment as per likely indication), and patient outcome i.e. death (Appendices).

We defined ‘major injury’ based on mechanism of injury, clinical presentations, and admission status, specifically, admitted penetrating or blunt abdominal injuries, admitted blunt or penetrating multiple injuries were considered to be major injuries.

Hospital burden of injury: based on the consideration that most hospital admissions are initially seen at an EC, we consecutively selected EC admissions from patients registers in alternative months in 2018 to estimate the proportion of injuries of the total EC census.

Care process: For the patient records retrieved, we reviewed the care-process variables for initial assessment in the EC: triaging categorization, assessment of airway, breathing, circulation, appropriateness of EC intervention; and for those admitted to definitive care: surgery options (Appendices).

Trauma deaths: similar records were accrued from the death registry for the major hospitals catchment areas (RITA offices in Moshi, Muhimbili and Mbeya) to assess trauma related deaths based on diagnosis or mechanism of injury (Appendix B) to determine what proportion of death occur in hospital versus pre-hospital.

To reduce the risk of source-document interobserver bias a peer reviewed proforma was developed based on standard trauma care guidelines and protocols [1,4–8]. The data abstraction team was familiarized and ascertained compliant with the data collection tool. All study authors from the participating hospitals verified the data before compilation and analysis. To minimize the effects of seasonal variations [27–29] in trauma incidence where some months may have more or less trauma incidences during a full year cycle i.e. major religious and social festivity, planting and harvesting seasons, school closure, rainy or cold seasons, etc. study participants were selected in alternating months in a complete 1-year cycle. This described technique [26,27] minimizes selection bias by roughly distributing major events that affect trauma occurrence in the local environment.

The study reviewed 30, 330 EC visits from MNH and 7938 from KCMC; and 13,300 outpatient records from Mbeya referral hospital medical record department, and further reviewed a total of 1138 injury admissions from MNH, KCMC and Mbeya referral Hospitals (Fig. 1).

Data from EC registries, patient files and from death registries were recorded in a Microsoft Excel® spreadsheet (Microsoft, Redmond WA). After coding and data cleaning, SPPS version 20.0 for Windows (IBM, Armonk NY) was used to organize the data and compute percentages, medians (interquartile ranges), proportions, and for generating tabulated reports.
Results

The EC caseloads at MNH and KCMC (38,268) showed the proportion of trauma patients ranged between 9 and 13%, Mbeya referral hospital caseloads were excluded due to inconsistency and deficiency in reporting. The total number of trauma cases admitted to various facilities was 1138 e.g. MNH (485), Mbeya referral hospital (358), and KCMC (295). Admitted cases defined as major injuries were reviewed for possible audit of the emergency and inpatient care processes: After applying selection criteria 480 of these cases were selected and subsequently assessed. From the same regional facilities, the death registries across these major hospital catchment areas yielded 2654 records and their characteristics were categorized to determine causes and the proportion of trauma-related deaths (Fig. 1).

Hospital trauma-admissions: age, gender and other characteristics

Adults accounted for 89% of all trauma patients, and males predominated at 84%. Median age [IQR] in adults was 30 years [24–40] and in the paediatric group was 6 years [4–10]. While 91% of the injured patients at EC did not have any medical insurance coverage, meaning they paid out-of-pocket for their care, only 8% possessed National Health Insurance Fund (NHIF) cover. Most injured persons were brought to the EC as a referral from lower level facilities (82%). Trauma-admissions were self-referred in 11% or brought by the police in 6%. Seventy-seven percent of the patients were transported by hospital vehicles (not formal ambulances) and 17% used personal vehicles or cars. The rest of the patients (< 6%) walked-in or were brought in a police van.

The top causes of injury were road traffic collisions (RTC) 69%, violence 20% and falls 9%. Other minor causes were attacks by animals and industrial injuries. There were missing records in most categories owing to an absence of adequate documentation, e.g. 80% on mode of transport to the facility, 14% on the mechanism of injury, and 23% on the mode of arrival (Table 1).

Airway patency and Oxygen saturation (SPO2) was normal in 51%. Respiratory rate (RR) was normal or mildly elevated in 88% of the cohort, generally breathing assessments that considered inspection, palpation, percussion and auscultation were normal in 25% of patients. Airway, breathing and respiratory-rate assessment were, however, inadequately recorded for 41%, 53%, and 67% of cases respectively (Table 2).

Pulse rates ranged between 60 and 100 in 67% of the cohort. Systolic blood pressure and diastolic blood pressure were normal in 59% and 73% respectively, and therefore the mean arterial pressure (MAP) was normal in 90%. Extremity assessment for capillary refill, temperature and diaphoresis was recorded as within normal limits in 93%. Blood pressure and pulse rate were reported in 90% and 86% respectively, while the examination of extremity was poorly recorded, being present in only 40% of charts (Table 3).

Many patients were reported to have normal Glasgow Coma Score/AVPU parameters (73%), however examination of pupils, and power of the extremity to detect clinical features of intracranial hematoma was not recorded in the majority (80%). Only Mbeya referral hospital and MNH reported the AVPU parameter, revealing a deficit in recording at the other facilities.

Multiple injuries with head injury were reported in 50%, isolated fracture was 26%, visceral injuries (chest & abdomen) 14%, and soft tissue injuries 10%. Blood tests were limited to haemoglobin, blood grouping and cross-matching, and full blood count and were only performed in 22% of the trauma patients. Ultrasound-scans were performed in 45% of the admissions, and over 90% were ‘focused assessment with sonography in trauma’ (FAST). Other radiological tests performed were plain x-rays (35%), skull x-ray (20%) and computer-tomography-scan (CT-scans) 28%.

Fractures and related wound management were the most reported operations in 43% and laparotomy in an additional 26% of admissions. Chest drains and craniotomy were each reported to be performed in 10%. Other procedures, such as tracheotomy, fasciotomy or amputations were performed in < 1% of the total cohort. Non-operative management in general surgery was 57%, and in Orthopaedics it was...
The average length of hospital-stay was 9.5 days, the average length of ICU stay was 8.2 days, and proportion of deaths among those admitted was 8%.

**Death registry statistics: age, gender, causes of death and characteristic of subjects in the main hospital-catchment areas**

A review of all the deaths recorded at the regional mortuaries was performed to identify the causes and determine the proportion of trauma deaths in the total cohort. Mortality causes ranged from infections, medical illnesses and related complications 54%, acute surgical related deaths (including trauma) 21%, neoplasia 19% and Paediatric conditions 7%. Trauma deaths occurred in 13% of the total death cohort, it constituted 67% of surgical related deaths and ranged between 8 and 16% of total deaths between the sampled regions.

In general, deaths incorporating trauma and non-trauma causes were dominated by adults at 95% and males by 58%. Similarly, trauma deaths occurred in adults in 93%, with median age [IQR] 42 years [24 – 44] in adults, and 9 years [5 – 13] in paediatric cases, however the proportion of trauma showed an 84% male predominance.

Eight percent of the trauma deaths were treated at the hospital prior to death, while 13% were admitted directly due to deaths on scene.

| Table 1 | Age, sex, funding, referral, transport and mechanisms of injury (n = 480). |
|---------|-------------------------------------------------------------------------|
| Age     | 0–14                       | 15–44                        | 45 or >                      | Total                        |
|         | KCMC n(%) | MNH n(%) | MZRH n(%) | Total n(%) |
|         | 28(10)  | 9(10)   | 15(15)    | 52(11)     |
|         | 216(74) | 69(78)  | 73(72)    | 358(74)    |
|         | 47(16)  | 10(11)  | 13(13)    | 70(15)     |
| Total   | 291(100)| 88(100) | 101(100)  | 480(100)   |
| Sex     | Male       | 252(87) | 77(87)    | 76(75)     | 405(84)     |
|         | Female     | 39(13)  | 11(13)    | 25(25)     | 75(16)      |
| Total   | 291(100)| 88(100) | 101(100)  | 480(100)   |
|        | NHIF       | 22(8)   | 4(5)      | 10(10)     | 36(8)       |
| Finance-mode | 269(92) | 80(90)  | 91(90)    | 440(91)    |
|         | None       | 0(0)    | 0(0)      | 0(0)       | 0(1)        |
| Total   | 291(100)| 88(100) | 101(100)  | 480(100)   |
|        | Healthcare facility | 235(80) | 72(82)    | 0(0)       | 307(64)    |
| Referral mode | Police   | 22(8)   | 2(2)      | 0(0)       | 24(5)       |
|         | Self-referral | 31(11) | 9(10)     | 0(0)       | 40(8)       |
|         | Not recorded | 3(1)    | 5(6)      | 101(100)  | 109(23)     |
| Total   | 291(100)| 88(100) | 101(100)  | 480(100)   |
|         | Hospital transport | 0(0)   | 66(75)    | 0(0)       | 66(14)     |
| Transport mode to the receiving hospital | Police van | 0(0) | 2(2)      | 0(0)       | 2(0.4)     |
|         | Private car or for fee | 0(0)   | 14(16)    | 0(0)       | 14(3)      |
|         | Walking or on a stretcher | 0(0) | 3(3.5)    | 0(0)       | 3(0.6)     |
|         | Not recorded | 291(100)| 3(3.5)    | 101(100)  | 395(82)     |
| Total   | 291(100)| 88(100) | 101(100)  | 480(100)   |
| Mechanism of Injury | RTC | 201(69) | 11(12.5) | 73(72) | 285(59.5) |
|         | Fall | 30(10) | 2(2) | 7(7) | 39(8) |
|         | Assault | 35(12) | 4(5) | 19(19) | 58(12) |
|         | Stab | 3(1) | 11(12.5) | 0(0) | 14(3) |
|         | Gunshot | 0(0) | 10(11) | 1(1) | 11(2) |
|         | Industrial/machinery, animal bite/attack/injury, self-inflicted, hanging | 3(1) | 1(1) | 0(0) | 4(1) |
|         | Not recorded | 19(7) | 49(56) | 1(1) | 69(14.5) |
| Total   | 291(100)| 88(100) | 101(100)  | 480(100)   |

**KCMC** - Kilimanjaro Christian Medical Center; **MNH** - Muhimbili National; **MZRH** - Mbeya Zonal Referral Hospital; **NHIF** - National Health Insurance; **RTC** - road traffic collision.

42%. The average length of hospital-stay was 9.5 days, the average length of ICU stay was 8.2 days, and proportion of deaths among those admitted was 8%.

A review of all the deaths recorded at the regional mortuaries was performed to identify the causes and determine the proportion of trauma deaths in the total cohort. Mortality causes ranged from infections, medical illnesses and related complications 54%, acute surgical related deaths (including trauma) 21%, neoplasia 19% and Paediatric conditions 7%. Trauma deaths occurred in 13% of the total death cohort, it constituted 67% of surgical related deaths and ranged between 8 and 16% of total deaths between the sampled regions.

In general, deaths incorporating trauma and non-trauma causes were dominated by adults at 95% and males by 58%. Similarly, trauma deaths occurred in adults in 93%, with median age [IQR] 42 years [24–44] in adults, and 9 years [5–13] in paediatric cases, however the proportion of trauma showed an 84% male predominance.

Eight percent of the trauma deaths were treated at the hospital prior to death, while 13% were admitted directly due to deaths on scene.

| Table 2 | Airway patency and breathing assessment among the admitted trauma patients in Tanzania (N 480). |
|---------|-----------------------------------------------------------------------------------------------|
| SPO2 & airway assessment | Normal SPO2, patent airway | 148(51) | 82(93) | 42(42) | 272(57) |
|         | Normal SPO2, deficient airway patency | 1(0.3) | 0(0) | 1(1) | 2(0.4) |
|         | Abnormal SPO2 or patency, and inadequate measurement of variables | 42(14.4) | 5(6) | 23(22.7) | 70(14.6) |
|         | Normal SPO2 or patency and inadequate measurements of parameters | 91(31.3) | 1(1) | 35(34.7) | 127(26) |
|         | Not recorded | 9(3) | 0(0) | 0(0) | 9(2) |
| Total   | 291(100) | 88(100) | 101(100) | 480(100) |
| Breathing rate | < 20 | 22(7.5) | 21(24) | 2(2) | 45(9) |
|         | 20–30 | 44(15) | 54(61) | 7(7) | 105(22) |
|         | 30–40 | 3(1) | 5(6) | 0(0) | 8(2) |
|         | > 40 | 0(0) | 2(2) | 0(0) | 2(0.4) |
| Not counted | 222(76) | 67(7) | 92(91) | 329(67) |
| Total   | 291(100) | 88(100) | 101(100) | 480(100) |
| Normal RR & breathing | 32(11) | 62(70) | 7(7) | 101(21) |
| Abnormal RR or breathing | 28(10) | 20(23) | 3(3) | 51(11) |
| Inadequate examination | 175(60) | 5(6) | 73(72) | 253(52) |
| No record or assessment reported | 56(19) | 1(1) | 18(18) | 75(16) |
| Total   | 291(100) | 88(100) | 101(100) | 480(100) |

**KCMC** - Kilimanjaro Christian Medical Centre; **MNH** - Muhimbili National Hospital; **MZRH** - Mbeya Zonal Referral Hospital; **SPO2** - arterial partial pressure of oxygen; **RR** - respiratory rate.
Most trauma patients had normal assessment variables during primary survey. Recordings were deficient on the usage of primary survey adjuncts such as cervical-spine or chest x rays. The usage of skull x-ray was as high as 20% and was comparable to the proportion of computer tomography (CT) scan for head and neck (28%). The primary survey variables: airway, breathing, circulation and disability statuses are fundamental to trauma protocols [1,4,6]. Likewise, primary-survey adjuncts such as 'FAST scan' ultrasound, chest and pelvic x-rays, gastric and urine catheters are key in guiding initial management and may offer a significant benefit in LMICs context [1,7]. The usage of CT scan, which is a mandatory investigation for assessment of traumatic brain injury [36] was noted to be low. In comparable studies originating from high-income countries the use of CT scan amounts to 87% of all trauma cases [37]. A previous study in Tanzania showed high user fee-cost and the low knowledge of traumatic-brain-injury protocols among the providers limited a wider utilization of CT scan, which may contribute to the low usage rates [38].

Hospital charts and theatre registers showed most patients were treated non-operatively (42%–57%) or by wound care and fracture related therapies (42%). The higher risk surgical operations such as laparotomies and craniotomies were only performed in 24% and 10% respectively, some types of operations involving major chest injuries or vascular injuries were completely absent. The expectation would be for the major and more complex trauma operations to be undertaken in referral hospitals [13]. The minor and moderate surgeries observed could indicate over-triage in the referring lower level hospitals, or
simply non-survival of major injuries and failure to arrive to appropriate hospitals.

Admission of only minor and moderate injuries to the highest-level hospitals may additionally exhaust scarce resources that could otherwise be allocated for more severely injured patients and may deskill professionals, through lack of skill-performance. Although studying reasons for the absence of major injuries in the referral hospitals is beyond the scope of the current study, these findings are similar to a previous report from Tanzania and is an important observation for stimulating further research. Countries with well-developed trauma systems maintain stringent regulations in designating trauma hospitals for ensuring centralization of crucial resources. High flow of major trauma cases to these hospitals would in turn necessitate a high level of trauma-surgery skills. Where a functional trauma system exists, practitioners are subjected to the necessary continuing educational programs to maintain proficiency.

Trauma care systems are designed to support lower level hospitals in providing adequate services according to their capacity. Where resources are limited such as in our context, the trauma care-packages recommended ensures cost-effective use of resources and will likely lead to improved patient outcomes. Ideally governments should incorporate essential trauma-care packages into existing health-funding systems, and to develop trauma care evaluation programs similar to those used for other essential services. Additionally, local health-financing systems (such as the NHIF) and other public healthcare funders need to design financing models for pre-hospital trauma care services, as this appears to be a major deficit in the continuum of healthcare-funding in Tanzania. Regulation at various levels will be necessary to ensure standardization of pre-hospital training and equipment standardization.

Regarding limitations: since this is a hospital-based study, it cannot estimate the overall burden of trauma across the entire community; the findings therefore are limited to the hospital-population. Additionally, we did not achieve 100% capture of trauma incident data, due to raw data inefficiencies, which may further underestimate the real trauma burden. Although we selected 480 admissions to study the care-process, the large amount of unrecorded data because of ‘deficient clinical recording’ may have reduced the data quality. Despite the described limitations, our results represent care process of the traumatic injured in Tanzania as it has included most of the major hospitals country-wide (3 out of 4 hospitals) and sampled major injured patients admitted across high and low peak injury periods. Further these results may be generalized to describe other situations in LMICs.

Conclusion

The study found a functional referral network from lower levels to major hospitals, and functional death registry systems across the country, however there were deficiencies in medical record documentation, utilization of trauma protocols during primary survey, and potential over-triaging in the referring hospitals. Given the deficiencies noted in improving trauma care services, the researchers recommend:

1. Improving the care-process in referral hospitals by adopting similar tools from the existing standardized treatment protocols and record-templates, procedural guidelines and outreach plans to lower-level hospitals within their catchment area.
2. Mechanisms should be developed for funding of trauma-care services, including pre-hospital services (e.g. coverage provided by the NHIF and its subsidiaries [community health fund]). Other funding options, such as the motor vehicle road accident fund and motor-vehicle insurance services should also be explored.
3. For improved clinical care it is important to incorporate components of the ‘trauma care-process’ and other necessary skills into the health-science curricula, with central regulation of post-graduate short-courses to enhance the provision of care.

4. Multidisciplinary teams of surgeons and other professional bodies (Tanzania Surgical Association and Emergency Medical Association of Tanzania among others) must regulate, oversee and adopt advanced levels of trauma education or equivalent courses for implementation locally, especially for care beyond the EC and in smaller facilities. To be able to accurately document the disease burden, it would be prudent to adopt practical trauma-registry formats (such as the recently proposed WHO minimum trauma dataset) into medical record systems countrywide, to ensure adequate recording of data.

Acknowledgements

We would like to acknowledge the exceptional support of Ndeki Uriro, Calister Imienda and the team at National Institute of Medical Research (NIMR) Tanzania; and Prof. V Rambiritch, Anusha Marimuthu, and the whole team at the Biomedical Research Ethics Committee (BREC) KwaZulu Natal, South Africa. This research was possible through the support of Patricia Mpuya and her team at Registration, Insolvency and Trusteeship Agency (RITA) offices; and the research assistants; Scholastica Luanda, Maria Mbatia, Onesmo Kachui, Melina Bonda and Naftari Mahimbo. We also thank the research responsible officials and colleagues from the emergency, surgery, pathology and registry departments at Muhimbili, KCMC, Mbeya referral, and Tumbi hospitals; and lastly, we thank the post-graduate office and the librarians at the University of KwaZulu-Natal, in particular we thank Veronica Jantjies for her endless support.

Dissemination of results

Results were shared with staff members at the data collection site through an informal presentations, and through emails to the National institute of medical research (NIMR), Registration, Insolvency and Trusteeship Agency (RITA) and hospital directors at KCMC, Tumbi, Mbeya-referral, Muhimbili hospitals in Tanzania. Further we have shared our findings with trauma surgeons through conference presentation during the 2019 Cape Town International Trauma Conference in Cape Town, South Africa.

Authors' contribution

Authors contributed as follow to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: MM contributed 60%; TCH 20%; HS 8%; and FS, JM, SU, AM, LNM and PB contributed 2% each. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of competing interest

Prof Tim Hardcastle and Dr Hendry Sawe are editors of the African Journal of Emergency Medicine. Prof Hardcastle and Dr Sawe were not involved in the editorial workflow for this manuscript. The African Journal of Emergency Medicine applies a double blinded process for all manuscript peer reviews. This study was supported through a CHS PhD scholarship from the University of KwaZulu-Natal. The authors declare no further conflicts of interest.

Appendices. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.afjem.2020.01.010.
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