PhD Submission

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Trauma Care in Sub-Saharan Africa: Challenges and Opportunities in Botswana and Tanzania for Implementing Afrocentric Systems.

Submitted in fulfilment of the degree PhD (Med) by linked peer-reviewed papers at the University of KwaZulu-Natal

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Declaration

Plagiarism

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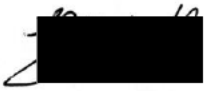
Signed:  Date: 05/04/2021

Timothy C Hardcastle

Frontispiece

‘Surgery is a practical affair. It has to be by its very nature. Does it have underlying philosophy? I think it does. It cannot escape the political, social, and economic factors that influence all human endeavors.

DR H. Mahler-Director General WHO,
XXII biennial world congress of the international
college of surgeons on surgery and health for all
Mexico City, Sunday 29 June 1980

Dedication

To my daughters Aika-Crista, Clare and Furaha

Note of thanks

Foremost, I thank the Lord for energy and passion to pursue this project to completion.

Thanks also to Abella, Aika-Crista, Clare and Furaha for the family time sacrificed.

Thanks to the many collaborators, expert advisors and co-authors of the papers for their input in the study design, advice on content and contributions. Thank you to my supervisor Prof. Timothy Hardcastle for your guidance over the years.

Without your support and patient tolerance, I would not accomplish this project.

Summary

Background: Injuries are a major healthcare challenge and consume vast resources. Injuries also cause enormous disease burden in Lower-Middle-Income-Countries (LMICs). Despite the known benefits of trauma systems for managing injuries, this approach is not widely practiced in LMICs. The research examined injury patterns and its current management, further the research assessed how the trauma system concept can be adopted in Africa using existing healthcare structures.

We aimed to: undertake a comprehensive Cochrane systematic review examining the utility and effect of trauma systems; to assess burden of 'trauma disease' and assess the current health care structure capability in provision of trauma care services in Botswana and Tanzania; further, we evaluated potential within existing healthcare structures for building trauma systems.

Method: After study approval for the PhD degree, the University approval followed, and site approval from various countries and institutions. The study examined the utility of trauma systems and designated trauma centers by using Cochrane guidelines. A protocol was published in the Cochrane library, and subsequently a systematic review was conducted. Further observational research was carried out to assess health care provision by using hospital records and in-person interviews of healthcare providers and administrators. The studies were carried out in pre-selected trauma-burdened hospitals in Botswana and Tanzania, using pre-defined proformas.

Results: We found that the utility and effectiveness of trauma systems is widely reported globally, however there are limitations of quality of the included primary studies.

Reports of primary research from Botswana and Tanzania showed efficient referral networks. Patients were transported by inter-facility hospital vans, commercial vehicles, police vehicles and private vehicles. Furthermore, the studies reported: well-functioning “death and birth registry” systems, financing systems, and emergency medicine physician trainings.

Deficiencies noted were due to: a high prehospital trauma death rate, injury burden in young adults, high rate of admission for minor and moderate injuries in referral hospitals, and predominantly minor to moderate trauma surgeries performed in referral hospitals instead of lower-level hospitals. Concurrently, there were deficiencies in the use of trauma protocols, recording of key patient information, organisation of trauma care, and provider knowledge and skills.

Conclusion: Sub-Saharan African countries have infrastructure in place that may be used to establish essential trauma systems. The high-cost trauma systems in HICs can be adapted to create low-cost models by improving the existing various prehospital care models in LMICS, building needed capacity in existing healthcare facilities, installing preventive measures and improving coordination of the trauma system components. This thesis provides suggestions to achieve these.

Chapter 1

Context of the thesis

Trauma is defined as the adverse physical effects of man's interaction with his environment and the injuries, physical, emotional or mental, resulting therefrom (1). Trauma systems are a system of interrelated healthcare components dedicated to injured patients, the components including: prehospital care services, dedicated trauma care-capable hospitals, trauma-care performance appraisal systems, effective communication structures for triaging patients, rehabilitation services designed to optimize injury outcomes, and injury prevention measures (2,3). Trauma healthcare is often referred to as trauma care.

About five million people die from injury every year and many millions more suffer non-fatal injuries (4). Furthermore, trauma accounts for losing 180 million disability-adjusted life years annually, and 90% of the burden occurs in Lower- and Middle-Income Countries (LMICs) (5,6).

Road traffic injuries cause an annual economic loss of about US$167.8 billion worldwide (7). The costs in Africa are less well documented, but likely in excess of many country's gross domestic product for healthcare (4).

In response, trauma care has developed into an organised trauma system in many countries (8,9), and it is reported to be effective in reducing the burden from trauma (10-13).

Trauma system development

The initial civilian trauma care was based on the importation of wartime experiences, and techniques to civilian hospitals (8). At that time, trauma care was provided in isolated trauma centers, however currently the trauma care is mainly based on the trauma system concept. The concept extrapolates from the original definition of the term 'system' and therefore describes the interrelated components, such as prehospital care, emergency and definitive care, rehabilitation and preventive measures, further it is checked by the quality and system appraisal measures enabled by trauma registry (2,3).

The initial trauma care that started as injury centers in the UK, South Africa and later in the US has now developed into a system that retrieves patients, and promptly delivers them to the appropriate level hospitals for definitive care, and offers rehabilitation and preventive care (1). To be functional, trauma systems require political and public support to ensure adequate resources (1,2). The need for resource allocation and quality system installation has led to a regionalised trauma systems model that has ensured the organisation of this care within a certain geographical location (3).

Trauma system models have used various resources to maintain skills and organisation of injury care: Advanced Trauma Life Support (ATLS) course (14), Definitive Surgical Trauma Care course (15), and many other organisations (16-19) have established training on core skills and critical knowledge to the frontline personnel.

In recent times, trauma system models advocated for LMICs (2, 19, 20) have used WHO resources (21), and similar ones from the Red Cross movement (22) to standardize training and trauma care practices in LMICs.

Current trauma system models in High Income Countries (HICs)

Many HICs have attained a mature trauma system (23). In such systems standards and quality are overseen by an accreditation organisation. A mature trauma system uses an accreditation system to achieve and maintain all its components (3,24,25). Designation of hospitals are usually according to their trauma care provision capacity, and ranges from level IV to level I (3,24,25). Further, in these countries the trauma system is run by a lead agency that ensures functioning of the network and interrelation of different components and communication stations. The lead agency also oversees bypass mechanism between hospitals, resource allocation, skills-sharing, rehabilitation and preventive services. Other functions of the lead agency is to ensure quality maintenance in regionalised systems and in other trauma networks outside the region and uses a trauma registry to monitor system performance (3,24,25). The well-functioning trauma system uses pre-hospital, in-hospital care and rehabilitation services to transition injured patients from one phase of care to the next by employing multi-disciplinary approaches in each level (3,24,25). Despite that, most developments in trauma systems are registered in HICs, there are only a few countries that have established a national trauma registry to date (23).

Association of Southeast Asian Nations & Middle-Income countries

The Association of Southeast Asia Nations (ASEAN) constitutes a number of the middle-income countries and some HICs that have adopted a trauma system. In some, they have established accreditation systems, and they designate hospitals according to their trauma care capacity (1). A recent report on development of trauma care using the WHO trauma maturity

index shows trauma system models are commoner in the ASEAN and Middle-income countries than in sub-Sahara Africa, and the distribution relates to country's economic status (23). In this report most of the middle-income ASEAN countries show they have attained a moderate maturity index. Many ASEAN countries have some components such as emergency services available, but lack a coordinated prehospital system, trauma registries and trauma care quality monitoring systems. Several countries in this group and other middle-income countries do not yet have an inclusive trauma system or National-wide trauma registry (1,23,26,27).

In India for instance, a recent study reported many of the state hospitals still endure deficient physical resources mainly because of a deficient organisation of care, in this study they described a mismatch between human and physical resources that has resulted in a dysfunctional system (27).

Sub-Sahara Africa and LMICs

Reports show that despite LMICs bearing the greatest trauma burden, there are greater limitations in skills, resources, and organizational capacity (28-31). Trauma patients in these countries suffer complex injuries from varied injury mechanisms such as Road Traffic Crashes (RTC), interpersonal blunt injuries, falls and weapon related injuries (20, 32-34). The complex injuries incurred would usually require a high level of skills and capabilities and a good organisation of care (2,20, 28, 31). In contrast, Sub-Saharan Africa and LMICs for a large part do not have organised trauma care systems (1,23). There are reports showing sub-Saharan Africa has shortages of doctors (34,35), deficient patient transport systems (36-40).

While the higher economic wealthier countries in upper middle-income countries and HICs enjoy more resource allocation to healthcare, the majority of LMICs are less developed and have fewer resources committed to trauma care (41,42). There are concerns that trauma systems described in HICs may not apply in these settings because of deficient resources, infrastructure and the existing complex mechanisms of injuries in adversity settings (20). The WHO reports the use of prehospital care by lay responders and non-medical transportation in some LMICs (2). The WHO essential trauma care initiatives have encouraged cost-effective approaches to curb the scourge of injuries (2). Locally devised systems must employ effective trauma care strategies and yet observe minimal resources in sub-Sahara Africa to bring about improvements required (1,2).

Working models for Sub-Sahara Africa—towards WHO and beyond

Sub-Saharan Africa faces inadequate personnel, deficiencies in skills and impassable terrain which complicates trauma care (20). The region also faces competing healthcare needs from infectious diseases (1,2). Effective trauma care systems must be customized to the country's level of economy and must not overburden the existing healthcare capacity (2). In countries where trauma systems are not yet available, the use of low-cost approaches in prehospital care, patient transport and prevention strategies has been documented (2,31). In essential service models such as the essential program on immunization (EPI) most Ministries of Health in LMICs have installed monitoring and evaluation systems that have ensured effective provision of immunization, supply chain and human skills (43). Trauma care in countries where there is none could benefit from borrowing some EPI strategies. The WHO trauma care guidelines (2,23,31) offer a convenient platform to establish such low-cost systems.

Systemized approaches in resource limited settings must address available structures and empower extant communities (1). Afro-centric trauma systems are based on possible available resources and existing traditional and nontraditional structures. It addresses cultures and mobilizes communities and political support to forge cooperation among various players in order to address regionalization of trauma care (1).

Chapter 2

Study context with aims and methods

In order to gain further insight into the trends in trauma care worldwide, the researchers undertook a Cochrane systematic review to assess the evidence for the effectiveness of trauma systems in both HICs and LMICs. The study was guided by the Cochrane's Effective of

Practices and Organisation of Care (EPOC) regulations. The protocol was published in the Cochrane database of systematic reviews prior to conduction of the research itself.

In addition, the researcher also conducted primary studies in the major hospitals in Tanzania and in Botswana to establish baseline information necessary for developing a functional trauma system in the LMICs context. A functional trauma system is described as opposed to 'organised trauma system' in HICs which is highly organised, closely coordinated and utilises costly mechanisms, infrastructures and protocols. The desired trauma systems in LMICs may only employ adapted infrastructure and low-cost protocols and aim to achieve an equivalent level of effectiveness in improving patient outcomes.

The aim of the primary study was to assess the possibility of setting up a trauma care system that is effective and yet affordable in LMIC's circumstances. We made emphasis not to replicate the HIC's high-cost organised trauma system. Such functional systems are flexible enough to allow local adaptations of the existing healthcare infrastructures in Sub-Saharan Africa setting and have therefore been previously coined Afro-centric trauma systems (1).

The research interrogated various data-systems including the trauma care process, death and birth registration systems, pathology departments, and the emergency medical department referral systems in the two respective countries.

Tanzania, a country that was recently upgraded to a 'lower' middle income country, bears a high rate of injuries (44,45) similar to many other LMICs (36-39), its burgeoning population, and urbanization suggests further escalation of traumatic injury trends, and calls for effective strategies. The country's health care system is decentralized; healthcare services are offered in hierarchies from healthcare posts, dispensaries, health centers to a higher hierarchy level such as specialized hospitals (46). The country's effort to manage these injuries include the recent

establishment of an Emergency Medicine training program, and development of emergency medicine departments in all major hospitals (42). However, so far there are no organized trauma system models in place, trauma care training is deficient and trauma-surgery specialization among health professionals is yet to start (47,48). Further, the national health insurance fund (NHIF) only provides about 32% coverage, and does not include prehospital emergency services (49).

On the other hand, Botswana, an 'upper' middle income country in sub-Saharan Africa, enjoys a higher social-economic level, good quality road networks country-wide, and a much lower population density. Similar to other LMICs, the high rate of RTC confront Botswana and lead to a high death rate (41,50). The country suffers competing healthcare needs from infectious diseases (28,35) in addition to the burden of trauma disease. In recent times, Botswana developed Emergency Medicine physician training and acquired a well-established emergency medicine department in her major hospitals (41, 51,52). Unlike other LMICs, the country boasts a subsidized health care system and a functional Motor Vehicle Accident fund system (53,54).

Description of the core research problem and its significance

Current trauma care approaches advised by WHO and the trauma societies include prehospital care services, trauma care-capable hospitals, trauma-care performance appraisal systems, effective communication systems for triage patients, and rehabilitation services (2,3,24,26). The proposed trauma system model has shown cost saving, improved resource utilisation, imparting necessary skills to hospitals due to pooling patients, improving quality and reducing morbidity and mortality (2). Such systems are desired in sub-Saharan Africa, where the burden of traumatic injuries is the highest, and where there are deficient resources (28).

Research shows instituting trauma systems where none exist may improve hospital performance and outcomes even for non-trauma diseases (2).

Despite the obvious need for such trauma systems in LMICs, the cost required has impeded implementation. Further, a lack of evidence for their effectiveness outside of HICs has likely led to less advocacy and funding.

The study assessed baseline information in the two sub-Saharan African countries to recommend how an Afro-centric trauma care system may provide optimal care at a reasonable cost.

Hypothesis

The researchers studied trauma care trends and further assessed how functional trauma systems could be developed in African settings while utilising existing structures proven to be functional. The term 'Afro-centric trauma system' was coined by Hardcastle (1) to describe the needed African contextual considerations while devising the trauma care system in Africa. This is a form of trauma uBuntu. In this series of studies, the authors examine the literature around trauma systems using a Cochrane evidence-based review. Further, they conducted primary studies to examine resources available, care processes, and organizational structures in Botswana and Tanzania. The research explores possibility of building trauma systems using WHO recommendations (2,31).

The hypothesis is that ***organized*** trauma systems and ***designated trauma centers*** adopted by LMICs improve outcomes among injured patients, and that sub-Saharan African countries exemplified by Tanzania and Botswana, though with differing capacity in their health systems, bear the potential to set up functional trauma systems.

Research questions and objectives

Research questions: injury and its impact are increasing in LMICS where trauma systems approaches are not widely practiced, further the current injury care systems in HICs may not be usable in LMICs. Can LMICs implement recommended trauma care approaches?

Objectives of the study:

1. To undertake a comprehensive Cochrane systematic review examining the utility and effect of trauma systems, designated trauma centers and the development thereof across the world using the Effective of Practice and Organisation of Care (EPOC) methods.
2. To assess burden of 'trauma disease' in Botswana and Tanzania through assessment of penetrating trauma and blunt trauma – subdivided as road-related and other, and assess adult versus paediatric injury.
3. To assess the current health care structure capability in provision of trauma care services in Tanzania and Botswana through analysis of the physical facilities, the human resources including the skill/education levels, the processes of care and adverse event avoidance methods, and analyze the capacity of the prehospital trauma system.
4. To evaluate potential opportunities within existing health care structures that can be used to build trauma systems in Tanzania and Botswana using a proposed modified, cost-effective, improved system based on best evidence and guided by local data, using the two African countries with contrasting social economic contexts.

Methodology and Study designs

After obtaining approval of the concept of the study and registration for the PhD degree at UKZN the necessary post-graduate and ethics approvals from the various countries and institutions were organized prior to any actual data accumulation. (See Appendices 3-5).

The study employed various methods to achieve the set objectives: in examining the utility of trauma system and designated trauma centers, a systematic review using Cochrane EPOC guidelines was performed. The study protocol was published as per Cochrane guidelines and subsequently a review was undertaken. (See Chapter 3)

Further observational research was carried out to assess health care provision systems using record reviewing, in-person interviews of healthcare providers and administrators in pre-selected trauma-burdened hospitals in Botswana and Tanzania. These studies employed cross-sectional research designs and chart-review of hospital records as well as interviewing healthcare providers.

Chapter 3

Organised trauma systems and designated trauma centres for improving outcomes in injured patients

i) Intervention Protocol

Cochrane Database of Systematic Reviews

Organised trauma systems and designated trauma centres for improving outcomes in injured patients (Protocol)

Mwandri M, Stewart B, Hardcastle TC, Rubiano AM, Gruen RL

Mwandri M, Stewart B, Hardcastle TC, Rubiano AM, Gruen RL
Organised trauma systems and designated trauma centres for improving outcomes in injured patients
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[Intervention Protocol]

Organised trauma systems and designated trauma centres for improving outcomes in injured patients

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ABSTRACT

This is a protocol for a Cochrane Review (Intervention). The objectives are as follows:

To assess the effects of organised trauma systems and designated trauma centres for improving outcomes in injured patients, specifically patient outcomes and adverse effects or harms.

BACKGROUND

Description of the condition

Trauma is the injury of an individual due to a number of potential mechanisms, including road traffic crashes, falls, contact with heat or hot objects or substances, weapons, electricity, bites and stings, and others. Trauma can be intentional (e.g. suicide attempt, as-sault) or unintentional, and either blunt (e.g. fall) or penetrating (e.g. gunshot wound). Furthermore, injuries can be defined by severity, from minor to severe or life-threatening to uniformly fa-tal. Given the frequency that these mechanisms occur in societies and the potential for serious consequences from each of them, in-jury is responsible for a large global health and economic burden.

Almost five million people die from trauma each year, which makes it a serious global health problem (Mock 2015). Additionally, trauma incurs 180 million disability-adjusted life years annually (Mathers 2004). Ninety per cent of this burden occurs in low- or middle-income countries (LMICs) (WHO 2013). In 2005, coun-tries lost an estimated USD 167.8 billion from road traffic injuries alone (Dalal 2013). In response, organised trauma care has devel-oped and evolved over many decades, and has led to the formation of trauma systems (Mullins 1999; Nijs 2003). There is emerg-ing evidence that these systems may be effective in reducing the burden from trauma in LMICs and thus, such systems have been replicated in many high-income countries (HICs) (West 1983; Shackford 1986; Mullins 1994; Nicholl 1997; Atkin 2005). Despite LMICs carrying the greatest trauma burden (WHO 2013;

Hardcastle 2013a; Hardcastle 2013b), few LMICs have adopted a formal trauma system. The World Health Organization (WHO) has recommended developing resource-appropriate trauma sys-tems, as described in their guideline documents, 'Prehospital Trauma Care Systems' and 'Guidelines for Essential Trauma Care' (Mock 2004; Sasser 2005). Further recommendations are based on feasibility of care considering resource limitations, pre-hospi-tal capability, and geographical challenges in LMICs (Hardcastle 2013a). Improvement in the planning and organisation of human and physical resources and institution of systemised trauma care is likely to improve outcomes of injured patients, especially where these services are poor or non-existent (Calvello 2013). However, the quality of evidence used for evaluating these systems remains insufficient.

Description of the intervention

Description of the intervention considers the template for inter-vention description, evaluation and replication guide (TIDieR) (Hoffman 2014). The name of the intervention is 'organised trauma systems', a pre-planned approach to the provision of the spectrum of trauma care. An organised trauma system stipulates how and when patients are moved to and between providers, who provides care, where it is provided, when it is to be available, and how the costs are recovered. Organised trauma systems offer ini-tial care and triage patients to the most appropriate level of care according to their needs. Organised trauma systems necessarily include pre-hospital and hospital services, and rehabilitation ser-vices. Trauma systems may be centralised within a specified geo-graphical area (regionalised). Pre-hospital care is made up of a com-munication system, initial medical services at the area of injury oc-currence, patient transport services (i.e. ambulance services), and includes necessary medical treatment during transportation. Hos-pital care is provided by hospitals designated as level I to IV trauma centres on the basis of trauma volume, range of available services, staffing requirements, educational/research capacity, and support of injury prevention initiatives. A level I centre has a full range of immediately available services and leadership in teaching, re-search, and injury prevention and control. Level II centres are able to initiate definitive care for all injuries but with a lesser capacity in research and certain services compared to level I. Level III centres provide assessment, stabilisation, and basic emergency operations. Level IV centres provide basic trauma life support (Mock 2004; Hardcastle 2011; ACS 2014). Additionally, an organised trauma system often includes programmes that support injury prevention initiatives, such as promotion of helmet-wearing among cyclists, appropriate seat belt use, education against alcohol and other illicit substance use among drivers and cyclists, and law enforcement for traffic offenders. Other preventive measures may involve necessary changes in legislation and engineering designs for cars and roads (Rivara 1997; Mock 2001; ACS 2014).

How the intervention might work

An organised trauma system may improve the outcome of severely injured patients by identifying those who require multidisciplinary care and promptly transporting them to an appropriate level of care. This system creates high levels of skills and expertise among providers through high patient volume and concentration of re-sources and therefore may lead to more intensive utilisation of re-sources. Regionalised trauma systems and trauma centres provide leadership and organisation of trauma care to the designated pop-ulation (Cole 2016). Trauma systems often support injury preven-tion programmes that may reduce the burden of injury. Trauma systems may also reduce barriers to care, improve the quality of care provided, use resources more efficiently, strengthen the trauma provider workforce by offering technical support to lower levels of care (level III and IV), offer a smooth referral mechanism within the system, and improve community health. Generally, centralisa-tion of healthcare systems has been documented to de-skill lower facilities, and delay patients' treatment (Atkinson 2004). However, trauma system centralisation may minimise delays by offering ap-propriate treatment at the scene and fast transportation, while con-tinuing necessary treatment. Models of trauma systems available in HICs are costly and may adversely affect healthcare provision for other services in low-income countries (Mock 2004).

Why it is important to do this review

Although several studies have reported reductions in the burden of injury and improvements in injury care after the creation of a trauma system, the study designs are weak (e.g. uncontrolled before-and-after studies) (Shackford 1986; Atkin 2005). Further-more, the relatively successful trauma systems in the USA have not been widely replicated in other regions (West 1983; Guss 1989; Mullins 1994), particularly in LMICs (Nicholl 1997). The lack of support for trauma system development in LMICs may be, in part, due to the lack of evidence for their effectiveness in low-resource settings.

Because of the large burden of trauma globally and high cost of resources for establishing trauma systems, it is important to assess their effectiveness with quality evidence. Doing so is particularly important for LMICs given the greater burden of trauma and crit-ical financial restraints. A quality evaluation of trauma system ef-fectiveness is likely to inform health policy and resource allocation decisions, and ultimately lead to improved care for the injured.

OBJECTIVES

To assess the effects of organised trauma systems and designated trauma centres for improving outcomes in injured patients, specif-ically patient outcomes and adverse effects or harms.

METHODS

Criteria for considering studies for this review

Types of studies

We will include the following types of studies.

- Randomised trials.
- Non-randomised trials with at least two intervention sites and two control sites.
- Controlled before-after studies that have at least two intervention and two control sites.
- Interrupted time series studies that have a defined point of time when the intervention occurred and must have a minimum of three points before and after the intervention.

Types of participants

We will include healthcare professionals providing care to patients who suffer major trauma (e.g. Injury Severity Score ≥ 15). We will exclude studies that include patients who predominantly suf-fer fragility fractures and those who have not been admitted to hospital.

Types of interventions

The intervention of interest will be the establishment of an organ-ised trauma system compared to non-trauma system care (current normal standard care for most LMICs). An organised trauma sys-tem is defined as a pre-planned approach to the provision of the spectrum of trauma services, including but not limited to, injury prevention and control initiatives, timely transport from the scene of the injury to the trauma care facility, availability of trauma care providers and services when needed, and rehabilitation (WHO 2013).

Types of outcome measures

Primary outcomes

- Patient outcomes (health outcomes, such as, mortality, morbidity, and recovery)
- Adverse effects or harms
  - Clinical, monitoring, or medication errors
  - Delays in standards of trauma care
  - Specific clinical adverse effects, such as sepsis, hospital-acquired or healthcare-associated infections, or surgical complications

Secondary outcomes

- Utilisation and access
  - Utilisation of services. It is expected that more seriously injured patients will be delivered to higher level trauma centres (level I and II) in a more timely fashion and with greater survival in trauma systems than in non-trauma systems. Utilisation of service indicators will include:
    - volume of trauma patients brought to the appropriate trauma centre
    - bed occupancy
    - length of hospital stay (including length of stay in intensive care unit)
    - appropriate trauma procedures performed
  - Access to services. This includes timely transporting of the severely injured to appropriate care, and it will depend on other services, such as ambulance services, availability of appropriate trauma care providers and services (e.g. trauma surgical services, intensive care, blood bank services). We will measure access to services using indicators such as:
    - patients' waiting time to access trauma services
    - injury-appropriate service time
    - ambulance service call volume, etc.
  - Social outcomes (e.g. community participation or uptake in injury prevention and control initiatives); examples include:
    - training lay persons to provide pre-hospital care in low- and middle-income countries (LMICs)
    - bystander care educational programmes
    - law enforcement for traffic offenders at the community level
- Quality of care provided
  - Adherence to standards of trauma care with tangible patient benefit (e.g. trauma care audit filters proposed by the American College of Surgeons or other groups) (Willis 2008; Juillard 2009; Shafi 2009; ACS 2014; Stewart 2016)
- Equity
  - Timely access to trauma care and differential effects of outcomes across advantaged and disadvantaged populations
- Knowledge
  - Population knowledge regarding injury prevention
  - Healthcare provider knowledge or skill regarding standards of injury care, performance in trauma moulage scenarios

Outcomes involving system organisation in trauma need to be measured over a long period (10 to 16 years) (Mock 2004). How-ever, other outcomes may be measured over a shorter time horizon (a few months to a few years) (Cole 2016).

Reporting of the outcomes listed here will not be an inclusion criterion for the review and we will include studies regardless of the assessed outcomes.

Search methods for identification of studies

We will conduct the searches with the advice and assistance of the Cochrane Effective Practice and Organisation of Care (EPOC) Group. We will not impose any restrictions on publication status, language, or country of publication.

Electronic searches

The Cochrane EPOC Group Information Specialist will develop the search strategies in consultation with the review authors. We will search the Cochrane Database of Systematic Reviews (CDSR) and the Database of Abstracts of Reviews of Effects (DARE) for primary studies included in related systematic reviews. We will search the following databases (from inception).

- Cochrane Central Register of Controlled Trials (CENTRAL), including the Cochrane EPOC Group's Specialised Register.
- MEDLINE (from 1946) In-Process and other non-indexed citations, OvidSP.
- Embase (from 1974), OvidSP.
- Cumulative Index to Nursing and Allied Health Literature (CINAHL) (from 1980), EbscoHost.
- Directory of Online African Journals (DOAJ).

We will use two methodology search filters to limit retrieval to appropriate study designs: a modified version of the Cochrane Highly Sensitive Search Strategy (sensitivity-and precision-maximising version-2008 revision; Lefebvre 2011) to identify randomised trials (Higgins 2011), and a Cochrane EPOC Group methodology filter to identify non-randomised trial designs.

Searching other resources

Grey literature

We will conduct a grey literature search to identify studies not indexed in the databases listed above; sources will include the sites listed below. We will document any additional sources in the review.

- OpenGrey (www.opengrey.eu).
- Grey Literature Report (New York Academy of Medicine; www.greylit.org).

Trial registries

- World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) (www.who.int/ictrp/en).
- ClinicalTrials.gov, the US National Institutes of Health (NIH) (clinicaltrials.gov).
- Health economic studies database
    - National Health Service-Economic Evaluation Database (NHS EED) for identifying studies that meet the study design.

We will also perform the following.

- We will review reference lists of all included studies, relevant systematic reviews/primary studies.
- We aim to contact authors of relevant studies/reviews to clarify reported published information and to seek unpublished results/data.
- We will contact researchers with expertise relevant to the review topic/EPOC interventions.
- We aim to conduct cited reference searches for all included studies in ISI Web of Knowledge; and screen individual journals and conference proceedings (e.g. handsearch).

We will also cross-check the references of included studies and relevant systematic reviews.

We will provide appendices for all strategies used, including a list of sources screened and relevant reviews/primary studies reviewed.

Data collection and analysis

Selection of studies

We will download all titles and abstracts retrieved by electronic searching to a reference management database and remove duplicates. Two review authors (MM and BS) will independently screen titles and abstracts for inclusion. We will code all the potentially eligible studies as either 'retrieve' (eligible or potentially eligible/unclear) or 'do not retrieve'. We will retrieve the full-text study reports/publications. Two review authors (MM and BS) will independently screen the full-text articles and identify studies for inclusion. We will identify and record reasons for exclusion of the ineligible studies. We will resolve any disagreement through discussion or, if required, we will consult a third review author (TH). We will list excluded studies with reasons for exclusion in the 'Characteristics of excluded studies' tables. We will collate multiple reports of the same study so that each study, rather than each report, is the unit of interest in the review. In addition, we will provide any information we can obtain about ongoing studies. We will record the selection process in sufficient detail to complete a PRISMA flow diagram (Liberati 2009), and a 'Characteristics of excluded studies' tables.

Data extraction and management

We will use a standard data collection form adapted from the Cochrane EPOC Group for extracting study characteristics and outcome data (EPOC 2013a). Two review authors (MM and BS) will independently extract the following study characteristics from

included studies and transfer the information into Review Man-ager 5 (RevMan 5) (RevMan 2014).

- Methods: study design, number of study centres and location, study setting, withdrawals, date of study, and follow-up
- Participants: number, mean age, age-range, gender, severity of condition, diagnostic criteria, inclusion criteria, exclusion criteria, and other relevant characteristics
- Interventions: intervention components, comparison, and fidelity assessment
  - We will use the template for intervention description and replication (TIDieR) criteria to asses completeness of reporting interventions (Hoffman 2014); we will use the following criteria
    - Brief name of the intervention
    - Description of rationale, theory, or goal of essential elements to the intervention
    - Description of physical or informational material used for the intervention
    - Description of each of the procedures, activities or processes used in the intervention, including enabling or supporting activities
    - Description of providers (background, expertise, training)
    - Mode of delivery of the intervention (face-to-face, by telephone, internet)
    - Description of location(s) infrastructure or relevant features of where intervention occurred
    - Description of: frequency, intensity, duration of the intervention
    - If intervention is tailored or adapted, describe why, when, and how
    - If intervention was modified, description of the changes
    - How well was their intervention planned (if fidelity or adherence was assessed describe how, by who, and if strategies for maintaining fidelity were employed)
    - How well was the intervention actually carried out, description of how the intervention adhered to the plan
- Outcomes: main and other outcomes specified and collected, and time points reported
  - For economic outcome of studies focusing on resource utilisation only, we will use the guidance provided by the Cochrane and Campbell Economic Methods Group (methods.cochrane.org/economics), that includes the following selected criteria
    - Is the chosen time horizon appropriate to include relevant costs and consequences?
    - Is the actual perspective chosen appropriate?
    - Are all important and relevant costs for each alternative identified?
    - Are all costs measured appropriately in physical units?
    - Are all important variables, whose values are uncertain, appropriately subjected to sensitivity analysis?
    - Do the conclusions follow from the data reported?
    - Does the study discuss the generalisability of the results to other settings and patient/client groups?
    - Does the article indicate that there is no potential conflict of interest of study researcher(s) and funder(s)?
    - Are ethical and distributional issues discussed appropriately?
- Notes: funding for trials, notable conflicts of interest of trial authors, and ethical approval

Two review authors (MM and BS) will independently extract out-come data from included studies. We will note in the 'Character-istics of included studies' tables if outcome data were reported in an unusable way. We will resolve disagreements by consensus or by involving a third review author (TH).

Assessment of risk of bias in included studies

Two review authors (MM and BS) will independently assess risk of bias for each study using the criteria outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011), and the guidance from the Cochrane EPOC Group (EPOC 2013b). We will resolve any disagreement by discussion or by in-volving a third review author (TH). We will assess the risk of bias according to the following domains.

For randomised trials, non-randomised trials, and controlled be-fore-after studies, we will assess the following domains.

- Random sequence generation.
- Allocation concealment.
- Blinding of participants and personnel.
- Blinding of outcome assessment.
- Incomplete outcome data.
- Selective outcome reporting.
- Baseline outcomes measurement.
- Baseline characteristics.
- Other bias.

For interrupted time series studies, we will assess the following.

- If the intervention is independent of other changes.
- If the shape of the intervention effect is prespecified.
- If the intervention is unlikely to affect data collection.
- If knowledge of the intervention is adequately prevented.
- If incomplete outcome data are adequately addressed.
- If the study is free from selective outcome reporting.
- If the study is free from other risks of bias.

We will judge each potential source of bias as either high, low, or unclear and provide a quote from the study report together with a justification for our judgment in the 'Risk of bias' table. We will summarise the 'Risk of bias' judgements across different studies for each of the domains listed. We will consider blinding separately

for different key outcomes, where necessary. Where information on risk of bias relates to unpublished data or correspondence with a trial author, we will note this in the 'Risk of bias' table. When considering treatment effects, we will take into account the risk of bias for the studies that contribute to that outcome.

Measures of treatment effect

We will estimate the effect of the intervention using the following.

- Risk ratios (RRs), adjusting for baseline differences for dichotomous data, together with the appropriate associated 95% confidence interval (CI).
- Mean difference (MD) or standardised mean difference (SMD) for continuous data, together with the 95% CI.

Where appropriate, measurement of treatment effect will use the same scale (i.e. quality of life, disability scales). We will ensure that an increase in scores for continuous outcomes can be interpreted in the same way for each outcome, explain the direction to the reader, and report where the directions were reversed, if this was necessary.

Measurement of treatment effect for cluster-randomised trials, randomised trials, and controlled before-after studies

We will extract the intervention effect estimate reported for out-comes in the included studies along with the P value, 95% CI, and the method used in their calculation. For dichotomous outcomes we will use RRs, and for continuous outcomes we will use SMDs. Ratios greater than 1 and differences greater than 0 between the control and intervention groups will represent benefit for the in-tervention group.

Measurement of treatment effect for interrupted time series studies

For interrupted time series studies, we will either use a regres-sion analysis with time trends before and after the intervention, adjusted for autocorrelation and any periodic changes, or auto-regressive integrated moving average (ARIMA) analysis. We will report outcome results as changes in level and slope. If analysis or reporting is not appropriate, we will re-analyse according to the recommendation given in the Cochrane EPOC Group guideline (Ramsay 2003; EPOC 2013c).

Unit of analysis issues

We will perform analysis at the same level as the allocation for the intervention and control group to avoid unit of analysis errors. For clustering designs, such as cluster-randomised trials, we will perform analysis, adjusting for clustering. We will extract and re-analyse results not adjusted for clustering. If we find a unit of anal-ysis error, and there is insufficient information to allow re-analy-sis, we will contact the original study authors to obtain necessary information; if we are unsuccessful, we will not report the CI and P value, and we will describe the incident as a 'unit of analysis error'.

Dealing with missing data

We will state missing data on the collection and extraction form; if data are missing at random, we will ignore their absence and perform analysis. If data are not missing at random, we will contact the original study authors for additional information; if unsuccessful, we will perform a sensitivity analysis to detect the impact of missing data (Higgins 2011).

Assessment of heterogeneity

We will investigate heterogeneity by visual inspection of forest plots and the Chi^2 test. Where there is no substantial heterogeneity (I^2 statistic is less than 50%) we will perform a meta-analysis (Higgins 2011). If we identify substantial heterogeneity and if there are an adequate number of included studies (more than 10), we will perform subgroup analyses for prespecified subgroups that are either of the following.

- High-income country (HIC) settings and low- and middle-income country (LMIC) settings.
- Adult trauma patients and paediatric trauma patients.

Assessment of reporting biases

We will assess reporting bias by performing the following.

- We will compare the outcome of studies plotted in a matrix for indicating unreported outcomes.
- We will search protocols, abstracts, or trial registries in databases, such as PubMed, and compare listed outcomes with the reported ones in the related published studies.
- We will compare the methods with result sections of published studies to detected unreported outcomes.

We will contact primary authors to supply the missing information, and if unsuccessful, we will perform a sensitivity analysis (Higgins 2011).

Data synthesis

We will pool data from studies we judge to be clinically homogeneous using RevMan 5 (RevMan 2014). We will undertake meta-analyses only when this is meaningful, i.e. if the treatments, participants, and the underlying clinical question are similar enough for pooling to make sense. When we encounter skewed data we will note that the data are skewed and consider the implication of this. Where multiple trial arms are reported in a single trial, we will include only the relevant arms. If two comparisons must be entered into the same meta-analysis, we will halve the control group to avoid double-counting.

We do not plan to conduct a full economic analysis given the marked variation in studies we will uncover and the inherent risk of significant heterogeneity. Therefore, in accordance with Cochrane guidelines, we will provide a narrative summary of economic re-sults instead of performing pooled analyses.

'Summary of findings' table

We will assess the certainty of evidence across multiple studies with similar interventions and outcomes using the GRADE approach, as described in the Cochrane EPOC Group worksheet for prepar-ing 'Summary of findings' tables (EPOC 2013d). We will rate the certainty of evidence as follows (EPOC 2016).

- High-certainty of evidence: this research provides a very good indication of the likely effect. The likelihood that the effect will be substantially different is low.
- Moderate-certainty of evidence: this research provides a good indication of the likely effect. The likelihood that the effect will be substantially different is moderate.
- Low-certainty of evidence: this research provides some indication of the likely effect. However, the likelihood that it will be substantially different is high.
- Very low-certainty of evidence: this research does not provide a reliable indication of the likely effect. The likelihood that the effect will be substantially different is very high.

We will create a 'Summary of findings' table using the following outcomes: patient outcomes, adverse effects, utilisation of services, access to services, quality of care provided, and knowledge.
Two review authors will independently assess the certainty of the evidence (high, moderate, low, and very low) using the five GRADE considerations (study limitations, consistency of effect, imprecision, indirectness, and publication bias) as it relates to the main outcomes (Guyatt 2008; EPOC 2013d). We will use meth-ods and recommendations described in Section 8.5 and Chapter 12 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011), the Cochrane EPOC Group worksheets (EPOC 2013d), and GRADEpro software (GRADEpro GDT 2014). We will justify all decisions to downgrade or upgrade the quality of the included studies using footnotes and make comments to aid readers' understanding of the review where necessary. We will con-sider whether there is any additional outcome information that we are unable to incorporate into meta-analyses, will note this in the comments, and will state if it supports or contradicts the in-formation from the meta-analyses. If it is not possible to meta-analyse the data we will present results in a narrative 'Summary of findings' table format (EPOC 2013d).

Subgroup analysis and investigation of heterogeneity We plan to carry out the following subgroup analyses.

- HIC settings and LMIC settings.
- Adult trauma patients and paediatric trauma patients.

The rationale for the first subgroup analysis is that HIC settings and LMIC settings differ in both human and physical resources. Such differences will almost certainly result in heterogeneity and require separate analyses.

The rationale for the second subgroup analysis is that patients of different ages have particular needs, and therefore require different resources, and this may lead to different outcomes.
For both subgroup analyses, we will assess the following.

- Patient outcomes
- Adverse effects or harms

We will apply a test of interaction to assess statistically significant differences between subgroups.

Sensitivity analysis

We will perform sensitivity analyses by employing multiple impu-tation methods (Higgins 2011), when the following occur.

- There are 'data missing not at random', and if efforts to obtain additional information from primary study authors are unsuccessful.
- If there are studies with high risk of bias included.
- When we have performed re-analysis (i.e. in a cluster-randomised trial where the intracluster correlation coefficient was not considered initially) for checking the stability of our results.

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We have based the Methods section of this protocol on a standard template used by Cochrane EPOC.

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* *Indicates the major publication for the study*

APPENDICES

Appendix 1. Description and inclusion criteria for study designs

Study designs included in Cochrane EPOC reviews			
Suggested terms	**Notes**	**Definition**	**Exclusions**
Randomised trial	Instead of **randomised controlled trial**, which is redundant.	An experimental study in which people are allocated to different interventions using methods that are random	Studies with only one intervention or control site. We recommend only including cluster randomised trials, non-randomised cluster trials, and controlled before-after studies with at least two intervention sites and two control sites In studies with only one intervention or control site, the intervention (or comparison) is completely confounded by the study site, making it difficult to attribute any observed differences to the intervention rather than to other site-specific variables
Non-randomised trial	Instead of controlled clinical trial. EPOC reviews do not include clinical trials (and randomised trials are also controlled clinical trials). Also instead of 'quasi-randomised controlled trials', which is used to mean different things by different authors	An experimental study in which people are allocated to different interventions using methods that are not random	We recommend only including controlled before-after studies with at least two intervention sites and two control sites
Controlled before-after study	Instead of controlled before-and-after.	A study in which observations are made before and after the implementation of an intervention, both in a group that receives the intervention and in a control group that does not	We recommend only including controlled before-after studies with at least two intervention sites and two control sites Studies in which data collection is not contemporaneous in study and control sites during the pre- and post-intervention periods of the study and/or does not use identical methods of measurement

(*Continued*)

Interrupted time series study	Use 'study' instead of 'design' or 'analysis'.	A study that uses observations at multiple time points before and after an intervention (the 'interruption'). The design attempts to detect whether the intervention has had an effect significantly greater than any underlying trend over time	Studies that do not have a clearly defined point in time when the intervention occurred, and at least three data points before and three after the intervention
Repeated measures study	Not in the EPOC checklist.	An interrupted time series study where measurements are made in the same individuals at each time point	Not applicable.

Appendix 2. Search strategies

This is the proposed MEDLINE search strategy (EPOC 2013a); we will adjust the strategy, as appropriate, for other databases.

1. ((plan* or develop* or institution or institute? or organi#ation* or organi#e* or designat* or stipulat* or dedicat* or implement*) adj2 (trauma* or polytrauma*)).ti,ab
2. ((polytrauma* or trauma*) adj2 (system? or network?)).ti,ab
3. traumatology/og
4. (trauma* or polytrauma*).ti,ab.
5. Regional Medical Programs/
6. 4 and 5
7. ((impact* or effect* or evaluat* or implement* or develop* or assess* or outcome* or centrali#ation or centrali#ed or regionali# ation or regionali#ed) adj5 (trauma centre* or trauma center* or trauma service? or trauma care)).ti,ab
8. trauma centers/og
9. or/1-3,6-8
10. randomized controlled trial.pt.
11. controlled clinical trial.pt.
12. multicenter study.pt.
13. pragmatic clinical trial.pt.

(*Continued*)

14. (randomis* or randomiz* or randomly).ti,ab.
15. groups.ab.
16. (trial or multicenter or multi center or multicentre or multi centre).ti
17. (intervention? or effect? or impact? or controlled or control group? or (before adj5 after) or (pre adj5 post) or ((pretest or pre test) and (posttest or post test)) or quasiexperiment* or quasi experiment* or pseudo experiment* or pseudoexperiment* or evaluat* or time series or time point? or repeated measur*).ti,ab
18. non-randomized controlled trials as topic/
19. interrupted time series analysis/
20. controlled before-after studies/
21. or/10-20
22. exp animals/
23. humans/
24. 22 not (22 and 23)
25. review.pt.
26. meta analysis.pt.
27. news.pt.
28. comment.pt.
29. editorial.pt.
30. cochrane database of systematic reviews.jn.
31. comment on.cm.
32. (systematic review or literature review).ti.
33. or/24-32
34. 21 not 33
35. 9 and 34

CONTRIBUTIONS OF AUTHORS

Andres M Rubiano and Russell L Gruen conceived the protocol.

Michael Mwanri and Barclay Stewart designed the protocol.

Timothy Hardcastle co-ordinated the protocol.

Michael Mwanri, Barclay Stewart, and Timothy Hardcastle wrote the protocol.

Russell L Gruen and Andres M Rubiano provided general advice on the protocol.

DECLARATIONS OF INTEREST

Michael Mwandri has no known conflicts of interest.

Barclay Stewart received a US National Institutes of Health (NIH)/Fogarty Global Health Research Fellow Grant (R25TW009345). This poses no conflict of interest to the current work.

Timothy Hardcastle is a consultant to a number of private institutions regarding emergency care or disaster planning for which he was reimbursed for time, travel, and expertise on an ad-hoc basis. In the same way he has received reimbursement for expert case review and testimony as a medico-legal expert in his field, again on an ad-hoc basis. This work was as an expert of the University of KwaZulu-Natal with a PhD in emergency systems development and disaster medicine. He has received speaker invitations to various national or international meetings or courses as an invited plenary speaker and the inviting organisations have funded some or all of his expenses as their guest. For most of these activities there was little profit and the activities are at most peripherally related to the work contained in this Cochrane EPOC review.

Andres M Rubiano has no known conflicts of interest.

Russell L Gruen has no known conflicts of interest.

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- No sources of support supplied

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ii) Review

Organised trauma systems and designated trauma centres for improving outcomes in injured patients

Review information

Review number: A030

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Abstract

Background

Trauma poses a serious global health problem, which may be partially addressed by trauma systems. Because of high cost of resources for establishing trauma systems, it is important to assess their effectiveness using high quality evidence. Doing so is particularly important for low-middle-income countries (LMICs) given the greater burden of trauma and critical financial restraints. A quality evaluation is likely to inform health policy and resource allocation decisions, and may improve care.

Objectives

To assess the effects of trauma systems and designated trauma centres on outcomes of injured patients in both LMICs and high-income countries (HICs). Specifically, to assess effects on: patient outcomes(mortality, morbidity, and adverse effects or harms); utilisation of services (including economic outcomes); access to services; social outcomes;and quality of care provided.

Search methods

We searched Cochrane CENTRAL, MEDLINE, EMBASE, and two trial registries on 14 November 2018.
We checked reference lists of all included reports, lists in the injury-related systematic reviews and conference proceedings from sub-Saharan Africa and the Africa Online Journals website to detect unpublished and potentially relevant records.

Selection criteria

We searched for records of randomised trials (RTs), non-randomised trials (NRTs), controlled-before-after studies (CBA), and interrupted time series (ITS) that compared outcomes of trauma systems or designated trauma centres to the usual care. Eligibility criteria considered RTs and NRTs with at least two intervention sites and two

control sites, CBA studies with at least two intervention and two control sites, and ITS studies with a defined point of time when the intervention occurred and a minimum of three points before and after the intervention. There were no restrictions on publication status, language, or country of publication.

Data collection and analysis

We used standard methodological procedures expected by Cochrane. Given the substantial heterogeneity of reports and outcome measures, we did not undertake a meta-analysis.

Main results

There were five ITS studies with 314,302 patients: three reports evaluated trauma system and two evaluated designated trauma centres. Two reports were from the US, two from the UK, and one from Norway.

Regionalisation of trauma system

Mortality: One report showed reduced mortality:20,357 participants,3-year relative effect -30%, change in slope (CI) -0.1 (-0.5.26,0.326); change in level (CI) -2.017 (-3.169,-0.864). Another study with two subgroups showed improved survival rate, authors reported change in level (+0.133%, P=0.678), and a change in slope (+0.07%, P = 0.006) in the overall trauma system group (248,234 participants); and in constant submitters group (110,863 participants) they reported change in level (+0.133%, P=0.678), and a change in slope (+0.08%, P = 0.023). The third study did not report mortality benefit:19,820 participants, 6-month relative effect 326%, change in slope (CI) 16.5 (-2.782, 35.782), change in level (CI) 98 (-2.809, 198.809).The certainty of evidence was low.

Morbidity: One study reported increased patients who attained 'good recovery': 19,820 participants, 6-month relative effect 8276%, change in slope 350.61 (105.44, 595.88), change in level 413 (-179.63, 1007.3). However the certainty of evidence was very low.

Utilisation of services: One report(19,820 participants) with two outcomes, showed reduced length of hospital stay: 6-month relative effect -24%, change in slope (CI) 0 (-1.75, 1.75), change in level -5.33 (-14.51, 3.85); and reduced length of intensive care stay: 6-month relative effect -18.182%, change of slope (CI) 0.5 (-0.74, 1.74), change in level -2 (-8.49, 4.49). Certainty of evidence was very low.

No studies reported adverse effect or harms, access to services, or quality of care provided.

Designation of trauma centres

Mortality: One study (7,247 participants**)** reported reduced mortality: relative effect -41.98%, change in slope (CI): -0.512(-2.256, 1.231), change level (CI) -3.595(-11.262, 4.072).The second study(18,644 participants) also reported reduced mortality: adults relative effect -67.13%, Change in slope 2.06 (10.25 to 29.6), change in level -17.52 (-42.27 to 7.23); paediatric relative effect -83.60%, change in slope -1.12 (-3.04 to 0.8), change in level -18.56 (-30.114 to -7,006). The certainty of evidence was moderate.

No studies reported morbidity, adverse effect or harms, utilisation of services, access to services, or quality of care provided.

Authors' conclusions

Regarding trauma system, there was low certainty evidence on reduction of mortality; and very low certainty evidence on reduction of morbidity, and on improved utilisation of services. Regarding trauma centres, there was moderate certainty evidence on reduction of mortality.

Plain language summary

Can healthcare networks designed to treat injured patients and specialist hospitals improve outcomes for injured patients?

Summary text

What is the aim of this review?

The review investigated the influence of two interventions: (1) setting up a treatment network for injured patients known as a trauma system and (2) specifying that certain hospitals should work as specialist trauma centres. We planned to investigate usefulness of these interventions on death, recovery from injury(morbidity), harms, community use of healthcare services, access to healthcare services, and quality of care provided (i.e. adherence to standard injury care).

Key message

The evidence regarding these interventions ranged from moderate to very low certainty and was based on a few reports.

We found a low certainty evidence that trauma systems reduce deaths. We found very low certainty evidence on usefulness of trauma system in improving recovery from injury, and on improving the use of healthcare services.

We found moderate certainty evidence on usefulness of trauma centres in reducing deaths, showing probably it reduce deaths.

We did not find studies reporting impact of trauma system or trauma centres on: harms, access to services, or quality of care provided.

What was studied in the review?

The review studied how trauma systems and trauma centres benefit patients in low-middle-income countries (LMICs) and high-income countries (HICs). The study compared trauma systems and trauma centres to the usual care (the care not provided under trauma systems or trauma centres). The comparison assessed influence of the type of care chosen on: death; recovery from injury; harm; use of services; access to service; and quality of care.

What are the main results of the review?

We found five reports that included data from 314,302 patients. Three reports assessed trauma system and two assessed designated trauma centres. All reports were from HICs: two from the USA, two from the UK and one from Norway. There were no reports from LMICs.

Reports showed a low certainty evidence that setting up a trauma system would reduce the number of deaths. There were no evidence proving any effect of trauma system on patients' recovery from injury, or on the use of services with regards to the injury care.
The reports on effect of trauma centre showed that probably it reduces death in injured patients.

How up to date is this review

Review authors searched for studies that have been published up to 14 November 2018.

Background

Description of the condition

Trauma describes a spectrum of physical injuries that arise from mechanisms as varied as low-energy falls, road traffic collisions, weapons, and burns. It is often categorised as intentional (e.g. suicide attempt, assault) or unintentional and blunt (e.g. fall) or penetrating (e.g. gunshot wound). Traumatic injuries can range from minor (e.g. ankle sprain) to un survivable (e.g. decapitation).

Almost five million people die from injury worldwide every year (Mock 2015) which is just the tip of the iceberg as many millions more people each year are non-fatally injured. Trauma is estimated to account for the loss of 180 million disability-adjusted life years annually (Mathers 2004). Ninety per cent of the burden occurs in low-middle-income countries (LMICs) (WHO 2013). Road traffic injuries result in an overall economic loss of US$ 167.8 billion worldwide (Dalal 2013). In response, trauma care has evolved over a number of decades, and has led to the development of organised trauma systems in many healthcare jurisdictions (Mullins 1999; Nijs 2003). There is emerging evidence that such systems may be effective in reducing the burden from trauma and they are rapidly becoming the accepted standard in many high income countries (HICs) (Shackford 1986; Mullins 1994; Nicholl 1997; Atkin 2005; Moore 2015).

Despite LMICs carrying the greatest trauma burden (WHO 2013; Hardcastle 2013a; Hardcastle 2013b), few have adopted a formal trauma system. The World Health Organization (WHO) has recommended developing resource-appropriate trauma systems, as described in their guideline documents, 'Prehospital Trauma Care Systems' and 'Guidelines for Essential Trauma Care' (Mock 2004; Sasser 2005). Further recommendations are based on feasibility of care considering resource limitations, pre-hospital capabilities, and structural challenges in LMICs (e.g., poor road infrastructure) (Hardcastle 2013a). Improvements in the planning and organisation of human and physical resources and institution of systemised trauma care may improve outcomes for injured patients, especially where these services are poor or non-existent (Calvello 2013). However, the quality of evidence used for evaluating these systems remains insufficient.

Description of the intervention

Organised trauma systems are a planned approach to the provision of trauma care (i.e. pre-hospital care, emergency care, surgical care, critical and acute care, rehabilitation). An organised trauma system stipulates how and when patients are moved to and between providers, who provides care, where it is provided, when it is to be available, and how the costs are recovered. Additionally, organised trauma systems oversee education and training, research, injury prevention and advocacy initiatives.

Organised trauma systems triage patients to the most appropriate level of care according to their needs. Trauma systems may be centralised within a specified geographical area (i.e. regionalised) to facilitate coordinated transport. Pre-hospital care is made up of a communication system, initial medical services at the area of injury occurrence, and patient transport services (i.e. ambulance services), and includes necessary medical treatment during transportation. Emergency, surgical, critical and acute care is provided by hospitals designated at a specified level of trauma care on the basis of trauma volume, range of available services, staffing requirements, educational/research priorities, and support of injury prevention initiatives. For example, one categorisation might require that level I centres offer a comprehensive range of clinical services immediately available on one site as well as providing leadership in teaching, research, and injury prevention and control. Level II centres would be able to initiate definitive care for all injuries but with a lesser capacity in research and certain services compared to level I. Level III centres would provide assessment, stabilisation, and basic emergency operations. Level IV centres would provide basic trauma life support (Mock 2004; Hardcastle 2011; ACS 2014). Additionally, an organised trauma system often includes programmes that support injury prevention initiatives, such as the promotion of helmet-wearing among cyclists, appropriate seat belt use, education against alcohol and other illicit substance use among drivers and cyclists, and firearm safety. Other preventive measures may involve necessary changes in legislation and engineering designs for cars and roads (Rivara 1997; Mock 2001; ACS 2014).

How the intervention might work

An organised trauma system may improve the outcome of severely injured patients by identifying those who require coordinated and multidisciplinary care and promptly transporting them to an appropriate level of care. This system creates high levels of skills and expertise among providers through high patient volume and concentration of resources. As such, trauma systems may lead to better utilisation of resources. Regionalised trauma systems and trauma centres provide leadership and organisation of trauma care to the designated population (Cole 2016).

Trauma systems often support injury prevention programmes that may reduce the burden of injury. Trauma systems may also reduce barriers to care, improve the quality of care provided, use resources more efficiently, strengthen the trauma provider workforce by offering technical support to lower levels of care (e.g., level III and IV), offer a coordinated referral mechanism within the system, and improve community health. However, centralisation of healthcare systems may de-skill lower facilities and delay patient treatment (Atkinson 2004). Trauma system centralisation may minimise delays by offering appropriate treatment at the scene and fast transportation, while continuing necessary treatment. However, models of trauma systems available in HICs are costly and may adversely affect healthcare provision for other services in LMICs (Mock 2004).

Why it is important to do this review

Although several studies have reported reductions in the burden of injury and improvements in injury care after the creation of a trauma system, the study designs are weak (e.g. uncontrolled before-and-after studies) (Shackford 1986; Atkin 2005). Furthermore, the relatively successful trauma systems in the USA have not been widely replicated in other regions (Guss1989; Mullins 1994; Nicholl 1997). The lack of support for trauma system development in LMICs may be, in part, due to the lack of evidence for their effectiveness in low resource settings. Because of the large burden of trauma globally and high cost of resources for establishing trauma systems, it is important to assess their effectiveness using high quality evidence. Doing so is particularly important for LMICs given the greater burden of trauma and critical financial restraints. A quality evaluation of trauma system effectiveness is likely to inform health policy and resource allocation decisions, and ultimately lead to improved care for injured patients.

Objectives

To assess the effects of organised trauma systems and designated trauma centres (compared to the usual care) on outcomes of injured patients in both LMICs and in HICs. Specifically, to assess effects on: patient's outcomes (e.g. mortality, morbidity adverse effects or harms); utilisation of services (including economic outcomes); access to services, and quality of care provided.

Methods

Criteria for considering studies for this review

Types of studies

We planned to include the following study designs:

- Randomised trials (RTs) and non-randomised trials (NRTs) with at least two intervention sites and two control sites
- Controlled-before-after (CBA) studies that have at least two intervention and two control sites
- Interrupted time series (ITS) studies that have a defined point of time when the intervention occurred and have a minimum of three points before and after the intervention

There were no restrictions on publication status, language, or country of publication.

Types of participants

We had planned to include patients with injury severity scores (ISS) of >15. However, a post-hoc decision was made to change ISS inclusion threshold to >9 in order to capture additional studies. We had planned to include healthcare professionals providing care to injured patients but this did not prove possible because of a lack of studies.

Types of interventions

The interventions of interest was: the establishment of an organised trauma system and designated trauma centres compared to non-trauma system care, or no-trauma centre care (i.e. current normal standard care for most LMICs). An organised trauma system was defined as a pre-planned approach to the provision of the spectrum of trauma services, including but not limited to, injury prevention initiatives, timely transport from the scene of the injury to the trauma care facility(trauma centre), availability of trauma care providers and services when needed, and rehabilitation. Trauma systems requires a presence of trauma centres which are specialised injury care hospitals often categorised in levels I- IV according to their service capacities (Jurkovich 1999; ACS 2014).

Types of outcome measures

Primary outcomes

We planned to assess the following outcomes:

- **Patient outcomes**
  - Mortality
  - Morbidity
- **Adverse effects or harms**
  - Clinical, monitoring, or medication errors
  - Delays in standards of trauma care
    - Specific clinical adverse effects, such as sepsis, hospital-acquired or healthcare-associated infections, or surgical complications

Secondary outcomes

- **Utilisation of services**
  - Utilisation of services (e.g. volume of trauma patients, bed occupancy, length of hospital stay, appropriateness of trauma procedures, and resource utilisation representing economic outcomes)
- **Access to services**
  - This would include timely transporting of the severely injured to appropriate care, and depend on other services, such as ambulance services, availability of appropriate traumacare providers and services (e.g. trauma surgical services, intensive care, blood bank services).
- Patients' waiting time to access trauma services
  - Injury-appropriate service time

- Ambulance service call volume, etc.

Quality of care provided

- Adherence to standards of trauma care with tangible patient benefit (e.g. trauma care audit filters proposed by the American College of Surgeons and other groups) (Willis 2008; Juillard 2009; Shafi 2009; ACS 2014; Stewart 2016)

Search methods for identification of studies

We conducted the searches with the advice and assistance of the Cochrane Effective Practice and Organisation of Care (EPOC) Group (Appendix 1).

Electronic searches

The Cochrane EPOC Group Information Specialist developed the search strategies in consultation with the review authors. We searched the Cochrane Database of Systematic Reviews (CDSR) and the Database of Abstracts of Reviews of Effects (DARE) for primary studies included in related systematic reviews.

We searched the following databases on 14 November 2018.

- Cochrane Central Register of Controlled Trials (CENTRAL), including the Cochrane EPOC Group's Specialised Register.
- MEDLINE (from 1946) In-Process and other non-indexed citations, OvidSP
- Embase (from 1974), OvidSP

We did not search Cumulative Index to Nursing and Allied Health Literature (CINAHL) (from 1980), EbscoHost after the expert advice from EPOC search specialist that due to its focus, CINAHL would not retrieve relevant results.

We used two methodology search filters to limit retrieval to appropriate study designs: a modified version of the Cochrane Highly Sensitive Search Strategy (sensitivity and precision maximising version 2008 revision; Lefebvre 2011)) to identify randomised trials (Higgins 2011), and a Cochrane EPOC Group methodology filter to identify non-randomised trial designs.

Searching other resources

Grey literature

We conducted a grey literature search to identify studies not indexed in the databases listed above; sources included the sites listed below.

- OpenGrey (www.opengrey.eu).
- Grey Literature Report (New York Academy of Medicine; www.greylit.org).

Trial registries

- World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) (www.who.int/ictrp/en).
- ClinicalTrials.gov, the US National Institutes of Health (NIH) (clinicaltrials.gov).
- National Health Service Economic Evaluation Database (NHS EED).

We searched the African Online Journals website up to 1 February 2019.

We contacted authors of relevant studies/reviews to clarify the report of published information and to seek unpublished results/data; we contacted researchers with expertise relevant to the review topic/EPOC interventions.

We manually searched cited references in all included studies; and screened individual journals and conference proceedings; cross-checked references of the included studies and relevant systematic reviews.

We have provided appendices for all strategies used, including a list of sources screened and relevant reviews/primary studies reviewed.

Data collection and analysis

Selection of studies

We downloaded all titles and abstracts retrieved to a reference management database and removed duplicates. Two review authors (MM and BS) independently screened titles and abstracts for inclusion and a third (TH) arbitrated disagreements. We coded all potentially eligible studies as either 'retrieve' (i.e. eligible or potentially eligible) or 'do not retrieve'. We retrieved the full-text reports for the former group. Two review authors (MM and TH) independently screened full-text articles and identified studies for inclusion. A third author (BS) was available in the event of disagreements that could not be resolved through discussion. We identified and recorded reasons for exclusion of the ineligible studies.

Data extraction and management

We used a standard data collection form adapted from the Cochrane EPOC Group for data extraction (EPOC 2013a). Two review authors (MM and TH) independently extracted the following study characteristics:

- Methods: study design, study centres and location, study setting, withdrawals, date of study, and follow-up
- Participants: number, mean age, age-range, gender, severity of condition, diagnostic criteria, inclusion criteria, exclusion criteria, and other relevant characteristics

- Interventions: intervention components, comparison, and fidelity of the assessment

The review authors used the template for intervention description and replication for assessing completeness of reporting interventions (Hoffman 2014) and have included:

- Brief name of the intervention
    - Description of rationale, theory, or goal of essential elements to the intervention
    - Description of physical or informational material used for the intervention
    - Description of each of the procedures, activities or processes used in the intervention, including enabling or supporting activities
    - Description of providers (background, expertise, training)
    - Modes of delivery of the intervention (face-to-face, by telephone, Internet)
    - Description of location (s) infrastructure or relevant features of where intervention occurred
    - Description of frequency, intensity, and duration of the intervention
    - If intervention is tailored or adopted, describe why, when, and how
    - If intervention is modified, description of the changes
    - How well they planned their intervention (if they assessed fidelity or adherence, describe how, by who, and whether strategies for maintaining fidelity were employed)
    - How well the intervention was carried out, and the description of how the intervention adhered to the plan

- Outcomes: main and other outcomes specified and collected, and time points reported

- For economic outcomes reported by studies focusing on resource utilisation only, we planned to use the guidance provided by the Cochrane and Campbell Economic Methods Group (methods cochrane.org/economics), that includes the following selected criteria. However, we did not identify any studies that reported economic outcomes.
    - Is the chosen time horizon appropriate to include relevant costs and consequences?
    - Is the actual perspective chosen appropriate?
    - Are all important and relevant costs for each alternative identified?
    - Are all costs measured appropriately in physical units?
    - Are all important variables, whose values are uncertain, appropriately subjected to sensitivity analysis?
    - Do the conclusions follow from the data reported?
    - Does the study discuss the generalisability of the results to other settings and patient/client groups?
    - Does the article indicate that there is no potential conflict of interest of study researcher(s) and funder(s)?

    - Are ethical and distributional issues discussed appropriately?

    - Notes: We have provided description of funding for trials, notable conflicts of interest of trial authors, and ethical approval

Assessment of risk of bias in included studies

Two review authors (MM and TH) independently assessed the risk of bias in each study by using the criteria outlined in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins 2011), and the guidance from the Cochrane EPOC Group (EPOC 2013b). A third author (BS) was available to arbitrate if necessary but all disagreements were resolved by discussion.

For RTs, NRTs, and CBA studies, we assessed the risk of bias according to the following domains:

- Random sequence generation
- Allocation concealment
- Blinding of participants and personnel
- Blinding the outcome assessment
- Incomplete outcome data
- Selective outcome reporting
- Baseline outcome measurement
- Baseline characteristics
- Other bias

For ITS studies, we assessed the risk of bias according to the following domains:

- If incomplete outcome data are adequately addressed
- If the study is free from selective outcome reporting

- If knowledge of the intervention is adequately prevented
- If the intervention is unlikely to affect data collection
- If the intervention is independent of other changes
- If the shape of the intervention effect is prespecified
- If the study is free from other risks of bias

We judged each potential source of bias as either high, low or unclear and provided justification for judgement on the risk of bias tables. We summarised our judgement on the risks of bias across different studies for each of the domains listed. We considered blinding for different key outcomes where necessary. Where information on the risk of bias was related to unpublished data or correspondence with a trial author, we noted this in the risk of bias table. When considering treatment effects, we took into account the risk of bias for the studies that contributed to that outcome.

Measures of treatment effect

We planned to estimate the effect of the intervention using the following.

- Risk ratios (RRs), adjusting for baseline differences for dichotomous data, together with the appropriate associated 95% confidence interval (CI).
- Mean difference (MD) or standardised mean difference (SMD) for continuous data, together with the 95% CI.

Where appropriate, we planned to report measurements of treatment effect using the same scale (i.e. quality of life, disability scales).

Measurement of treatment effects for cluster-randomised trials(cRTs), randomised trials, and control- before-after studies

We planned to extract the intervention effect estimate reported for outcomes in the included studies along with the P value, 95% CI, and the method used in their calculation. For dichotomous outcomes we planned to use RRs and, for continuous outcomes, SMDs. Ratios greater than 1 and differences greater than 0 between the control and intervention groups were determined a priori to represent benefit for the intervention group. However, no cRTs, RTs, or CBA studies were included in this review.

Measurement of treatment effects for interrupted time series studies

For ITS studies we reported outcome results as changes in level and slope. When analysis and reporting was not appropriate, we re-analysed the data using segmented regression and followed the recommendation given in the Cochrane EPOC Group guidelines (Ramsay 2003; EPOC 2013c).

Unit of analysis issues

We planned to perform analysis at the same level as the allocation of the intervention and controls to avoid unit of analysis errors in the studies with clustering designs. In the event of a unit of analysis error, and there being insufficient information to allow re-analysis, we planned to contact the study authors for this information. If this was unsuccessful we planned not to report the CI and P value and simply record a 'unit of analysis error'. This was not necessary as none of the included studies utilised cluster designs.

Dealing with missing data

We planned to ignore the absence of data missing at random. When data were not missing at random, we contacted the study authors for additional information and used electronic methods to retrieve data from graphs (Huwaldt 2004). Although we planned to undertake a sensitivity analysis to estimate the impact of missing data, this proved unnecessary because there were insufficient studies to undertake a meta-analysis.

Assessment of heterogeneity

We investigated heterogeneity by visual inspection of forest plots and the Chi^2 test. We had planned to perform subgroup analyses for the following subgroups in the event of encountering substantial heterogeneity but an adequate number of included studies (more than 10). However, subgroup analyses were not possible as insufficient studies were included in the review. Similarly, there was substantial heterogeneity (I^2 statistic more than 50%) and so a meta-analysis was not undertaken (Higgins 2011).

- High income countries and LMICs settings.
- Adult and paediatric trauma patients

Assessment of reporting biases

We compared the outcome of studies plotted in a matrix for indicating unreported outcomes. We searched protocols, abstracts, and trial registries to compare listed outcomes with those reported in published studies. We also compared the methods with result sections of published studies to detect unreported outcomes.

Data synthesis

As described in Assessment of heterogeneity, meta-analysis was not performed due to excessive heterogeneity. We followed EPOC recommendations (EPOC 2013a) for the analysis and reporting of the ITS studies by presenting outcomes along two dimensions: change in level and change in slope. Change in level is an immediate effect of the intervention measured by the difference between the fitted value for the first post-intervention time point and the predicted outcome at the same point. Change in slope expresses the longer-term effects of intervention. Where primary studies did not report ITS analyses according to EPOC recommendation, we requested additional data from the primary authors and performed appropriate re-analyses.

We did not plan to conduct a full economic analysis given the anticipated scale of heterogeneity between studies. Instead, we planned to provide a narrative summary of economic results, although this was not possible as the included studies did not report economic outcomes.

'Summary of findings' table

We assessed the certainty evidence in individual studies using the GRADE approach as described in the Cochrane EPOC Group worksheet for preparing a summary of findings tables (EPOC 2013d). We rated certainty evidence based on EPOC recommendation (EPOC 2016) as described below.

- High certainty evidence: this research provides a very good indication of the likely effect. The likelihood that the effect will be substantially different is low.
- Moderate certainty evidence: this research provides a good indication of the likely effect. The likelihood that the effect will be substantially different is moderate.
- Low certainty evidence: this research provides some indication of the likely effect. However, the likelihood that it will be substantially different is high.
- Very low certainty evidence: this research does not provide a reliable indication of the likely effect. The likelihood that the effect will be substantially different is very high.

We created a summary of finding tables and included the following outcomes:

- **Primary outcomes:** patient outcomes (mortality, morbidity, and adverse effects or harm).
- **Secondary outcomes:** utilisation of services, access to services, and quality of care provided.

Two review authors evaluated the certainty of evidence (high, moderate, low, and very- low) using GRADE domains (risk of bias, inconsistency, indirectness, imprecision, publication bias, plausible confounding and large effect) as they relate to the main outcomes (Guyatt 2008; EPOC 2013d). We used methods and recommendations described in chapter 12 of the Cochrane Handbook (Higgins 2011), the Cochrane EPOC Group worksheets (EPOC 2013d), and GRADEpro software (GRADE 2015). We explained all decisions to downgrade or upgrade the quality of the included reports using footnotes to aid readers' understanding of the review where needed. Because it was not possible to perform a meta-analysis, we presented results in a narrative summary of finding tables.

Subgroup analysis and investigation of heterogeneity

We planned to undertake subgroup analyses between HICs and LMICs settings, and between adult and paediatric trauma patients. We could not perform these subgroup analyses because of the limited numbers of primary studies, and because of substantial differences in the reported outcomes.

Sensitivity analysis

We had planned sensitivity analyses using multiple imputation methods under the following circumstances, although these were not appropriate due to the limited number of studies.

- There are 'data missing not at random', and if efforts to obtain additional information from primary study authors are unsuccessful.
- If there are studies with high risk of bias included.
- When we have performed re-analysis (i.e. in a cluster-randomised trial where the intra cluster correlation coefficient was not considered initially) for checking the stability of our results.

Results

Description of studies

Results of the search

We conducted a literature review up to 14 November 2018 and identified 11,985 from database searching and 157 from other sources. After excluding duplicates, we screened 6,780 reports. We assessed 112 full-text reports for eligibility and excluded 107 reports as ineligible (Characteristics of excluded studies). We included five reports in the review (Figure 1).

Included studies

The characteristics of the five included reports are presented in Characteristics of included studies.

Study design and setting

All reports were ITS design, from HICs, specifically USA (Rotondo 2009; He 2016), the UK (Metcalfe 2014; Moran 2018), and Norway (Groven 2011).

Participant characteristics

The five reports included a total of 314,262 participants. The number of participants ranged from 7,247 to 248,234 across the included reports (Groven 2011; He 2016; Metcalfe 2014; Rotondo 2009; Moran 2018). Three reports included participants with ISS >9 (Groven 2011; Metcalfe 2014; Moran 2018), one ISS ≥15 (He 2018), and one ISS ≥16 (Rotondo 2009). Males were predominant in the three studies that reported (61-73% of patients) data on the sex of participants consistent with injury epidemiology broadly (Groven 2011; Moran 2018; Rotondo 2009).

Interventions and follow-up

Included reports examined two specific interventions: trauma system regionalisation (Metcalfe 2014; He 2016; Moran 2018) and trauma centre designation (Rotondo 2009; Groven 2011).

Trauma system regionalisation involves forming a local network for managing, transporting and caring for injured patients. This may include designation of specific trauma centres (below) but also other interventions (e.g., transfer and care protocols) that permit a number of healthcare facilities to work together to deliver trauma care.

In one report, hospitals with different capabilities in a single region formed a single regionalised trauma system (Metcalfe 2014). A larger study reported data from the regionalisation of trauma services across England (Moran 2018). The third study report described how a regional trauma network was formed by establishing a field triage protocol, the trauma care protocols, and creating injury-prevention programs (He 2016).
Trauma centre designation involves reconfiguring individual hospitals to help them specialise in the care of injured patients. One such hospital elected a trauma director, instituted the trauma policies and guidelines developed a trauma-team activation protocol, and established referral mechanisms (Groven 2011). In another study, the health agency added a considerable financial investment to the academic hospital to support the incomes of the core staff as well as instituting clinical care guidelines (Rotondo 2009).

Outcomes

Primary outcomes

Mortality:Reported by three studies by various measures: in-hospital (Rotondo 2009; Metcalfe 2014; He 2016), 30-days (Groven 2011), and survival to 30 days (Moran 2018). A study by Moran and colleagues (Moran 2018) reported the Ws statistic which describes the difference between actual and predicted survival rates standardised for differences in patient case mix (Hollis 1995).
Morbidity: One study (Metcalfe 2014) assessed morbidity using Glagow outcome score and reported 'good outcome' at discharge.
Adverse effect or harms: No studies that reported this outcome were found.

Secondary outcomes

Utilisation of services: One study (Metcalfe 2014) reported this outcome as: hospital length of stay and intensive care unit (ICU).
We did not find studies reporting access to services, or quality of care provided.

Excluded studies

We excluded 107 full-text reports. The main reasons for exclusion were ineligible study design as most studies were conducted as a simple description of before-and-after interventions without a suitable control. Some studies were of a time series design but with insufficient number of observations according with Cochrane recommendations on characteristics of excluded studies (EPOC 2013c). A description of all excluded studies is provided in the Characteristics of excluded studies.

Risk of bias in included studies

As all included reports utilised ITS designs, only the ITS risk of bias criteria were used, as described in Assessment of risk of bias in included studies.

Incomplete outcome data (attrition bias)

We judged the included ITS studies (Rotondo 2009; Groven 2011; Metcalfe 2014; He 2016; Moran 2018) low risk because the number of post-intervention participants were similar or not markedly less than in the pre-intervention participants.

Selective reporting (reporting bias)

We judged the ITS studies (Rotondo 2009; Groven 2011; Metcalfe 2014; He 2016; Moran 2018) low risk because all main outcomes in methods section were reported in results section.

Other potential sources of bias

Knowledge of intervention is adequately prevented

We judged all studies (Rotondo 2009; Groven 2011; Metcalfe 2014; He 2016; Moran 2018) to be at unclear risk of bias in this domain as the study participants (i.e. patients) are unlikely to have known about the intervention. However, healthcare professionals (who are also likely to influence outcomes through differences in patient care) will likely have known about changes associated with the intervention.

Intervention is unlikely to affect data collection

We judged three studies (Rotondo 2009; Groven 2011; He 2016) to be at low risk because they utilized the same source of data and methods before and after intervention. However, two studies (Metcalfe 2014; Moran 2018) were at high risk as reporting Trauma Audit and Research Network (TARN) may have been affected by the intervention, which included financial incentives to hospitals that required reporting of cases to the trauma registry.

Intervention independent of other changes

We judged studies biased if there were major historical or other events that interfered with the intervention and outcomes. We judged four studies (Rotondo 2009; Groven 2011; He 2016; Moran 2018) to be at low risk because no such events were identified and because of their long study duration. One study was judged to be high risk because its short duration could not exclude the impact of other events that were external to the intervention.

The shape of intervention effect is prespecified

We judged all five studies (Rotondo 2009; Groven 2011; Metcalfe 2014; He 2016; Moran 2018) to be low risk because the point of intervention was taken as the point of analysis.

Study is free from other bias

We judged four studies (Groven 2011; He 2016; Metcalfe 2014; Moran 2018; Rotondo 2009) to be at low risk of bias because no other concerns were raised during the assessment process. One study (Metcalfe 2014) was judged to be high risk because its short duration meant that it was vulnerable to seasonality or other secular changes.

Effects of interventions

Trauma system 'before regionalisation' compared to 'after regionalisation' for improving outcomes in injured patients (Summary of findings table 1)

The review identified three reports (He 2016; Moran 2018; Metcalfe 2014) that compared the trauma system before regionalisation and after regionalisation. The authors reported some of the pre-planned primary and secondary outcomes (Mortality, morbidity and utilisation of services)

Primary outcomes

Mortality: One study by He and colleagues (He 2016) reported reduced mortality: 20,357 participants, 3 years relative effect -30%, a change in slope (CI) -0.1 (-0.526, 0.326), change in level (CI) -2.017 (-3.169, -0.864). A study by Moran and colleagues (Moran 2018) reported survival benefit in two subgroups; in the overall trauma system (248,234 participants) they reported change in level (+0.133%, P=0.678), a change in slope (+0.07%, P = 0.006); and in the constant report submitters (110,863 participants) they reported change in level (+0.133%, P=0.678), a change in slope (+0.08%, P = 0.023). Metcalfe and colleagues (Metcalfe 2014) reported no mortality benefit:19,820 participant, 6 month relative effect 326%, a change in slope (CI) 16.5 (-2.782, 35.782), change in level (CI) 98 (-2.809, 198.809). The certainty of evidence was low.

Morbidity: One study (Metcalfe 2014) assessed morbidity by Glasgow outcome scale and reported improvement in patients who attained 'good recovery' after trauma system regionalisation: 19,820 participants, 6 months relative effect 8276%, a change in slope 350.61 (105.44, 595.88), change in level 413 (-179.63,1007.3). However the certainty of evidence was very low.

Adverse effect or harm: No studies that reported this outcome.

Secondary outcomes

Utilisation of services: A study by Metcalfe 2014 (19,820 participants) reported two outcomes: reduced length of hospital stay in injured patients: 6 months relative effect -24%, a change in slope (CI) 0 (-1.75,1.75), change in level -5.33 (-14.51, 3.85); and reduced ICU length of stay: 6 months relative effect -18.182, change of slope (CI) 0.5 (-0.74, 1.74), change in level -2 (-8.49,4.49).

Access to services: There were no studies that reported this outcome.

Quality of care provided: There were no studies that reported this outcome.

Trauma centre compared to usual care for improving outcomes in injured patients (Summary of findings table 2)

Primary outcomes

Mortality: Two studies (Groven 2011; Rotondo 2009) reported mortality in all patients, mortality in ISS 15-24, mortality in ISS > 24, and mortality in both paediatric and adult age groups (Table 1).These studies provided moderate certainty evidence that designation of trauma centres probably reduced mortality. One study (7,247 participants) reported reduced mortality: relative effect -41.98%, change in slope (CI): -0.512(-2.256, 1.231), change level (CI) -3.595(-11.262, 4.072). The second study(18,644 participants) also reported reduced mortality: adults relative effect -67.13%, Change in slope 2.06 (10.25 to 29.6), change in level -17.52 (-42.27 to 7.23); paediatric relative effect -83.60%, change in slope -1.12 (-3.04 to 0.8), change in level -18.56 (-30.114 to -7,006). The certainty of evidence was moderate.

Morbidity: There were no studies that reported this outcome.

Adverse effects or harms: There were no studies that reported this outcome.

Secondary outcomes

Utilisation of services: There were no studies that reported this outcome.

Access to services: There were no studies that reported this outcome.

Quality of care provided: There were no studies that reported this outcome

Discussion

Summary of main results

We included five studies which showed two types of interventions: trauma system regionalisation and trauma centre designation. Studies reported patient outcomes (mortality, morbidity), and one study additionally reported a secondary outcome e.g. utilisation of services: length of stay in hospital and in ICU. There were no reports of adverse effects or harm, and no reporting of other pre-planned outcomes (access to services, and quality of care provided). We could not undertake a meta-analysis because of differences in outcome measures and a limited number of primary studies.

The evidence for the effectiveness of the trauma system regionalisation ranged from low to very low certainty. In some studies, the evidence showed that the intervention probably improved patient outcomes by reducing mortality (He 2016) and improving survival rate (Moran 2018). In one study (Metcalfe 2014) it was uncertain if trauma system regionalisation affected patient morbidity (severe disability, and good outcome) or affected utilisation of services (length of stay in hospital and in ICU).

The evidence for effectiveness of trauma centre designation was moderate, and showed that this intervention probably reduced mortality (Groven 2011; Rotondo 2009).

We found that all eligible studies assessing trauma systems and trauma centres were from HICs and none were found from LMICs. Further, we found that studies addressing this subject did not use the quality methods recommended by Cochrane collaboration for evaluating effectiveness of intervention.

Overall completeness and applicability of evidence

We conducted a comprehensive literature search to identify the best available clinical evidence reporting the effectiveness of organised trauma systems and designated trauma centres; and identified all eligible studies. We performed appropriate re-analyses according to the recommendations provided by EPOC guidelines when necessary. For the studies that required additional data from corresponding authors, we sent emails requesting this additional information. We were successful in only one out of 18 requests sent. This led to the disregarding many potential primary studies and perhaps good evidence for the effectiveness of trauma systems and designated trauma centres on injured patients. However, we acknowledge the difficulty and complexity in

assessing databases used long ago when writing these primary research papers. Occasionally, we could not contact primary authors,especially in the case of papers published prior to electronic communication.
The evidence presented in this review may bring about an awareness of these gaps and may shape future injury research for both HICs and LMICs.

Quality of the evidence

Certainty of evidence for the effectiveness of the trauma system ranged from low to very low; in trauma centre designation the certainty of evidence was moderate.
There were no randomised trials(RTs), and therefore we used observational studies. All reports were initially downgraded by one level owing to their design because observational studies carry a high risk of bias. Upgrading the certainty of evidence by one level in all studies was made because patients admitted to trauma systems or trauma centres are sicker than their counterparts in the usual care hospitals; regarding this as a plausible confounding effect. On observing a large effect estimate, we upgraded studies by one level because of a large effect size; with a consideration that the effects of the trauma system and trauma centres are substantial to severely injured patients. We further downgraded the certainty evidence of studies based on precision, or short duration of study (Appendix 2).
Perfoming GRADE narrative assessment (Murad 2017) has led to combining studies with various levels of quality i.e. studies that could potentially be moderate and others that are likely low or very low certainty. This has resulted to indirectness and subsequently lowered the quality of evidence for studies that would otherwise be rated at a higher level of evidence.
With only a few studies reporting interventions acceptably, according to Cochrane recommendations (EPOC 2013c; EPOC 2013d), there is a limitation to the body of evidence on the effectiveness of trauma systems and designated trauma centres.

Potential biases in the review process

The review authors attempted to obtain additional information to enable re-analyses when outcome measures were not up to the requirements of EPOC group. When there were no additional data, some outcome measures were left unreported, and this could form a potential risk of bias.

Agreements and disagreements with other studies or reviews

We found several reviews reporting the effectiveness of trauma systems in LMICs. However, none of these used Cochrane methodology or equivalent rigorous methods in assessing the effectiveness of interventions. In a recent study, Moore and co-workers, using less restrictive inclusion criteria, also reported a low quality of evidence for the effectiveness of the trauma system; and a very low quality of evidence for the effectiveness of helicopter transport (Moore 2017). Reynolds and co-workers provided stratification of interventions and outcomes in 32 LMICs, summarizing comprehensive reports of trauma-care interventions using observational studies (Reynolds 2017). Other reviews (Celso 2006; Mann 1999; Jurkovich 1999) have reported trauma system-related reduction in mortality utilising population-based studies and trauma registries. In particular to LMICs, Henry and co-workers reported improved injury outcomes for pre-hospital trauma systems in LMICs (Henry 2012).
We did not find eligible primary studies reporting adverse effects or harms, access to services, social outcomes, quality of care, equity, or knowledge. These studies, although limited by their methods and quality of evidence, have described positive impacts on trauma systems in improving injury outcomes.

Authors' conclusions

Implications for practice

There is a substantial limitation in the body of evidence evaluating the effectiveness of trauma systems and trauma centre designation. The conclusion drawn by this review on the effectiveness of trauma centres and trauma systems is based on a limited number of primary studies. However, trauma systems and designated trauma centres can streamline injury management and effectively manage resources by pooling both resources and patients; furthermore, these systems may ensure a high level of skills due to the high patient volume. Stronger certainty evidence could aid advocacy for more liberal creation of trauma centres and trauma systems, in turn these may effectively prevent and manage injuries, especially in LMICs where the burden is the largest.

Implications for research

The review stresses the need to conduct well designed primary research to evaluate the effects of interventions in trauma care. Because of the many contributing factors surrounding the research into system change, such as project financing, lack of a ready control group, or the observational nature of many such projects, the methods for these studies are prone to a high risk of bias. Many researchers have employed historical control designs to assess periods before and after the intervention. Such studies could provide good evidence if they adjust methods to meet Cochrane collaboration standards. Other types of observational studies of better quality such as CBA designs are uncommon in trauma research. The observational study designs (CBA, and ITS) may provide better quality data where there are challenges of methods, or where it is unethical to use RTs. This review exposes fundamental gaps and methodological deficiencies in the available research for assessing the effects of interventions in trauma care. These findings may impact future trauma care research and the quality of the body of evidence.

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Contributions of authors

Michael Mwandri wrote and coordinated preparation of the protocol; and wrote and coordinated preparation of the review.
Barclay Stewart, Timothy Hardcastle, Andres Rubiano, and Russell Gruen, prepared and contributed to the protocol, provided critical-review and edited both the protocol and the review.
Juan Puyana contributed to initial conception of the protocol and has edited, provided critical-review to the final draft
Jemma Hudson provided statistical expertise to the review
David Metcalfe critically revised the draft

Declarations of interest

Michael Mwandri has no known conflicts of interest.
Barclay Stewart received a US National Institutes of Health (NIH)/Fogarty Global Health Research Fellow Grant (R25TW009345). This poses no conflict of interest to the current work. He has provided trauma care and system consultation for non-governmental organisations. No financial benefit was obtained by this work.
Timothy Hardcastle is a consultant to a number of private institutions regarding emergency care or disaster planning for which he was reimbursed for time, travel, and expertise on an ad-hoc basis. In the same way he has received reimbursement for expert case review and testimony as a medico-legal expert in his field, again on an ad-hoc basis. This work was as an expert of the University of KwaZulu-Natal with a PhD in emergency systems development and disaster medicine. He has received speaker invitations to various national or international meetings or courses as an invited plenary speaker and the inviting organisations have funded some or all of his expenses as their guest. For most of these activities there was little profit and the activities are at most peripherally related to the work contained in this Cochrane EPOC review.
Jemma Hudson has no known conflicts of interest.
Andres M Rubiano has no known conflicts of interest.
Juan Puyana has no known conflicts of interest.
Russell L Gruen has no known conflicts of interest.
David Metcalfe has no known conflicts of interest.

Differences between protocol and review

We planned to assess: primary outcomes such as mortality, morbidity, adverse effect or harms; and secondary outcomes such as utilisation of services,access to services, social outcomes, quality of care provided, equity and knowledge. However due to methodological requirement we chose the most relevant outcomes judged, and excluded: social outcomes, equity and knowledge.
We did not search Cumulative Index to Nursing and Allied Health Literature (CINAHL) (from 1980) EbscoHost, with the view that, because of its focus, CINAHL would not retrieve relevant results.
We did not include healthcare workers as participants, as there were no primary studies reporting such outcomes.
We found most reports comparing regionalised trauma systems(a network of trauma systems within a geographical region or province) to usual care, hence we have included both 'regionalised trauma systems' as well as 'non regionalised trauma system' as trauma system.
In some primary studies injury severity score (ISS) cut-off for inclusion criteria are lower than what we stipulated in our protocol (ISS >15), for instance ‘ISS 9 and above’(Groven 2011);We included studies with lower ISS because although their entry point were ‘ISS 9 and above’, to a large extent they included ISS 15 and above; these were the best descriptions obtained.
We planned to undertake subgroup analyses between HIC settings and LMIC settings; and between, adult and paediatric trauma patients. We did not undertake a meta-analysis or subgroup analyses because of the limited numbers of primary studies, and because of substantial heterogeneity in the reported outcomes. We omitted all components related to meta-analysis.

Characteristics of studies

Characteristics of included studies

Summary of findings tables

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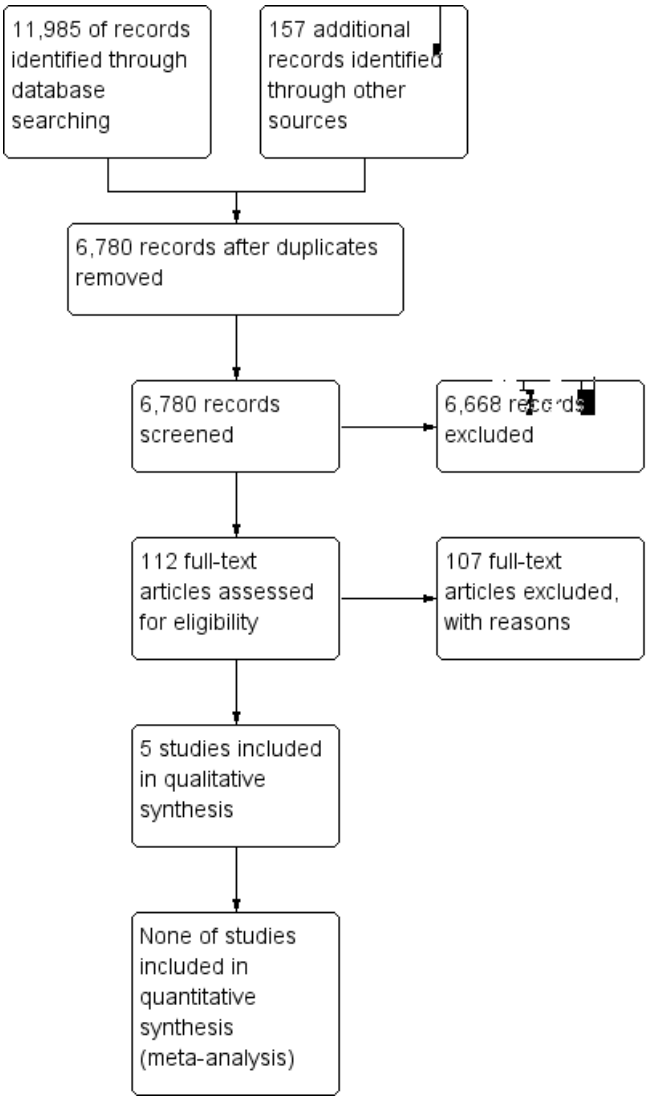
Classification pending references
Data and analyses
Figures
Figure 1



Study flow diagram

Figure 2

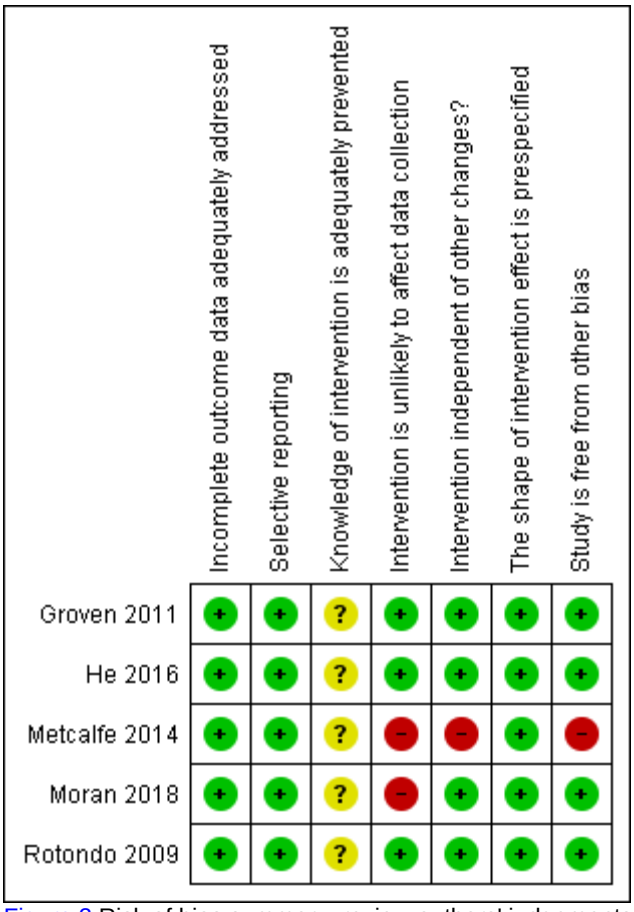


Figure 2 Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

Sources of support

Internal sources

- No sources of support provided

External sources

- The Australian Satellite of the Effective Practice and Organisation of Care (EPOC) Group receive funding from the National Health and Medical Research Council, Australia

Feedback

Appendices

1 Search strategies

1 The Cochrane Library up to 14th November 2018

No.	Search terms
#1	((plan* or develop* or institution or institute? or organi*ation* or organi*e* or designat* or stipulat* or dedicat* or implement*) near/2 (trauma* or polytrauma*)):ti,ab
#2	((polytrauma* or trauma*) near/2 (system? or network?)):ti,ab
#3	[mh traumatology/og]
#4	(trauma* or polytrauma*):ti,ab
#5	[mh "Regional Medical Programs"]
#6	#4 and #5
#7	((impact* or effect* or evaluat* or implement* or develop* or assess* or outcome* or centrali*ation or centrali*ed or regionali*ation or regionali*ed) near/5 (trauma centre* or trauma center* or trauma service? or trauma care)):ti,ab
#8	[mh "trauma centers"/og]
#9	{or #1-#3, #6-#8}

2 Medline (Ovid MEDLINE® Epub Ahead of Print, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to 14th November 2018

No.	Search terms
1	((plan* or develop* or institution or institute? or organi#ation* or organi#e* or designat* or stipulat* or dedicat* or implement*) adj2 (trauma* or polytrauma*)).ti,ab.
2	((polytrauma* or trauma*) adj2 (system? or network?)).ti,ab.
3	traumatology/og
4	(trauma* or polytrauma*).ti,ab.
5	Regional Medical Programs/
6	4 and 5
7	((impact* or effect* or evaluat* or implement* or develop* or assess* or outcome* or centrali#ation or centrali#ed or regionali#ation or regionali#ed) adj5 (trauma centre* or trauma center* or trauma service? or trauma care)).ti,ab.
8	trauma centers/og
9	or/1-3,6-8
10	randomized controlled trial.pt.
11	controlled clinical trial.pt.
12	multicenter study.pt.
13	pragmatic clinical trial.pt.
14	(randomis* or randomiz* or randomly).ti,ab.
15	groups.ab.
16	(trial or multicenter or multi center or multicentre or multi centre).ti.
17	(intervention? or effect? or impact? or controlled or control group? or (before adj5 after) or (pre adj5 post) or ((pretest or pre test) and (posttest or post test)) or quasiexperiment* or quasi experiment* or pseudo experiment* or pseudoexperiment* or evaluat* or time series or time point? or repeated measur*).ti,ab.
18	non-randomized controlled trials as topic/
19	interrupted time series analysis/
20	controlled before-after studies/
21	or/10-20
22	exp animals/
23	humans/
24	22 not (22 and 23)
25	review.pt.
26	meta analysis.pt.
27	news.pt.
28	comment.pt.
29	editorial.pt.
30	cochrane database of systematic reviews.jn.
31	comment on.cm.
32	(systematic review or literature review).ti.
33	or/24-32
34	21 not 33
35	9 and 34

3 Embase 1974 to 14th November 2018

No.	Search terms
1	((plan* or develop* or institution or institute? or organi#ation* or organi#e* or designat* or stipulat* or dedicat* or implement*) adj2 (trauma* or polytrauma*)).ti,ab.
2	((polytrauma* or trauma*) adj2 (system? or network?)).ti,ab.
3	exp *traumatology/
4	(trauma centre* or trauma center*).ti,ab.

5	exp *"organization and management"/
6	3 or 4
7	5 and 6
8	((impact* or effect* or evaluat* or implement* or develop* or assess* or outcome* or centrali#ation or centrali#ed or regionali#ation or regionali#ed) adj5 (trauma centre* or trauma center* or trauma service? or trauma care)).ti,ab.
9	(trauma* or polytrauma*).ti,ab.
10	*health care planning/
11	9 and 10
12	1 or 2 or 7 or 8 or 11
13	randomized controlled trial/
14	controlled clinical trial/
15	quasi experimental study/
16	pretest posttest control group design/
17	time series analysis/
18	experimental design/
19	multicenter study/
20	(randomis* or randomiz* or randomly).ti,ab.
21	groups.ab.
22	(trial or multicentre or multicenter or multi centre or multi center).ti.
23	(intervention? or effect? or impact? or controlled or control group? or (before adj5 after) or (pre adj5 post) or ((pretest or pre test) and (posttest or post test)) or quasiexperiment* or quasi experiment* or pseudo experiment* or pseudoexperiment* or evaluat* or time series or time point? or repeated measur*).ti,ab.
24	or/13-23
25	(systematic review or literature review).ti.
26	"cochrane database of systematic reviews".jn.
27	exp animals/ or exp invertebrate/ or animal experiment/ or animal model/ or animal tissue/ or animal cell/ or nonhuman/
28	human/ or normal human/ or human cell/
29	27 not (27 and 28)
30	25 or 26 or 29
31	24 not 30
32	12 and 31

4 Grey Literature up to 14th November 2018

New York Academy of Medicine, Grey Literature Report: http://www.greylit.org				
		7/27/2015	8/30/2017	11/14/2018
No.	Search terms	Results	Results	Results
	trauma system	12	2 (links below)	0
	trauma network	0	0	0
OpenGrey: http://www.opengrey.eu/				
No.	Search terms	Results	Results	Results
	"trauma system*"	5	0	0

	"trauma network*"	0	0	0
	"trauma service*"	0	2	0
	"trauma care*"	7	0	0
	"trauma centre*"	2	0	0
	"trauma center*"	8	0	0

5 Trials Registers up to 14th November 2018

ClinicalTrials.gov		
No.	Search terms	Results
	"trauma service*" OR "trauma network*" OR "trauma system*" OR "trauma centre*" OR "trauma care" OR "trauma center*"	18
8/30/2017	"trauma service" OR "trauma network" OR "trauma system" OR "trauma centre" OR "trauma care" OR "trauma center" | Interventional Studies	153
11/14/2018	"trauma service" OR "trauma network" OR "trauma system" OR "trauma centre" OR "trauma care" OR "trauma center" | Interventional Studies	179
WHO International Clinical Trials Registry Platform (ICTRP)		
No.	Search terms	Results
	trauma service* OR trauma network* OR trauma system* OR trauma centre* OR trauma care OR trauma center*	43
8/30/2017	trauma service* OR trauma network* OR trauma system* OR trauma centre* OR trauma care OR trauma center*	68
11/14/2018	trauma service* OR trauma network* OR trauma system* OR trauma centre* OR trauma care OR trauma center*	95
NHS Economic Evaluation Database (NHS EED)		
29/01/2020	*trauma*	109

6 Websites: Potential eligible unpublished research from LMICs

Website name/organisation	**URL**	**Date**	**Notes**	**No. items identified**
African Journals Online(AJOL)	https://www.ajol.info/	01/2010-February 2019	Search for potential eligible research from LMICs	0
College of Surgeons of East Central and southern Africa Congress (2010-2018)	http://www.cosecsa.org/about/publications/ecajs-journal	01/2010 - 12/2018	Search for potential eligible research from LMICs	0
Southern Africa Research Society congress 2010-201	http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0038	01/2010 - 12/2018	Search for potential eligible research from LMICs	0

College of Surgeons of West Africa congress proceedings 2014-2015	https://www.ncbi.nlm.nih.gov/m/pubmed/26587528/	February 2019	Search for potential eligible research from LMICs	0

7 Relevant systematic reviews searched

Relevant systematic reviews in the last 10 years (references cross-checked)

[("Trauma Centers/organization and administration"[Mesh]) AND "Systematic Review"[Publication Type] AND ("last 10 years"[PDat])Search]

1. Moore L, Champion H, Tardif PA, Kuimi BL, O'Reilly G, Leppaniemi A, Cameron P, Palmer CS, Abu-Zidan FM, Gabbe B, Gaarder C, Yanchar N, Stelfox HT, Coimbra R, Kortbeek J, Noonan VK, Gunning A, Gordon M, Khajanchi M, Porgo TV, Turgeon AF, Leenen L; Impact of Trauma System Structure on Injury Outcomes: A Systematic Review and Meta-Analysis. International Injury Care Improvement, World J Surg. 2018 May;42(5):1327-1339. doi: 10.1007/s00268-017-4292-0. Review.
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3. Hajibandeh S, Hajibandeh S.J Who should lead a trauma team: Surgeon or non-surgeon? A systematic review and meta-analysis.Inj Violence Res. 2017 Jul;9(2):107-116. doi: 10.5249/jivr.v9i2.874. Epub 2017 May 15. Review.
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8. Kim YJ. Relationship of trauma centre characteristics and patient outcomes: a systematic review.J Clin Nurs. 2014 Feb;23(3-4):301-14. doi: 10.1111/jocn.12129. Epub 2013 Feb 28. Review.
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10. Moore L, Stelfox HT, Turgeon AF. Complication rates as a trauma care performance indicator: a systematic review.Crit Care. 2012 Oct 16;16(5):R195. doi: 10.1186/cc11680. Review
11. Evans C, Howes D, Pickett W, Dagnone L. Audit filters for improving processes of care and clinical outcomes in trauma systems.Cochrane Database Syst Rev. 2009 Oct 7;(4):CD007590. doi: 10.1002/14651858.CD007590.pub2. Review.
12. Henry JA, Reingold AL. Prehospital trauma systems reduce mortality in developing countries: a systematic review and meta-analysis. Journal of trauma and acute care surgery. 2012 Jul 1;73(1):261-8
13. Hill AD, Fowler RA, Nathens AB. Impact of inter hospital transfer on outcomes for trauma patients: a systematic review. Journal of Trauma and Acute Care Surgery. 2011 Dec 1;71(6):1885-901
14. Kristiansen T, Søreide K, Ringdal KG, Rehn M, Krüger AJ, Reite A, Meling T, Næss PA, Lossius HM. Trauma systems and early management of severe injuries in Scandinavia: review of the current state. Injury. 2010 May 1;41(5):444-52
15. Butler DP, Anwar I, Willett K. Is it the H or the EMS in HEMS that has an impact on trauma patient mortality? A systematic review of the evidence. Emergency Medicine Journal. 2010 Sep 1;27(9):692-701

Other relevant systematic reviews

1. Celso B, Tepas J, Langland-Orban B, Pracht E, Papa L, Lottenberg L, Flint L. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centres following the establishment of trauma systems. Journal of Trauma and Acute Care Surgery. 2006 Feb 1;60(2):371-8
2. Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. Journal of Trauma and Acute Care Surgery. 1999 Sep 1;47(3):S25-33
3. Jurkovich GJ, Mock C. Systematic review of trauma system effectiveness based on registry comparisons. Journal of Trauma and Acute Care Surgery. 1999 Sep 1;47(3):S46-55
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2 GRADE evidence profiles

Trauma system regionalisation compared to 'before regionalisation' or usual care for improving outcomes in injured patients

Outcomes	Study/Partcipants (ITS design)	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Large effect	Plausible confounding	Certainty (overall score)
Mortality. Assessed with: Death as a proportion of seriously injured patients, and injured patients survival rate follow up: range 1 to 12 years	**He 2016** (20357 Participants) **Metcalfe 2014** (19820 Participants) **Moran 2018** (248,234 participants)	Serious[1]	Not serious[2]	Not serious[3]	Serious[4]	None	Large[5]	Would reduce demonstrated effect[6]	Low
Morbidity. Assessed with: Proportion of patients discharged in a 'Good recovery' state Follow up: 1 to 12 months	**Metcalfe 2014** 19820 Participants	Very serious[7]	Not serious	Not serious[3]	Serious[8]	None	None	Would reduce demonstrated effect[6]	Very Low
Utilisation of services. Assessed with: Duration of hospital stay Follow up: 1 to 12 months	**Metcalfe 2014** 19820 Participants	Very serious[7]	Not serious	Not serious[3]	Serious[8]	None	None	Would reduce demonstrated effect[6]	Very Low

[1] Downgraded to serious risk of bias owing to their design(observational), one study with 7% weight had a very short study duration, the rest of the studies had a low risk of bias
[2] Studies exhibits consistency in the direction of magnitude of the effect, one study with 7% weight is inconsistent but would not influence a global consistency due to its low weight
[3] Studies address the clinical question at hand in terms of population, interventions and outcomes across studies
[4] Downgraded because narrative synthesis was conducted, estimates not precise; However studies bear adequate number of participants, one study with 7% weight had wider CI (judged not serious due to its low weight)
[5]Upgraded because of a large magnitude of effect and strong association of trauma system and patient outcome
[6]Upgraded because of plausible confounding (trauma system likely admitted sicker patients than the usual hospitals, therefore confounding against detection of observed effect)
[7]Downgraded to serious risk of bias owing to their design(observational), further downgraded due to a very short duration of follow up
[8]Down graded due to wider CI crossing a line of no effect

Trauma centre compared to usual care for improving outcomes in injured patients

Outcome	Study (ITS design)	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Large effect	Plausible confounding	Certainty (overall score)
Mortality. Assessed with: Death proportion in a trauma population Follow up: 7 to 10 years	**Groven 2011** Participants: 7247 **Rotondo 2009** Participants:18644	Serious[1]	Not serious[2]	Not serious[3]	Serious[4]	None	Large[5]	Would reduce demonstrated effect[6]	Moderate

[1] Downgraded to serious risk of bias owing to their design(observational)
[2] Studies exhibits consistency in the direction of magnitude of the effect
[3] Studies address the clinical question at hand in terms of population, interventions and outcomes across studies
[4] Downgraded because narrative synthesis was conducted, estimates not precise; However studies bear adequate number of participants
[5]Upgraded because of a large magnitude of effect and strong association of trauma system and patient outcome
[6]Upgraded because of plausible confounding (trauma system likely admitted sicker patients than the usual hospitals, therefore confounding against detection of observed effect)

Chapter 4

Primary Studies from Botswana

Botswana ranks among countries with high injury incidence, a literature review shows there are no formal trauma systems and emergency medical services utilisation is low. The WHO, through its essential trauma care guidelines, has recommended an affordable and functional trauma system in settings where none exists. In order to assess the feasibility for this trauma system establishment, we conducted baseline surveys of injury mechanisms, patient characteristics, care process, hospital burden and resources availability.

In the 1st report (*Mwandri MB, Hardcastle TC. Burden, characteristics and process of care among the pediatric and adult trauma patients in Botswana's Main Hospitals. World Journal of Surgery. 2018 Aug 1;42(8):2321-8.*) we interrogated hospital data to determine magnitude of injury, care process and patient characteristics. In the 2nd report (*Mwandri MB, Hardcastle TC. Evaluation of resources necessary for provision of trauma care in Botswana: an initiative for a local system. World Journal of Surgery. 2018 Jun 1;42(6):1629-38*) we further investigate hospital data to determine whether resources in healthcare facilities satisfy the minimum WHO recommendation for essential trauma care provision.

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https://doi org/10 1007/s00268-018-4528-7

ORIGINAL SCIENTIFIC REPORT

Burden, Characteristics and Process of Care Among the Pediatric and Adult Trauma Patients in Botswana's Main Hospitals

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Abstract

Background Botswana is notable among countries with high rates of Road Traffic Collisions (RTC); like many other lower–middle-income countries (LMICs), it lacks trauma systems. The World Health Organization recommends 'Essential Trauma Care' in countries with no formal trauma systems. The proportion of injuries in Emergency Departments and the care process were investigated to gain an overview for enabling the design of a relevant LMICs trauma system.

Method Blunt and penetrating trauma patients were included from three major hospitals, examining the proportion of injuries, patient characteristics, the care process and comparing these between pediatrics and adults. Data are presented using descriptive statistics.

Results The proportion of trauma ranged between 6 and 10% of Emergency Department cases. Pediatrics constituted 19%, and 59% of all patients were male. The median age was 28 years [IQR 17–39] and 8 years [IQR 4–11] for adults and pediatrics, respectively. The leading causes of injuries were: falls in pediatrics (55%) and interpersonal violence in the adults (34%), followed by RTC in both children (20%) and adults (30%). The public inter-hospital vehicles transported 77% of pediatrics and 69% of adults, while formal ambulance transported only 9% of pediatrics and 22% of adults. The median Emergency Department waiting time for pediatrics was 187 min [IQR 102–397] and for adults was 208 min [IQR 100–378]: Most were triaged as non-urgent (70% pediatrics and 72% adults), and the majority were discharged (84% pediatrics and 76% adults).

Conclusion The Emergency Department workload of injuries is notably high, with differing mechanisms of injury and transport modes between pediatrics and adults: Waiting time is severely prolonged for urgent and critical patients. Diagnoses, triage categories and patients disposition were similar.

Introduction

Botswana, a middle-income country in southern Africa, ranks among the highest incidence of Road Traffic Colli-sions (RTC) worldwide [1], leading to a high death rate due to injury resembling many other developing countries [2]. The analysis of Emergency Medical Services (EMS) and injury care in Africa has shown most injured patients use commercial motor vehicles such as taxis or buses, or public inter-hospital transfer vehicles (referred in these studies as 'ambulances'), motorcycles or police vehicles [3–7], and

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there is severe shortage of general doctors and specialists for managing both adult and pediatric trauma patients [8, 9].

Because of the specific needs of injured children, pediatric trauma systems have evolved from the adult-focused trauma systems and are reported to attain better patient outcomes [10, 11]; however, deficiencies in human resource capacity in low- and middle-income-countries (LMICs) have resulted in non-specialist medical care, despite the known success of pediatric trauma systems [8, 10–12]. The WHO proposed the Essential Trauma Care (ETC) guidelines as a cost-effective and affordable pack-age for countries with no formal trauma systems; similar to the formal trauma system, ETC package encompasses pre-hospital care, hospital care and rehabilitation and has shown success in some LMICs [13–16].

The innovative solutions proposed for LMICs are based on the use of the existing infrastructures and resources, for instance the use of non-medical personnel first responders, the adaption of surveillance systems from mortality data and the use of commercial vehicles, police vehicles and other public means of transport for pre-hospital transport [2, 17].

Design of the proposed system for LMICs is supported by research demonstrating that the most lethal injuries, including head injuries and hemorrhage, can be initially managed by simple measures and prompt transfer to appropriate health-care facilities [17–20]. Mapping the potential injury-prone areas and studying the local determinants as well as local needs in terms of skills and resources may offer effective prevention and management planning [21, 22].

This study aimed to investigate the hospital trauma workload by assessing patient characteristics, modes of transport, and mechanisms of injury, Emergency Department injury proportions and the waiting time for both the pediatrics and adults, to gain an overview for enabling the design of a relevant LMICs trauma system.

Materials and methods

Botswana's public health system has two referral hospitals, seven district hospitals, 17 primary hospitals and over 200 clinics, which receive referrals from health posts. On the other hand, there are two major private hospitals and many private clinics run by general practitioners or medical specialists [23, 24]. This study was undertaken utilizing convenience sampling of the two public referral hospitals, two major private hospitals and one district hospital that receive high volumes of trauma patients, which are Princes Marina hospital, Nyangabgwe referral hospital and Mahalapye district hospital; as well as Lenmed-Health Bokamoso private hospital and Life-Gaborone private hospital. Ethical approval was granted by the Biomedical Research Ethics Committee (BREC) at the University of KwaZulu-Natal (UKZN) [BREC (BE487-14)] and the Botswana health research and development division institutional review board [PPME 13/18/1 IX (112)]. Further permissions to use hospital data were granted by individual hospitals.

The most recent available data from the study period (August–September 2015) in the Emergency Departments were included, in one hospital the most recent accessible data(at the time of this study) were November 2014 due to installation of an electronic medical system that was being carried out at that time, patient's information was categorized as pediatrics and adults and compared to assess incidence, gender distribution, residential locations, mode of transport to hospital, triage score [25] on arrival, mechanisms of injury, diagnoses, Emergency Department waiting time and patient disposition. The statistical program SPSS version 20.0 for Windows (IBM, Armonk NY) and Microsoft Excel (Microsoft Redmond WA) were utilized in data analysis. Data are presented as mean, frequency, proportion, median and interquartile range (IQR), as appropriate.

Results

Patient characteristics: burden, age and sex distribution

A total of 504 patient charts for blunt and penetrating injuries were included, and victims of burn, drowning, chemical ingestion or other forms of injuries were excluded. Because of missing information in various categories assessed, the numbers of included individuals was less than the initial 504 charts and varied between the different assessment categories.

The proportion of trauma patients in this study ranged between 6 and 10% of all Emergency Department admissions. The WHO pediatric age cutoff of 14 years was used to define the pediatric age group, whereas adults accounted for 80% of all trauma patients. The median age of adults was 31[IQR 25–42] and for pediatric age was 8 years [IQR 4–11].

As shown in Table 1, the majority of patients, 53% males and 49% females, were in the prime economically productive age group (25–54); typical of the trauma population males predominated at 59%.

Table 1 Age and sex distribution of trauma patients in Botswana's main hospitals

Age categories	Male n (%)	Female n (%)
0–4	12 (4)	14 (7)
5–9	26 (9.1)	15 (7 5)
10–14	20 (7)	15 (7 5)
15–19	19 (7)	14 (7)
20–24	35 (12)	17 (8 5)
25–29	46 (16)	31 (15.5)
30–34	46 (16)	19 (9 5)
35–39	19 (7)	25 (12.5)
40–44	16 (6)	9 (4 5)
45–49	18 (6)	11 (5 5)
50–54	6 (2)	3 (1 5)
55–59	10 (3)	7 (3 5)
60–64	5 (2)	4 (2)
65–69	1 (0.3)	6 (3)
70–74	3 (1)	3 (1 5)
75–79	1 (0.3)	1 (0 5)
80–84	2 (1)	2 (1)
[85	1 (0.3)	4 (2)
Total	286 (59)	200 (41)

Trauma patient's areas of residence and location of injury

Of the 56 residential reported, 83% of pediatric patients and 70% of adults resided in only five locations and dis-played similar residency distribution pattern across the two age groups. These five locations are all along the busy A1 main road and around the major hospitals in Gaborone municipality and its surroundings as shown in Fig. 1.

Trauma patient characteristics: mechanism of injury, diagnoses, triage score, mode of transport and Emergency Department disposition

Patient characteristics summarized in Table 2 show falls to be the leading mechanism of injury in pediatrics (55%), while interpersonal violence (combined assault, stabs and gunshots) dominated in adults (34%); fortunately, vio-lence-related mechanisms were only 8% of the pediatric age group. Road Traffic Collision was the second most frequent mechanism in both pediatric (20%) and adult (30%) patients. The most common three diagnoses were: soft tissue injuries, long bone fractures and head injury, a similar pattern for both pediatrics and adults. Long bone fractures, however, occurred in higher proportion among pediatrics than in adults.

Trauma patient's triaging at Emergency Department utilized the validated South African Triage Score: routine (green), urgent (yellow), very urgent (orange) and critical (red) [25].The pattern of severity trend for both pediatric and adult groups was similar (p value [0.05).

The public inter-hospital vehicle network was the most frequent used means of pre-hospital transport: It is com-prised of a fleet of panel vans fitted with a patient gurney, however, without other EMS equipment or EMS-trained crew. Formal EMS ambulance was the second most fre-quent mode of transport and was used more significantly by the adults.

Most of the trauma patients were eventually discharged from Emergency Department after the initial consultation, while less than a quarter was admitted. The pattern of patient disposition from the Emergency Department was similar for both pediatric and adult groups.

Emergency Department waiting time and patient triage categories

The median waiting time at Emergency Department for the pediatric group was 187 min IQR [102–397] and for adults was 208 min IQR[100–378] (Fig. 2); there were noticeable outliers among the adult group.

The severely injured patients in the red and orange categories failed to achieve their target time (immediate and \ 10 min), while only 15% of the yellow and 25% of non-acute green categories achieved 60 min waiting time (Fig. 3).

Discussion

This study found pattern of injury mechanisms to be sim-ilar to the ones described in other sub-Saharan African countries [4–6, 26]. The proportion of injuries in the Emergency Department (6–10%) was lower than 20% previously reported [22, 27–31]. This lower proportion likely results from the exclusion of burns, drowning, chemical ingestions and other forms of injuries that have not been evaluated by trauma systems. While the pediatric cases seemed to be only 20%, it may reflect a considerable magnitude of pediatric trauma when the pediatric popula-tion for Botswana (30% of total population) is considered [30]; in other countries, the proportion of children is reported to be up to 43% [4, 5, 31–34]. Similar to other injury studies, the proportion of injury was found to be the highest in the 'prime economically productive age group,' [4, 5, 27, 31, 35], constituting a further burden, especially for sub-Saharan Africa's work-force, which is already struggling with an enormous burden of infectious diseases, such as HIV and tuberculosis [36]. A recent Lancet

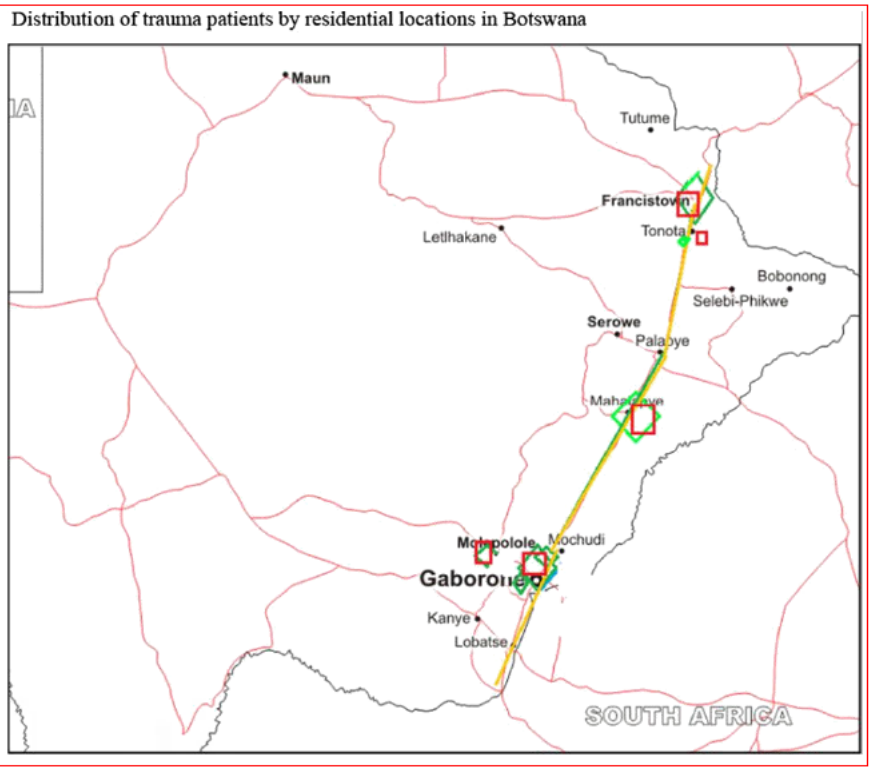

Fig. 1 Botswana map showing the distribution of trauma patients by residential locations Source: modified from d-map.com (Red squares and green crystals—adult and pediatric trauma patients respectively; Yellow line—A1 road)

Commission report on global surgery highlighted the role of injuries and other surgical conditions in poverty propagation and called for nations to improve the access to surgery [37].

The observed pattern of the residential areas for adults and pediatric patients was similar, with most patients located around major cities, where there are major hospitals, and along the busiest highway (Fig. 1), patients residential pattern is also in keeping with Botswana's population distribution [38] and may indicate a high burden of injuries in these locations and a greater ability to access hospital care compared to the rest of the country. Previous studies have shown that proximity of trauma centers to potential injury-prone geographical locations and promptness in transportation of trauma victims relates to patients outcomes [14, 20, 21]. The evaluation of residential location from patient's charts may therefore serve as an initial guide for placement of trauma centers and subsequent planning of the trauma system.

Generally, the use of formal EMS was very low, with most patients using the public inter-hospital vehicle network. The extensive use of the inter-hospital transport network was similarly documented in a previous report [27]. Comparing the use of formal EMS for pre-hospital transport between the two age categories, adults demonstrated a far better usage compared to the pediatric group; furthermore, police vehicles usage was registered in a lesser extent among the adult group and was not used in the pediatric group, possibly relating to mechanism of injury such as RTC and violence which are commoner in adults and attract police involvement.

In contrast to other African countries, South Africa seems to have a more accessible formal EMS [39], while the rest mainly utilize commercial vehicles or police vehicles for pre-hospital transport [3–7]. Previous studies have advised improvement by developing local pre-hospi-tal systems from the existing ones through implementing innovative solutions, such as the use of trained commercial providers and the use of police vehicles for hospital transport [2, 12]. By upgrading the training of the staff working in the inter-hospital network vehicles and estab-lishing central control, one could easily implement cost-effective improvements in pre-hospital care in Botswana.

Most Emergency Department visits for trauma patients constituted non-urgent conditions (green and yellow), and the pattern was similar for both pediatric and adult groups. The proportion of more severely injured patients (orange and red categories) was only about a third; comparable trends of triage categories have been reported in Botswana [27, 40] as well as in South Africa [41, 42], while there

Table 2 Trauma patient characteristics: mechanism of injury, diagnoses, triage categories, mode of transport and Emergency Department disposition

Assessment variable	Pediatrics n (%)	Adults n (%)	p value
Mechanism of injury			
Assault	7 (8)	107 (27)	\0.05
Stab	0 (0)	26 (7)	
Road Traffic Collision	18 (20)	118 (30)	
Fall	50 (55)	96 (25)	
Sport-related injuries	8 (9)	22 (6)	
Industrial/machinery-related injury	0 (0)	2 (0.5)	
Animal bites	3 (3)	10 (2)	
Farm injuries	1 (1)	4 (1)	
Household injuries	5 (5)	5 (1.25)	
Gunshot	0 (0)	1 (0.25)	
Trauma patients diagnoses			
Soft tissue	44 (51)	215 (58.1)	
Long bone fractures	34 (40)	74 (20)	[0.05
Head injuries	7 (8)	44 (12.25)	
Chest injuries with hemo/pneumothoraces	0 (0)	6 (1.6)	
Penetrating abdominal injury	0 (0)	6 (1.6)	
Dislocations	1 (1)	7 (2)	
Cervical spine injury	0 (0)	4 (1)	
Multiple injuries (*polytrauma)	0 (0)	12 (3.2)	
Maxilla facial injuries	0 (0)	1 (0.25)	
Emergency Department triage categories			
Green	13 (15)	63 (17)	[0.05
Yellow	49 (55)	207 (55)	
Orange	26 (29)	89 (24)	
Red	1 (1)	14 (3.7)	
Black	0 (0)	1 (.3)	
Type of transport type utilized			
[?]Public hospital van (patient transport)	44 (77)	191 (69)	\0.05
[#]Self-referral (commercial/private cars, or unknown)	8 (14)	10 (3.6)	
Formal ambulance services	5 (9)	62 (22.4)	
Police vehicles	0 (0)	13 (5)	
Trauma patients Emergency Department disposition			
Discharged	76 (84)	267 (76)	[0.05
Admitted	14 (16)	80 (23)	
Death	0 (0)	2 (1)	

*Polytrauma—defined as injuries constituting more than two significant injuries

[?]Public hospital van-panel-van fitted with a patient gurney, without other EMS equipment or EMS-trained crew

[#]Self-referred patients are patients presenting at the Emergency Department without a referral letter from a lower-level hospital or clinic, and the mode of transport used could not be determined (between private vehicles, or commercial type)

were no data from other African countries on this variable. Patients in green category have non-urgent injuries that are recommended to be treated within 4 h, while the yellow category has a target waiting time of 60 min and very urgent(orange) and critical(red) categories are recommended to be attended in 'less than 10 min' and 'immediate,' respectively [25]. These findings show that although the yellow category had the majority of trauma patients (55%), only 15% achieved the recommended Emergency Department waiting time, while, on the other

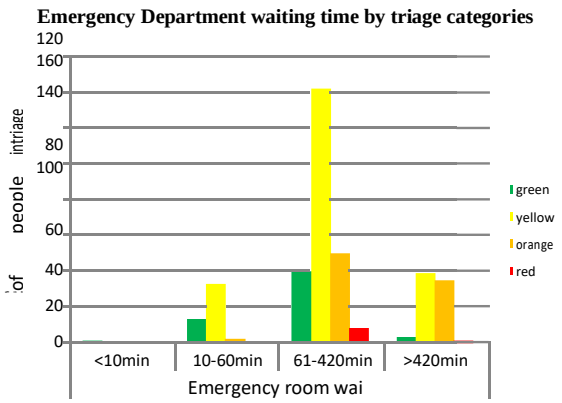

Fig. 2 Median waiting time (IQR) among pediatric and adult trauma patients' categories in Botswana

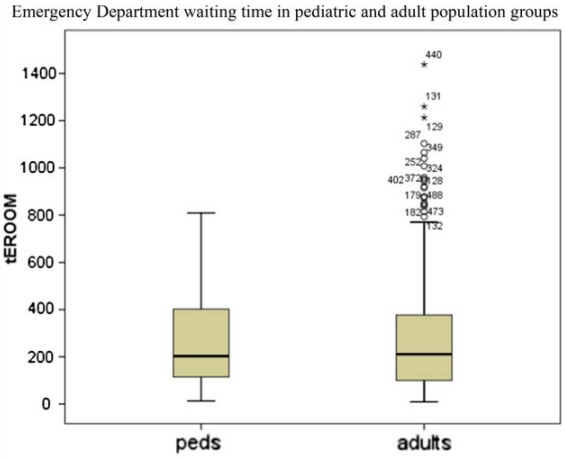

Fig. 3 Emergency Department categories and waiting time for trauma patients in Botswana. tEROOM Emergency room waiting time, AGECART age group categories, peds pediatric

hand, none of the patients in the orange and red categories achieved the recommended waiting time. These delays in initial emergency care due to protracted Emergency Department waiting time could hinder or delay urgent surgical interventions. The poor 'waiting-time' performance is unacceptable for the severely injured (yellow and red) and confound the efforts to establish formal EMS and improve the access to surgery and emergency services [2, 37, 43–47]. Emergency Department waiting time has been utilized as a trauma system audit filter and is an important factor for optimal outcome of severely injured patients; its improvement is in keeping with the aims of trauma systems and global surgery initiatives [2, 17–20, 37, 43].

In relation to patient severity in terms of the triage categories, the high rate of patients discharged directly from the Emergency Department could be a result of inappropriate referrals and over triaging in lower-level facilities. Inappropriate referrals have been reported to result in wastage of resources by treating minor injuries in referral centers [43]. It is therefore speculated that inappropriate referrals may have led to the protracted waiting time observed, which could be averted by instituting inclusive trauma systems that empower lower-level facilities with the skills to definitively treat less severe injuries [43, 44].

Study limitations

This study could not establish the overall burden of trauma patients as it utilized hospital data; instead, it has provided a snapshot of the proportion of trauma patients presenting to the Emergency Department.

The use of hospital data may well underestimate the actual number and proportions of trauma patients, care process and outcomes (such as mortality) as it does not account for out-of-hospital cases: the comparison with other studies is therefore based on similar hospital data and not prevalence studies.

Causes of prolonged waiting time could not be interrogated by this study in more detail (e.g., a lack of emergency doctors, delayed imaging and laboratory, or lack of admission beds).

Conclusion and recommendations

Emergency Departments in Botswana hospitals are confronted with high proportions of trauma patients due to blunt and penetrating injuries, who mostly present with less severe injuries, the majority being of soft tissue in nature, which could be treated in lower-level facilities, given adequate resources. Falls, interpersonal violence and RTC predominate as the leading causes of injury. The care process as signified by Emergency Department waiting time and the pre-hospital transport system is deficient. The comparison between pediatric and adult groups shows a close similarity in patient characteristics and challenges in the care process among these categories.

Areas for future intervention include: injury prevention for targeting falls, violence, as well as improvement of pre-hospital services, and the reduction of prolonged Emergency Department waiting time. Owing to the existing extensive public hospital inter-hospital transport network, providing training to the current staff, improving equipment and merging this transport network into the formal ambulance system could mitigate the obvious deficiency

and catapult the pre-hospital services in Botswana to more appropriate functionality.

Care-process variables such as patients waiting time, triage categories and rate of patient's disposition may be used for auditing the quality of trauma care in this setting.

Trauma care organization as described in the ETC guideline may improve the situation in Botswana, and the ETC guideline among other things directs how to ensure minimum necessary resources and skills, institution of triage and referral protocols in lower-level facilities, appropriate data collection, monitoring and quality improvement systems and finally the development of inclusive trauma care.

These findings and recommendations may be useful for planners, educators and policy makers in Botswana and across many LMICs due to similarities of challenges in trauma care provision.

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Compliance with ethical standards

Conflict of interest The authors declared that they have no conflict of interest or disclosures.

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ORIGINAL SCIENTIFIC REPORT

Evaluation of Resources Necessary for Provision of Trauma Care in Botswana: An Initiative for a Local System

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Abstract

Background Developing countries face the highest incidence of trauma, and on the other hand, they do not have resources for mitigating the scourge of these injuries. The World Health Organization through the Essential Trauma Care (ETC) project provides recommendations for improving management of the injured and building up of systems that are effective in low–middle-income countries (LMICs). This study uses ETC project recommendations and other trauma-care guidelines to evaluate the current status of the resources and organizational structures necessary for optimal trauma care in Botswana; an African country with relatively good health facilities network, subsidized public hospital care and a functioning Motor Vehicle Accident fund covering road traffic collision victims.

Method A cross-sectional descriptive design employed convenience sampling for recruiting high-volume trauma hospitals and selecting candidates. A questionnaire, checklist, and physical verification of resources were utilized to evaluate resources, staff knowledge, and organization-of-care and hospital capabilities. Results are provided in plain descriptive language to demonstrate the findings.

Results Necessary consumables, good infrastructure, adequate numbers of personnel and rehabilitation services were identified all meeting or exceeding ETC recommendations. Deficiencies were noted in staff knowledge of initial trauma care, district hospital capability to provide essential surgery, and the organization of trauma care.

Conclusion The good level of resources available in Botswana may be used to improve trauma care: To further this process, more empowering of high-volume trauma hospitals by adopting trauma-care recommendations and inclusive trauma-system approaches are desirable. The use of successful examples on enhanced surgical skills and capabilities, effective trauma-care resource management, and leadership should be encouraged.

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Background

The highest trauma incidence is found in developing coun-tries where resources for curbing the scourge of injury are minimal [1]. The Essential Trauma Care (ETC) project shows there are very low presence of skills, resources, and organizational capacity in areas confronted with the highest burden of trauma in developing countries [2]. Trauma patients in these countries present with wider and varied

diagnoses resulting from varied mechanisms of injuries; while Road Traffic Collision (RTC) dominates, there are other emerging mechanisms relating to weapon violence and actions of terror such as gunshots and bomb-blasts [3–6], all these require the presence of adequate skills and capabilities in hospitals for prompt and continuous trauma care. The Advanced Trauma Life Support (ATLS) course founded by the American College of Surgeons [7] promulgates the core skills, and knowledge necessary for initial care of severely injured patients, while Definitive Surgical Trauma Care course which is run worldwide by the International Association for Trauma and Intensive Care, teaches core skills for definitive management [8].These core courses [7, 8] and many others [9–11] designed for frontline personnel provide adequate skills in initial and subsequent management of severely injured patients.

Trauma systems, which are common in developed countries, utilize organized and regionalized approaches to retrieve injured patients, provide them with prompt on-site initial management and timely transport to appropriate hospitals [1]. The developed country approach to trauma systems employs stipulated guidelines to ensure the presence of skilled persons such as trauma surgeons and many other subspecialties [12–15]; however, in developing countries, it may not be possible to have all these resources [2].

There are a number of suggestions for establishing local trauma-care systems [16, 17]. Although developing nations require a similarly effective trauma system as in the developed countries, their approach may be too expensive to be feasible for low–middle-income countries (LMICs). The Essential Trauma Care project provides guidelines to help improve trauma care in LMICs through recommendations of the essential minimum requirements of human, physical, and organizational resources where there is no formal trauma system [2]. Botswana and other LMICs have been assessed by using these recommendations [18].

This study re-assesses the hospital capacity for managing severely injured patients in Botswana, a country with a health facilities network covering most of its habitable landmass, subsidized hospital care [19–21], and a relatively well-functioning Motor Vehicle Accident (MVA) fund, which covers medical costs for the RTC victims [22]. The current study employs templates derived from ETC guidelines, and protocols based on the ATLS and the DSTC curricula to assess the physical resources, human resource capacity and skill-set, and the organization of trauma care.

Methods

Botswana's public health system is well organized. With a population of two million, it has two main referral hospitals, seven public district hospitals, over 200 primary hospitals and 800 health posts [19, 20]. Eighty percent of the population resides along the central and northern provinces, where the two main referral hospitals and one high-volume trauma district hospital are located [23]. This study was conducted in these three major public hospitals: Princess Marina and Nyangabgwe referral hospitals and Mahalapye district hospital. Research ethic review board approval was granted by the University of Kwazulu-Natal in South Africa and the Botswana Ministry of Health [BREC (BE487-14) and (PPME 13/18/1 IX(112), respectively]. Further, permissions to use hospital data were granted by individual hospitals. The researchers interviewed: nurses in charge, doctors and heads of departments in the emergency and surgical departments. An interview questionnaire with 87 items was used to assess the presence of equipment and consumables for managing: airway, breathing and circulation problems, and laboratory, blood transfusion, and radiology services. Physical verification of equipment and consumables confirmed the presence of the listed items.

Knowledge pertaining to initial management of trauma patients was evaluated by convenience sampling of on duty nurses and doctors. Selected participants were exposed to a simulated accident scenario and thereafter assessed to determine how they would respond in such situations using a checklist based on ETC and ATLS guidelines constructed specifically for this study was used for scoring their responses (Appendix Tables 6 and 7).Based on ETC and DSTC curricula and recommendations [2, 8], the hospital capacity to perform definitive surgical procedures was evaluated by interviewing personnel in operating theaters and cross-checking the surgical-operation registers (Appendix Table 8).

Results

The assessment of the physical resources required for trauma management, staff knowledge, hospital infrastructure, and organization of services is described.

Assessment of physical resources necessary for airway and breathing management

Eighteen components were used to assess adequacy of resources for initial airway and breathing management. All three hospitals, irrespective of their designations, had most of the equipment and consumables essential for trauma care. Portable x-rays were available in the main radiology areas, and not in emergency rooms (Table 1).

Table 1 Assessment of physical resources for management of airway and breathing problems in emergency room

Assessment unit	Hospitals		
	Nyangabgwe	Mahalapye	Princess Marina
1. Oxygen supply/cylinders	1	2	3
2. Oropharyngeal airway	CT	CT	CT
3. Suction unit-powered	6	13	4
4. Suction tubes (*P *A)	+	+	+
5. Yankauer or stiff suction tip	+	+	+
6. Bag-valve-mask	CT	CT	CT
7. Nasogastric tubes(*P *A)	+	+	+
8. Laryngoscope (*P *A)	CT	+	+
9. Magill forceps	–	CT	–
10. Endotracheal tube (*P *A)	+	+	+
11. Hard neck collars	+	+	+
12. Spine boards	+	+	–
13. Pulse oximeter	3	3	4
14. Ventilator machine	–	1	1
15. Underwater drain set (*P *A)	+	+	+
16. Crash cart trolleys (*P *A)	2	1	2
17. Crash cart trolleys maintenance protocol	+	+	+
18. Portable x-ray machine	AH	AH	AH

**P* pediatric size, **A* adult size, *CT* available in crash trolley, + service or consumables adequately available, – service, equipment or consumable not available, *AH* available in the hospital but not stationed at emergency room

Assessment of resources necessary for managing circulatory problems in trauma patients

Four items out of 13 assessed were missing; however, these were all nonessential according to the ETC grid. None of the hospitals had a functioning emergency room theater although one of the hospitals had a space designed for emergency theater within the emergency room. Generally, hospitals possessed all essential items as per ETC. All hospitals had portable laptop ultrasound machines for Focused Assessment Sonography for Trauma (FAST); in one hospital, the machine was stationed in the emergency room; in the other two hospitals, the ultrasound was stationed in the main radiology suite and could be deployed to the emergency room when needed. Fluid warming and rapid infusion equipment were present in theaters and intensive care units but not in the emergency room (Table 2).

Assessment of personnel knowledge of initial management of a severely injured patient

There were between two and four registered nurses taking shifts in emergency room of the hospitals visited, and between one and two doctors stationed at the emergency room during each 12-h shift. Six nurses and four doctors were assessed and scored based on the developed instruments. None of the nurses had undertaken trauma-related courses, and none of the doctors were ATLS certified. Participants in the nursing cadre scored between 3 and 11 points out of a possible 23 expected; while two doctors of the four demonstrated good knowledge by scoring correctly between 18 and 19 points out of possible 25 expected, while the other two doctors scored only 4 and 5 points, respectively (Appendix Tables 6 and 7).

Evaluation of hospital capability for definitive trauma surgery procedures for severely injured patients

Evaluation of surgical capacity considered minimal for managing severely trauma patients based on ETC guidelines and the DSTC manual showed Mahalapye, the district hospital located along the major highway with high trauma incidence could only perform six procedures out of the 30 listed, while the remaining two referral hospitals had the capacity to perform 28–30 of the listed procedures (Appendix Table 8).

Rehabilitation services and other trauma care supporting infrastructure

Most of the necessary core services and subspecialties were present; there was a good number of operating rooms in all

Table 2 Assessment of physical resources for initial management of circulation problems in emergency room

Assessment unit	Hospitals		
	Nyangabgwe	Mahalapye	Princess Marina
1. Cannular (14, 16, 18) (*P*A)	+	+	+
2. Central venous catheters	+	+	+
3. Intraosseous needles	–	–	–
4. IVF crystalloids	+	+	+
5. Rapid infusion equipment	AH	AH	AH
6. Fluid warming equipment	AH	AH	AH
7. Focused Assessment Sonography for Trauma (FAST)	AH	AH	+
8. Central venous pressure monitoring	–	–	–
9. Arterial pressure monitoring	–	–	–
10. Emergency operation theater	–	–	–
11. Foley catheters(*P *A)	+	+	+
12. BP machines & cuffs (*P *A)	+	+	+
13. Blood transfusion capacity	+	+	+

P pediatric size, *A* adult size + service, equipment or consumable adequately available, – service, equipment or consumable not available, *AH* available in ICU and in operating theaters, or in the main radiology suite only

hospitals, as well as the presence of supporting services for trauma rehabilitation: A few specialties, including vascular, plastic, and maxillofacial surgery, were not present or were only occasionally present (Table 3). Each hospital had physiotherapists (ranging from three in the district hospital to eight in the national referral hospital), occupational therapists, and orthotic specialists providing outpatient rehabilitation services such as physical therapy; aids such as clutches, wheelchairs, orthoses, and limbs-prosthesis, among others. The national referral hospital had a dedicated inpatient service with full-time physiotherapists, medical officers, and nurses allocated for spine-injured patients and had one speech and language therapist. Some of the hospitals had functioning Arterial Blood Gases (ABG) analyzers and ventilators in the emergency room (Table 4).

Trauma-care organization and quality improvement programs

None of the hospitals had a designated trauma team or any organizational structures particular to trauma care. The situation was similar in the two major referral hospitals and the district hospital (Mahalapye), which is often confronted with mass causalities from frequent RTC. However, all hospitals had a disaster committee made up of members from all clinical units. A notification system for mass casualty commonly uses an alarm to summon clinical staff (doctors and nurses) to the emergency department; however, usually staff come on a "voluntary basis." It was interesting to note that this was perceived as a "trauma-team" by some of the interviewees. Hospitals had frequent ad hoc training in emergency medicine, which is presented as part of a normal continuing medical education plan (Table 5).

Discussion

Physical, human resources, and organizational structure are the key components for improving outcome of severely injured patients [2, 17]. This study found adequate physical resources for initial management of airway, breathing, and circulation as well as rehabilitation services, all meeting or exceeding minimal requirements stipulated in the ETC guidelines (Tables 1 and 2) [2]. Hanche-Olsen et al. previously conducted a similar assessment and subsequently introduced countrywide trauma-team training and sensitization of trauma-care improvement [18].Our finding that demonstrated the presence of adequate resources could be a result of such previous initiatives. Studies from many other developing countries report severe shortages of basic physical resources for surgical care at district hospitals [24–27]. The WHO through the ETC project embarked on initiatives to tackle these challenges by recommending systems that should be incorporated into local public health plans [2], while many other similar guidelines serve to streamline and improve trauma care [12–15] and may be used to supplement ETC recommendations where needed. The way forward for entities which exceed ETC guidelines

Table 3 Trauma-care supporting services in Botswana's main hospitals

Subject/activity	Assessment item	Hospitals		
		Nyangabgwe	Mahalapye	Princess Marina
Specialists and core services available in the hospital	1. General surgeons	3	1	8
	2. Anesthesiologists	5	1	8
	3. Nurse-anesthetists	5	3	6
	4. Pediatric surgeons	1	0	1
	5. Orthopedic surgeons	2	3	4
	6. Neurosurgeons	2	0	2
	7. Vascular surgeons	0	0	0
	8. Thoracic surgeons	1	0	1
	9. Maxillofacial surgeons	0	0	1
	10. Radiologists	2	0	2
	11. Urologists	3	0	0
	12. ENT surgeons	2	0	2
	13. Plastic surgeons	0	0	0
	14. Intensive care nurses	NA	1	4
	15. Multiple theaters for multi-specialties	4	3	10
	16. Dedicated emergency theater	0	1	0
	17. Adult ICU beds	5	3	10
	18. Neonatal ICU beds	10	1	4
Other supporting services available routinely	19. Occupational therapists	?	?	?
	20. Physiotherapy services	?	?	?
	21. Social work services	?	?	?
	22. Dietitian services	?	?	?
	23. Orthotic services	?	?	?

? Service available, – services not available, NA missing data (information unavailable during data-collection)

would obviously be to modify the grid according to local circumstances or adopt superior guidelines as to improve and sustain the trauma-care progress: For instance, in South Africa, the trauma society has provided recommendations for trauma centers, and maintain guidelines that guide trauma practice countrywide [14].

Knowledge of trauma care for most of the emergency room providers was found to be inadequate. There has been a previous report which offers teaching experience in such scenarios within LMICs context: In Ghana for instance, following reports on deficiencies in trauma-care knowledge, the Kwame Nkrumah University of Science and Technology started to provide short tailor-made trauma courses, which led to improved skills [28]. Many other similar instances in sub-Saharan Africa [29–32] offer practical learning experiences considering LMICs resources. In comparable situations, higher income countries ensure adequate trauma-care skills among their providers by ascertaining proper training and certification and strict adherence to stipulated guidelines [12–15].In this study, the deficiencies in capacity to render a wider range of surgery for critical trauma conditions in the busiest district hospital represent a great human resource and skills problem in Botswana and likely many other LMICs.

Assigning surgical roles to non-specialists (task-shifting) has been described in LMICs, but remains limited to minor to moderate non-complex injuries and surgeries [33, 34].

Surgery outreach programs; considering short distance the district hospital is situated from referral hospitals may improve patient care in the short term. Partnership between the ministry of health and training organizations such as the College of Surgeons of East, Central and Southern Africa, among others, has been described as a cost-effective way for generating specialists in LMICs [34, 35]. The effective long-term changes in human resources procurement and development for trauma care will likely result from: functioning trauma systems [2, 12–15, 36, 37], and research-oriented curricula in universities which address local trauma care needs [3–6]: an example being in Niger,

Table 4 Trauma-care supporting services and resources in the emergency room

Assessment item	Nyangabgwe	Mahalapye	Princess Marina
Services and equipment available			
1 Emergency bay beds	5	10	10
2 Emergency bay surge capacity	15	15	25
3 Wheeled trolleys	10	10	10
4 Wheelchairs	2	4	0
5 ECG Monitors	1	1	6
6 Defibrillator	1	2	1
7 Ventilators	0	1	2
8 Ultrasound scan machine	AH	AH	?
9 X-ray machine	AH	AH	AH
10. CT scanner	AH	–	AH
11. MRI scanner	AH	–	–
12. Chemistry analyzer	AH	AH	AH
13. Hematology analyzer	AH	AH	AH
14. ABG analyzer	–	?	?

? Service available, – service not available, AH service available in the hospital and not in emergency room

Table 5 Assessment of hospitals' capacity for trauma-care organization

Assessment theme	Hospitals		
	Nyangabgwe	Mahalapye	Princess Marina
1 Presence of trauma team (if yes explain composition)	–	–	–
2 Presence of trauma team activation protocol (If yes explain composition)	–	–	–
3 Presence of ongoing in-house trauma training (If yes explain who are the conveners)	–	–	–
4. If answer to 3 is yes, how many times did the trauma training (mentioned above) run in the past year	–	–	–
5 Presence of Quality Improvement initiatives (mortality- and morbidity-meetings, panel review etc.)	–	–	–
If yes mention which one is conducted and how many times per quarter (3 month) and who are the members			
6 Presence of protocol for handover of polytrauma patients	–	–	–
If yes describe			
7 Presence of protocol for transferring polytrauma patients between specialists or facilities	–	–	–
If yes describe			
8 Dedicated trauma registry	–	–	–

– Service or provision not available

where the local university developed a surgery program to address needs in the district settings [38], and the prior mentioned instances may work well for Botswana and many other LMICs.

Trauma-care organization, such as the presence of trauma teams, trauma-team training, quality improvement initiatives, policies for receiving or referring trauma patients, and presence of a trauma registry, did not exist in any of the hospitals evaluated in Botswana. Studies in Africa have previously showed poor trauma-care organization, resulting to poor care even in presence of the necessary physical resources. In a recent report, researchers in Ghana identified the absence of trauma-care organization as the cause of high mortality and morbidity in a local hospital [39], while elsewhere, for instance in the UK, incorporating trauma organization to the standard practices showed improvement in quality of care and survival [40]. Trauma-care organization is a low-cost initiative, which

may be more easily replicated in LMICs than many other components of the trauma system. The ETC project through its guideline and other guidelines strongly advo-cates for establishment of trauma-care organization [2, 12–15].The Bellagio essential surgery group, like the ETC project [2, 33], urges nations to establish trauma-or-ganization key persons in high ministerial positions: In these models, individuals with appropriate background and skills are recommended to oversee trauma-care develop-ment at the ministry of health level.

Limitations

This study used surgical register data and indirectly interviewed heads of departments to assess hospital capabilities in performing complex definitive trauma surgical operations, instead of conducting interviews with multiple individual practitioners, although our method was practical, it may have overestimated the capabilities. The high trauma-volume district hospital included in this survey receives much more attention from the government than an average district hospital in Botswana; therefore, the findings in this hospital may reflect far better conditions than other district hospitals. It is therefore worthy to consider that our convenience sampling during interviews and inclusion of the three specific hospitals may have intro-duced confounders in the results that may be difficult to generalize.

Conclusion and recommendations

Assessment of resources for airway, breathing, circulation, and rehabilitation services using ETC guideline shows Botswana meet or exceed recommendations stipulated. There were, however, inadequacies in knowledge of initial trauma care among emergency room providers, while capacity for managing severely injured patient was lowest in the district hospital. Lack of trauma-care organization was evident in all hospitals, despite the previous initiatives. Considering hospital locations and population distribution in Botswana, establishing a capable trauma center in the district hospital along the busiest highway will enable best care of the injured. Utilization of trauma courses such as DSTC, ATLS, Advanced Trauma Course for Nurses (ATCN), or their replicas may ensure adequate capabilities in trauma hospitals and mitigate deficiencies of the necessary skills. Because there are some components that already exceed ETC recommendations, adopting trauma-center guidelines that have been piloted in Africa context, such as the one described by Hardcastle et al. [14], may be suitable for Botswana.

System-wise approach, borrowing from primary care models as discussed, and ultimately inclusive trauma system may improve the current situation. The findings of this research can be used for: promoting further training, medical curricula development, recruitment by ministries of health and hospitals, and skills re-assessment, and accreditation by medical professional bodies.

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Appendix

See Tables 6, 7 and 8.

Table 6 Simulation description and scoring checklist for assessment of nurses' knowledge of initial management for the severely injured patients

Participant identification
Designation
Courses undertaken
Randal, a front seat unrestrained passenger was thrown out of the car after head-on collision. Half an hour later he was picked up by road patrol and rushed to a nearby specialist's hospital, and he was found semiconscious, BP 80/50, with noisy breathing, pulse rate of 110/min, and his trousers soaked with blood.
(a) Considering primary survey (ABCDE), what would you do to manage him? (within your capacity) (total score 23 marks)
A. Asses for Airway and
B. Breathing by:
1. Feeling for airway patency,
2. Trachea position,
3. Looking for breathing pattern/signs of distress,
4. Listening to the chest for problems with breathing
Manage airway and breathing by:
1. Clearing airway (and insertion of oral/nasal airways)
2. Perform Jaw thrust–Chin lift
3. Protect C Spine/placing on hard neck collar
4. Giving oxygen/bag-valve-mask device

Table 6 continued

5 Treating tension pneumothorax by needle thoracostomy(insertion on the second intercostal space)
6 Sealing open pneumothorax
C. Assess the circulation and presence of shock by:
1 Looking for color or pallor
2 Feel warmth of extremities
3 Assess for capillary refill
4 Use adjuncts such pulse oximeter
5 Look for external hemorrhage
6 Control external hemorrhage by pressure
7 Insert large bore cannular and run 1 L of warmed crystalloid fast
8 Draw blood for grouping x matching, CBC, chemistry
9 Insert foley and record urine output
D. Assess for consciousness
1 Assess pupils dilation/motor(lateralization)
2. prevent secondary Brain injury by administering high flow oxygen
E.
1. Cover the patient
2. Re-assess (and record)

Table 7 Simulation description and scoring checklist for assessment of doctor's knowledge of initial management of the severely injured patients

Participant identification	
Courses undertaken	
Randal a front seat unrestrained passenger was thrown out of the car after a head-on collision. Half an hour later, he was picked up by road patrol and rushed to a nearby specialist's hospital. He was found semiconscious while the driver was confirmed dead at the scene.	
With regard to primary survey, considering 'airway/breathing'(total score 25 marks)	
(a) How would you assess him (4 marks), (ii) recommend management of the possible life-threatening conditions (6 marks)	
(b) Recommend assessment of 'circulation' with regard to possible sources of bleeding (9)	
(c) Recommend a plan for initial assessment and management of disability(6)	
Scoring checklist	
A, B Assessment-considering 'airway/breathing' (i) how would you assess him—4 marks	
Look, listen, feel	1. Face
	2. Mouth
	3. Neck
	4. Chest
Recommend management—of the possible life-threatening conditions—6 marks	
Focus to exclude	1. Airway obstruction
Life-threatening conditions listed	2. Tension pneumothorax
	3. Open pneumothorax
	4. Massive pneumothorax
	5. Pulmonary contusion and flail chest
	6. Cardiac tamponade
C, Recommend assessment of 'circulation' with regard to possible sources of bleeding	
Expected	
Focus on shock by assessing sources of bleeding	1. Pallor
	2. BP
(mentioning of vital signs and the focus-sites 1 mark total 9 marks)	3. Pulse rate
	4. Temperature
	5. External bleeding
	6. Chest
	7. Abdomen
	8. Pelvis
	9. Long bones
D, Recommend your plan for initial assessment and management of 'D' disability—6 marks	
Expected	
Assessment	1. Glasgow coma scale(GCS)
	2. Pupils
	3. Lateralizing signs
Management	4. Oxygenation
	5. Maintaining perfusion
	6. Intubation if GCS is 8 or below

Table 8 Assessment of hospital capability for performing advanced definitive trauma surgery procedures

Head and neck injuries	
1 h Performing burr-hole for intracranial hemorrhage	3. h Exposing the injured carotid artery
2 h Performing craniectomy for intracranial hemorrhage	4. h Repairing lacerated external jugular vein
Cardiothoracic injuries	
5 h Performing anterolateral thoracotomy	10. h Managing subclavian artery injuries
6. h Performing median sternotomy	11. h Repairing traumatic cardiac injury
7 h Performing clamshell thoracotomy	12. h Cross-cramping aorta in traumatic aortic Injury
8. h Stopping traumatic internal-mammary bleeding	13. h Performing pulmonary tractotomy
9 h Exposing subclavian injuries in its entire course	14. h Cross-cramping pulmonary main bronchus
Abdomen and pelvis	Musculoskeletal injuries
15. h Performing diagnostic laparoscopy	23 h External fixation of long bones
16. h Performing trauma laparotomy	24. h Fixation of long bones by plates
17. h Packing of the bleeding liver	25. h Managing lower extremity compartment syndrome
18. h Shunting of the aortic injury	26 h Saphenous vein graft harvesting
19. h Shunting of iliac artery injury	27 h Performing vein interposition graft
20. h Repair of lacerated Inferior vena cava	28 h Repairing brachial artery injuries
21. h Providing various core temperature re-warming technique	29. h Performing fasciotomy of lower extremity
22. h Performing damage control surgery	30 h Performing escharotomy in its entirety

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These reports show Botswana was confronted with a high incidence of trauma due to RTC. While its emergency rooms are frequented with trauma cases, its capacity to manage severe injuries is limited by low usage of formal emergency medical services (EMS), and the absence of a formal trauma system. Although Botswana seems to exceed minimal resources for the WHO essential trauma care guidelines, there are care process limitations such as over triage in lower-level hospitals, limited trauma-care skills among providers, deficient capacity for critical surgery procedures in trauma hospitals, and deficient organisation of care. These limitations constitute their trauma-care challenges and place it in a similar situation to other LMICs. Comparable challenges to these findings have been found in other LMICs with no trauma systems, and they are discussed in these reports. Botswana, having more resources than the minimal recommendation stipulated by WHO for essential trauma-care, may need to devise its own trauma care guidelines to suit its situation. A similar initiative was undertaken in South Africa, the only sub-Saharan African country with a well-functioning trauma system.The recommendation from these two reports may be generalised to other countries in LMICs. Further, they may be used for research, training and for service planning.

Chapter 5

Primary study from Tanzania

Tanzania is confronted with high rates of trauma incidence and suffers limited capacity to respond to trauma scourges. Similar to situations in many other LMICs as defined before in this thesis, Tanzania requires trauma care systems to manage its healthcare resources, develop appropriate organisation of care, and build up skill capacities among health professionals [2,28].

The economic and service-provision gains that may arise from instituting a trauma care system have been described by individual researchers and the WHO in the essential trauma care guidelines (2, 28). These benefits result from pooling of patients, which results in less resource utilisation and escalation of skills necessary among healthcare providers, with better skill retention. For instance, the meager resources such as hospitals or healthcare professionals needed in care provision would be efficiently utilised by using a well-organised care system for sifting patients to appropriate hospitals in an inclusive trauma system (2).

In order to build an efficient trauma system in LMICs, important basic steps must include conducting a local needs assessment, hence the following study in Tanzania evaluated the existing healthcare structures and critical entities for developing a trauma system. The study assessed the hospital burden of injuries, characteristics of trauma patients, and the trauma care process. Further, the study assessed the performance of trauma care processes and their impact by comparing hospital and out-of-hospital trauma deaths within the same catchment areas.

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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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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.

African relevance

- Injury is a leading cause of mortality and morbidity in Africa, yet systems for management thereof are lacking in most developing countries
- This study assesses the trauma burden in major Tanzanian facilities and identifies areas of inefficiencies in trauma care management, while also proposing cost-effective solutions
- Professional bodies, training institutions and other relevant authorities may use these suggestions to improve trauma care in Tanzania and beyond.

Introduction

The burden and complexity of injuries is increasing in lower and middle-income countries (LMICs) [1–3]. The mortality risk after major trauma is 6 times higher than in developed countries [1]. High - income countries (HICs) achieve lower injury mortality rates because of standardized protocols, training and the availability of material resources or trauma-care system infrastructure [4–6]. For logistical and economic reasons, the WHO recommends the Essential Trauma Care (ETC) guidelines and similar approaches for LMICs, and advocates improvement of road safety and improvement of trauma-care services [1,3,7].

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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 centres, 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® spread sheet (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.

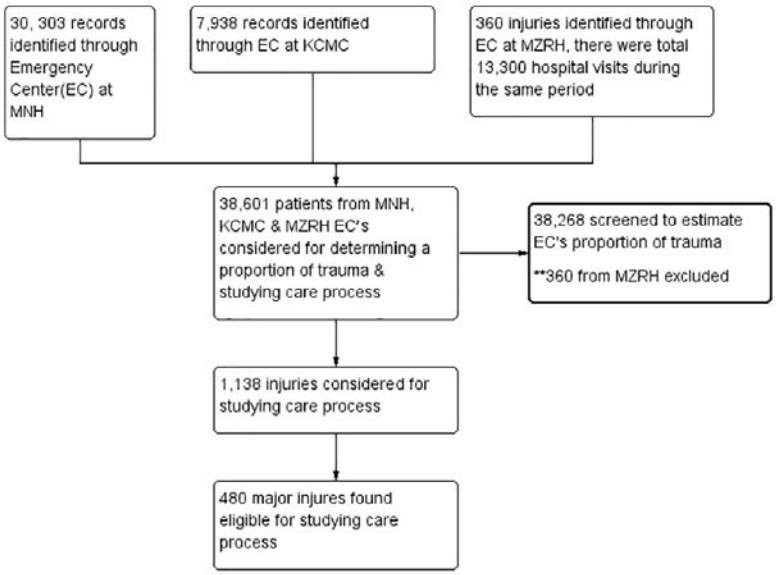

Fig. 1. Emergency Centre visits and in-hospital trauma admissions.

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).

Care-process and outcome of the admitted trauma patients across major hospitals in Tanzania

Airway patency and Oxygen saturation (SPO_2) 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

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Table 3
Assessment of the admitted trauma patients in major hospitals: the initial findings on heart rate, and blood pressure (N 480).

		KCMC n(%)	MNH n(%)	MZRH n(%)	Total n(%)
Pulse rate	< 60	3(1)	0(0)	2(2)	5(1)
	60–100	188(64)	55(63)	35(35)	278(58)
	100–120	70(24)	15(17)	12(12)	97(20)
	120–140	11(4)	9(10)	2(2)	22(4)
	> 140	4(1)	5(6)	2(2)	11(2)
	Not recorded	15(5)	4(4)	48(47)	67(14)
	Total	291(100)	88	101(100)	480(100)
SBP range	< 70	1(0.3)	1(1)	0(0)	2(0.4)
	70–79	2(0.7)	2(2)	0(0)	4(0.8)
	80–89	9(3)	2(2)	3(3)	14(2.9)
	90–125	175(60)	44(50)	32(31)	251(52)
	126–140	71(24)	24(27)	15(15)	110(23)
	> 140	21(7)	8(9)	15(15)	44(9)
	Not recorded	12(4)	7(8)	36(36)	55(11)
	Total	291(100)	88(100)	101(100)	480(480)
DBP range	< 40, or un recordable	2(0.6)	2(2)	0(0)	4(1)
	40–50	23(8)	7(8)	2(2)	32(7)
	51–59	42(14)	7(8)	7(7)	56(12)
	60–80	164(56)	43(49)	33(32)	240(50)
	81–90	32(11)	21(24)	17(17)	70(14)
	> 90	16(5)	2(2)	6(6)	24(5)
	Not recorded	12 (4)	6(7)	36(36)	54(11)
	Total	291(100)	88(100)	101(100)	480(100)
MAP range	< 65mmhg	13(4)	7(8)	3(3)	23(5)
	65-75mmhg	43(15)	9(10)	5(5)	57(12)
	76-110mmhg	216(74)	61(69)	50(50)	327(68)
	> 110	7(2)	5(6)	7(7)	19(10)
	Not recorded	12(4)	6(7)	36(35)	54(11)
	Total	291(100)	88(100)	101(100)	480(100)
Assessment of the extremity	Normal findings[a]	42(14)	57(65)	76(75)	175(36)
	Abnormal findings[b]	5(2)	7(8)	1(1)	13(3)
	Not recorded	244(84)	24(27)	24(24)	292(61)
	Total	291(100)	88(100)	101	480(100)

KCMC - Kilimanjaro Christian Medical Centre; MNH - Muhimbili National Hospital; MZRH - Mbeya Zonal Referral Hospital; DBP - diastolic blood pressure; SBP - systolic blood pressure; MAP - mean arterial pressure.
[a] Normal findings - normal-capillary refill and warm
[b] Abnormal findings - cold, sweaty & clammy.

Discussion

In this study, like many in LMICs [1,30–32] we observed that trauma primarily affected the younger population (aged 15–44) and males (Table 1), and like other reports [19] trauma comprised 10–13% of EC admissions. Deaths occurring before hospital admission were two-fold that of hospital trauma deaths, i.e. in one hospital, trauma deaths were 8% while the corresponding rate from the death-registry during the same period was 16%, suggesting many deaths prior to hospital arrival. Furthermore, trauma contributed to most causes of deaths after surgical intervention (64%). It is likely this rate is underestimated by the undetermined deaths and inadequate recording. These findings are comparable to a pattern of trauma deaths that has been previously reported [1,30–32] and suggests that 'in-hospital' data underestimates the scourge of trauma [31,32]. Trauma care requires a significant amount of material resources, time and highly skilled providers [1,2,4–6,8] hence appropriate planning based on needs is desired. Previous work [9,34,35] supports the review of death registries in LMICs for trauma surveillance as this may offer more robust data for realistic planning and performance assessment.

Most patients arrive at the EC by hospital transport while relatively few arrive by police vehicles or private transport. Further, it was noted that most referred patients arrived from the surrounding lower-level hospitals and did not possess health-insurance. Road traffic collisions were the most common cause of injuries, the other causes being assaults and falls. The presence of hierarchical hospital networks, hospital transport systems and the involvement of police in transferring patients offers an opportunity to forge a practical pre-hospital trauma system, since the vehicles exist, and the facilities exist, but need additional staff training and equipment. In similar contexts, researchers have constructed pre-hospital trauma systems using lay-persons and pre-existing primary hospital networks [7].

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 appro-

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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.

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Appendices. Supplementary data

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The report made an important key observation for trauma care development in Tanzania. The study identified a well-functioning patient referral system, transport network and potential financing systems that can be cost-effectively converted to, or utilized in, trauma care system development. It also points out trauma care challenges such as poor-quality patient records, inefficient triage, and the lack of a protocolized care process. The need for system installation, changes in health professional training and continued appraising have been identified, options highlighted and recommendations provided. Findings have been compared against other LMICs and hence recommendations may be used in other similar contexts in Sub Sahara Africa.

Chapter 6

Synthesis, Conclusion and Recommendations

The Cochrane review showed many injury-related deaths and disabilities occur in LMICs. Similar findings were reported in many primary studies in LMICs and sub-Saharan Africa (20, 32-34). Comparative reports in HICs show lower death rates and morbidity associated with the implementation of trauma system approaches. These HICs' approaches may not be feasible in LMICs because of their high cost (55-58). Therefore, it was imperative to investigate the effectiveness of the trauma system in order to advocate for practical solutions in LMICs.

Primary studies in Botswana and Tanzania in this thesis sought to understand in-hospital burden of traumatic injuries, process of care, resources available, and patient-outcomes in the main hospitals (55-57). This is novel work in that most prior studies have focused on one facility or one pathology, thus limiting the generalizability of the findings.

Findings from the Cochrane review showed several primary researchers reported usefulness of trauma systems in managing injuries. The review reported reductions in deaths, complications from injuries, and cost in HICs. However, there were limitations to the evidence of effectiveness due to the lack of high-quality primary studies (59).

Reports of primary studies in both Botswana and Tanzania showed higher prehospital trauma deaths than hospital deaths, predominant injury incidents in youth and young adults, deficiencies in recording of medical data (55-57). Despite limited human and material resources (2,28) both countries exhibited inappropriate triage of minor injuries to referral hospitals and subsequent high rate of minor surgeries performed in these hospitals. Such

minor surgeries could be undertaken at lower-level hospitals to allow more complex conditions to be managed in referral hospitals (55-59).

Concurrently, the primary studies report showed there was a well-functioning referral network from lower-level to higher-level hospitals, an established inter-facility patient transport system (albeit with limited training and staff-skill), and common use of commercial vehicles, police vehicles and private vehicles for transporting patients. Furthermore, both countries possessed a functioning death and birth registry system, a healthcare financing system, and emergency medicine physician training programs (56-58). In Botswana, a formal ambulance system was more used and resources in some hospitals exceeded the WHO essential trauma recommendations (52,56-57).

Conclusion

Countries in sub-Saharan Africa have systems and infrastructure in place that may be improved to establish and progressively build up the needed trauma systems. Deficiencies in triaging, recording of patient data, funding, personnel knowledge and skills, hospital technical capacities and organisation of care could be managed by instituting trauma system approaches advised by the WHO, and by borrowing from other functional trauma systems worldwide. Utilizing existing opportunities and resources in individual countries may create Afrocentric systems that use existing systems and ensure affordability and an improvement in overall patient outcomes. This may eventually lead to formalized trauma systems over time.

Recommendations

Utilisation of standard trauma care protocols in referral hospitals and high-level hospitals may improve over-triaging, care processes and better manage resources. Hierarchies in the health facilities that exist may adopt standard referral systems to sift (or triage) the non-urgent patients. Regional and provincial hospitals could steer regionalised trauma systems by giving trauma care administrative roles to the health management team leadership structures, such teams are already in existence in almost every region or province. Further, the lead health teams in the region could utilize and expand existing outreach programs to build capacity in the lower-level facilities to act as level 4 and 3 trauma centers. Roles similar to accreditation of trauma centers could be incorporated and amalgamated with other quality care roles that regional health boards are already performing.

The need for an Emergency Medical Service component could be developed using the wide-spread interhospital transport network already in existence by using the patient transport vans and panel-vans already present in every facility but based at the hospitals and by training of the crews. The gap in equipment and skills of the crew in these vehicles could be easily managed locally by adapting and modifying equipment, or procurement of extra equipment and setup locally relevant training and accreditation instruments. Trauma care training already exists in Botswana and Tanzania through their emergency medicine departments, further the training could be overseen by trauma leads from each of the health boards in the district or region. To fill in the gap, commercial vehicles that are already widely in use could be improved by appropriate regulation, and accreditation of the crew and equipment. This can be achieved by, for example, creating private-public partnerships for initial care and patient transportation. Further, this will require recognizing prehospital professional cadres and training in Tanzania where prehospital crews are not yet registered or accredited.

Adopting formal trauma registries will ensure a recording system that will include all important patient variables to enable quality assessment, and patient outcome evaluations to appraise trauma care. Adaptation of practical trauma registry models should be advocated, and should be incorporated into trauma care curricula and taught to frontline healthcare personnel. Existing nationwide mortality registries should be redesigned to provide opportunities for trauma care appraisal for quality of care.

Advocacy to encourage funding for prehospital care will quickly improve quality, increase the number of providers, foster training and eventually may reduce prehospital mortality and morbidity. Health boards are in a good position to ensure these, where there are no centralized systems. Health boards and trauma leads may involve private and non-private partners who are already engaging in prehospital transport, or patient retrieval, such as the fire department, police department, Red Cross societies and funding bodies that exist.

Regional health boards such as regional health management teams should eventually form regionalised trauma systems with aims to set up trauma prevention and treatment systems as described above. Ministries of health should utilize the existing supporting system to their regional health boards similar to the one used in ‘essential services packages’. This is a current pressing need for both Tanzania and Botswana, and this likely applies to the rest of sub-Saharan Africa since they share similar challenges, as evidenced in recent reports from a number of countries in the region (60-65).

Ministries of health, relevant healthcare professional bodies including the National Surgical societies, Emergency Medicine physician societies, nurses and allied health professional boards, and training institutes should review curricula for frontline trauma-care personnel. Major reviews of health professional curricula will address gaps noted in the providers knowledge on trauma care, and its organisation, and provide trauma research skills that are

pertinent for quality care. A collaboration of local and regional professional bodies such as the College of Surgeons of East Central and Southern Africa, West African College of Surgeons, or the Association of Surgeons of South Africa, may hasten regional harmonization and maintain standards. Finally, the recent interest among African countries in the World Health Organisation's National Surgical Obstetric and Anaesthesia Plan concept would also enhance trauma care capacity, through improved overall care of surgical pathology and the overlap of hospital quality of care initiatives. This latter plan aims to address all aspects of surgical and related care from the system perspective and includes trauma care provision.

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Appendix 1

Protocol

Trauma Care in Sub-Saharan Africa: Challenges and Opportunities in Botswana and Tanzania for Implementing Afrocentric Systems.

PhD Protocol – University of Kwa-Zulu Natal (UKZN)

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2. Prof. Lawrence Museru, MD; Mmed(Gen Surg.);MSc(O/T); FCS(ECSA); - University of Dar es salaam, Tanzania

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Summary of the proposed research

Background: *Because of the rising incidences of traumatic injuries in our individual countries as reflected in the global burden of diseases, there has been a growing need for improving injury prevention and its management. It is established that most injuries occur in developing countries where capacity and resources for managing it are minimal or non-existent. Over decades, developed countries have designed and used systemized approaches in managing traumatic injuries referred to as trauma systems. The developed countries' trauma system has proved to be the most effective approach in preventing and managing injuries, however it is thought to be too expensive and impractical for Africa. The WHO and many other researchers in this area have proposed alternative approaches, Afro-centric trauma system is one such approach looking comprehensively into capacity, dynamics and techniques for trauma systems in developing countries. The entities of the trauma system include care for the injured from the accident scene, transport to the most appropriate health facility, and continued care that ensures recovery to a functional state. Municipal hospitals and regional hospitals in Africa could act as the center of coordination for trauma system and could be improved to form comparable 'designated trauma centers' in developed*

countries. This study aims to assess the burden of trauma, the prevailing health system capacity, and investigate potential opportunities within the existing healthcare structure that can be used to build local trauma systems for both Tanzania and Botswana. The study will as well analyze the utility and effectiveness of the trauma system employed across the world through systematic review of literature. The research is part of a requirement for PhD studies on trauma surgery at the university of Kwazulu Natal (UKZN), South Africa.

Method:

Authorization will be sought from Ethic committees at UKZN, Botswana and Tanzania, and permission requested from hospitals. Based on burden of trauma patients, four main hospitals in Tanzania and another four main hospitals in Botswana will be included in the study. In Botswana, the study will enroll Princes Marina hospital, Gaborone private hospital (GPH), Mahalapye and Nyangagbwe hospitals. In Tanzania, the study will include; Muhimbili, Kilimanjaro Christian Medical center (KCMC), Mbeya referral hospitals, and Tumbi trauma hospital. Other institutions such as the birth and death registry department and fire department will also be studied.

By conducting interviews, assessing checklists, and reviewing the process of care on registers and patient files we will investigate the hospital burden of injury, process of care for trauma victims, physical resources and human resources and their skills capacity, organisation of trauma services, patient's outcome, and opportunities for implementing of trauma system.

Outcome:

The findings will demonstrate the prevailing capacity as trauma care is concerned, and will be important for devising trauma care protocols relevant to local setup, advising trauma practices, human and physical resource development and planning. Further findings will advise educators, policy-makers, and many other relevant stakeholders in health provision in Tanzania and many other developing countries.

Keywords. *'Trauma System', 'Trauma centers', 'Emergency Medical Services' (EMS), Injury, 'Low and middle-income countries' (LMICs)*

Introduction

Tanzania and Botswana are two extremes in Africa, as far as economic and health performance indicators are concerned [1,2]. On one hand Botswana enjoys developed road networks, low population density and much more resources allocated for health services [2,3] while Tanzania has longer and poorer road networks, high population numbers, high traffic congestion in her cities and less resources allocated for health services [4]. There is a direct correlation between road infrastructure, the economy, health resources and occurrence of trauma and its outcome [5]. Previous studies in Africa have shown differing patterns and burden of trauma [6, 7]. We are proposing a study of these two study populations to gain a greater understanding of the

diversity of patterns and burden of trauma, opportunities available and challenges as an initiative to guide our version of a trauma system.

Background and Literature review.

Although the world's data on causes of mortality and morbidity is dominated by infectious diseases, trauma equally imposes significant morbidity and mortality comparable to infectious and many other noninfectious conditions[11, 12]. The burden of the 'trauma disease' worldwide is currently 12%, mostly because of road traffic accidents in developing countries, the current estimates for Africa are reported to be at least 50/100000 injuries and mortality rate of up to 131/100000, this rate is projected to rise by 80% by 2020[12].

For decades, organized trauma systems have grown to become the best mode of caring for trauma patients [13]. We trace the history of trauma system development back to the lessons learned from conflicts and wars [14,15]. Since then there has been extensive development of trauma systems in high-income countries (HICs) led by the USA.

Trauma system encompasses pre-hospital and in-hospital care, rehabilitation, preventive strategies and goes hand in hand with provision of Emergence Medical Services (EMS) [9,16]. We recognize it that a well-organized trauma system decreases mortality by up to 20% and decreases medically preventable deaths by 50% [17].

The development of infrastructure and systems catering for trauma patients in high-income countries (HICs) is unmatched to the middle and lower income countries and speculated that if imported to resource limited countries, it may paralyze health systems for its high cost [9]. Although there is a demonstration of improved patient's outcomes in countries with well-set trauma systems [18,19]. It is not known if high-cost interventions and systems used in HICs are responsible for the improved patient's outcome. Researchers have suggested that the use of low cost-effective measures in the low and middle-income countries (LMICs) could improve patient's outcome [9].

Because of varying economical and health care provision in LMICs, the trauma care provision services are in different development stages; for instance, in Africa, it is only South Africa which has established EMS and a trauma system model, though still in its infancy [20]. Nevertheless, efforts to improve trauma care from other African countries have been registered, though at a much lower capacity; in Uganda, for example, there has been trauma team training that resulted in an improvement in practical skills and improved patient's care [9]. In several other African countries, utilization of Essential Trauma Care (ESTC) guidelines in assessing facility capacity found adequate resources matched to the level of facilities, but generally there has been deficiencies in organization of care [17].

For both pre-hospital and in-hospital trauma management in LMICs, studies have shown the process to be workable and beneficial when building on the existing system. In Ghana, for instance, a study on the pre-hospital system found that training members of community such as taxis and truck drivers improves their participation in the rescue and provision of pre-hospital care [17, 21].

Because of the complexity of importing trauma systems from HICs and lack of concrete evidence of cost effectiveness of high-cost resources used in HICs, the WHO's trauma guidelines recommends building a cost-effective systems that will fit LMICs [9, 22]. However, where standards of the prevailing trauma system exceeds the WHO recommendations, a further step should be taken to update the standards based on the capacity of individual country [10], the Afro-centric notion of trauma system is built on this concept [20].

This study aims to assess the burden of trauma, the prevailing health system capacity, and investigate potential opportunities within the existing healthcare structure that can build local trauma systems for developing countries. The study will also analyze the utility and effectiveness of the trauma system across the world through systematic review of literature.

Aims of the study:

The aim is to assess the burden of injury, trauma care systems and the potential to implement a trauma system in LMICs in Sub-Saharan Africa.

Objectives of study.

1. To undertake a comprehensive systematic review examining the utility and effect of Trauma Systems and designated Trauma Centers and the development thereof across the World.
2. To assess burden of 'trauma disease'.
3. To assess the current health care structure capability in provision of trauma care services
    a. Analyse the physical facilities
    b. Analyse the human resources including the skill/education levels
    c. Analyse the processes of care and adverse event avoidance methods
    d. Analyse the capacity of the prehospital trauma system
4. To evaluate potential opportunities within existing health care structure that can be used to build up the trauma systems in Tanzania.
5. To propose a modified, cost-effective, improved system based on best evidence and guided by local data, using the two African countries.

Hypothesis

We hypothesize that sub-Saharan Africa countries exemplified by Tanzania and Botswana, though with differing capacity in their health systems, have potential to set up functional trauma systems.

Methodology

Study area:

The major consultant hospitals in Botswana: Princes Marina hospital, Gaborone-Private, Mahalpye and Nyangabgwe hospitals, and in Tanzania: Muhimbili, Kilimanjaro Christian Medical center (KCMC) and Mbeya referral hospitals, and Tumbi trauma hospital. Others are: death registry departments, fire and ambulance departments.

Study population:

Health care providers and administrators in facilities and institutions caring for the injured patients. We will use trauma chart review, patient registry and records. There will be no direct patient interview or contact or medical intervention.

Sample description:

We will employ convenience sampling based on trauma volume and feasibility in accessing the hospitals. Eight major pre-selected public and private major hospitals will be selected. We will study the process of care for trauma patients, resources and outcome of injured patients admitted to these hospitals. We will randomly interview doctors, nurses and administrators in the emergency and theater sections. We will conduct interviews in hospitals for a minimum of 3 shifts per day to ensure 24 hours human-resource coverage. Reviews of information from fire and ambulance departments and death registry departments will be conducted on a convenience - basis.

Methods and data collection:

The data collection forms (Appendix 2: Tables 1-9) are based on WHO guidelines [8,9], adopted trauma-care enquiry forms [24], and trauma systems guidelines [10,25].

Ethical Aspects:

The study toward the PhD will undergo review by the Academic Leader, University of KwaZulu Natal (UKZN), and the Biomedical Research Ethics Committee (BREC) Ethics Committee of UKZN to receive approval. Similar reviews would be undertaken by Botswana and Tanzania Research Ethics Committees.

All identified participants will be informed of the purpose and details of the study and requested to voluntarily take part by signing written consent (Appendix 2: Consent form). Participants will be free to withdraw from the study. The benefit of the study which is to improve the outcome of traumatic injuries by addressing capacity of health care provision system will be explained to participants. Participants will be re-assured about the safety of the study in protecting the collected information and in observing confidentiality. Collated information will be stored in investigators computers under password

maintained by the principal investigator. Where paper hard copy records are necessary, they will be protected by locking them in safe cabinets at the University of Botswana or Arumeru District Hospital, and University of Dar es salaam in Tanzania where researchers have affiliations. Access will be given for the study purposes only.

Data will be analysed in aggregates thereafter, individual's information will not be identified, and there will not be name identification on questionnaires or data forms. In case of discovery of information which has a life-threatening implication to patients, we will address it to the relevant authorities while observing agreed confidentiality. The raw data will be stored in a secure environment and will be destroyed in 5 years as per UKZN research policy.

Data analysis and results:

Using SPSS statistical software (SPSS, USA), continuous variables will be summarized using mean (SD) and categorical variables in percentages. *P* value less than 0.05 will be considered statistically significant. A narrative description will be used to summarize findings where necessary.

The results will be formulated into a series of published papers with the candidate as the lead or second author (in accordance with UKZN rules for the PhD by research).

All papers will be addressing the themes outlined in the objectives. No individual patient will be named and only collated comparative data will be presented in the public domain. Final Thesis submission will include a complete literature review, the methods and the published / in-press papers with a concluding summative chapter and section on recommendations for implementing the work in Botswana and Tanzania

Funding& Budget

This project will largely depend on self-funding and on post-graduate grants from UKZN for covering University tuition fees, costs of travel, stationery and results dissemination. However, a lack of funding from UKZN will not prevent the study from commencing.

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Appendix 2

Consent form, Data forms and Questionnaires

Consent form

Information Document and Informed Consent Form

Trauma care in Sub-Saharan Africa: challenges and opportunities in Botswana and Tanzania for implementing Afrocentric systems. (BREC 487/14)

Dear potential participant

Introduction:
Trauma is among the leading causes of morbidity and mortality in Africa comparable to infectious disease. The burden of trauma is rising in developing nations where there is also limited resources for its management.
This research is approved toward a PhD at UKZN aiming to conduct a need analysis for developing a local Trauma System in low and middle-income countries. Information will be gathered by interviewing health care workers and hospital administrators. Other means of gathering information will be by reviewing records, registries and conducting audit of resources in health care facilities. This study is purely an observational study involving registry and records reviewing that will be performed by the investigator. The study will also interview important stakeholders in trauma management, as such no monetary or any other form of remuneration for participating in this research will be offered.

Involvement:
By consenting to participate, you agree to undergo an interview by responding to a questionnaire administered by the researcher. The questions will relate to physical and human resources and skills required for caring for the injured patient, adverse events during caring for injured patients and patient outcomes.

Confidentiality:
All information collected during this research will be confidential. We will use a code instead of your name. The code dictionary will be maintained by the investigator for the duration of the study only and it will be locked in safe cabinets accessible by the research team only. Results from this study may be shared with the scientific community through publications/reports. However, information on the publications/reports will come from analysis of aggregated data with no possibility of identifying individual study participants such as yourself, no any identifiers will be used in any collated data or publications.
Withdrawal from the study:
Your participation in this study is voluntary; you therefore have a right to withdraw from the study anytime. In case of withdrawal your information will be destroyed and will not be used as part of the data.

Risks and Benefits:
There are no risks involved in participating in this study. Results of this research will help to improve the care of the injured patient by providing information for better planning health care provision and training of health care workers. The raw data will be stored in secure environment and will be destroyed after 5 years as per UKZN research policy.
Contacts: If you have questions regarding your participation in this study, you may contact the following

Dr. Michael Mwandri
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or

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or

The University of Kwazulu Natal Biomedical Research Ethics Committee (BREC):
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Written Consent / Agreement:
I_____ (name of participant) being of a sound mind to consent, have been informed about the study entitled '**Trauma Care in Sub-Saharan Africa: Challenges and Opportunities in Botswana and Tanzania for implementing Afrocentric systems.** I have been given the opportunity to ask questions concerning the study and these have been answered to my satisfaction. I understand that I may at any time during the study revoke my consent and withdraw from the study without any penalty or any consequence. I therefore volunteer to participate in this study.
Signature of participant _____ Date_____
Signature of witness _____ Date _____

Data forms& Questionnaires

Table 1: Burden, care process

	Hospital file	1	2 ..
2	Date		
3	Admission point (EMD, inter hospital transfer, OPD clinics, etc)		
4	Gender		
5	Age		
6	Insurance providers(NHIF, AAR, SHIBU etc..., or other.. mention)		
7	Diagnosis		
8	Mechanism of injury- if apply(*NA-not apply) or NR- not recorded		
9	Admission point (A&E/EMD, clinic, interhospital transfer etc.) - *continue if only patient is traumatic and admitted*		
10	Time to initial hospital (*H)/injury site(*S) (in 24hours) - if apply, or NR- not recorded[i.e. *H -1200hrs: *S - 4400hrs, *S-NR; *H-1230]		
11	Triage category in prehospital((*P)/initial hospital(*I)[i.e. R-red, Y yellow, G-green, B-black, NR- not recorded] for example *P-R; *I-NR)		
12	Score adequacy of prehospital documentation (Total points scored, *A- referal letter/form absent) Use Appendix 001		
13	Triage category at A&E(EMD) /or at admission point		
14	A&E(EMD) initial investigations - or adjuncts (Y/N, mention tests if Y)		
15	Treatment offered at A&E(EMD), or at admission point ([*1-- treatment 1], [*2--treatment 2 etc])		
16	Score adequacy of trauma hospital documentation (write total points scored, after reviewing EMD notes) Use Appendix 002		
17	Time for Surgeons review(*1 surgical intern, *2 Surgery registrar, *3 Surgery resident, *4 oncall-surgeon(in 24 hours)		
18	Time for ward admission(in 24 hours)		
19	Diagnoses(if changed after surgeons review)		
20	Other treatment offered after surgeons review(CODE as [*1- treatment 1], [*2 treatment 2 etc]		
21	Time to operation-theater (in 24-hours)[from nurse chart]		
22	Time to surgery/procedure (in 24-hours)[from anaesthesia chart]		
23	Surgery/procedure duration (from anaesthesia chart or equivalent time)		
24	Type of surgery(* 1 st surgery, *2 nd Surgery..etc) (Surgery type CODE serially as per [*a], [*b], ...etc)		
25	Outcome (Dischaged, Death, DAMA, referral, others *CODE)		
26	Length of hospital stay in days		
27	Length of ICU stay in days		

	APPENDIX 001		
2	***ADEQUACY OF PREHOSPITAL TRAUMA PATIENT DOCUMENTATION- ASSESSMENT AND SCORING GUIDE**		
3	**Items**	Description grid (Score 1 point per response)	**Score**
4	**1.1 Who was injured**	Name[1point]	
5		Age[1point]	
6		Sex[1point]	
7	**1.2 When did it occur?**	Time of injury[1point]	
8	**1.3 Where did it occur**	Address/location [1point]	
9	**2. Who provided care**	**Professional category** i.e police, doctors/nurses[if applicable] or family/passerby/good-samaritan/ driver/fellow passengers etc.[1point]	
10	Score only one response		
11	**3.1 What caused the injury**	Mechanism of injury[1point]	
12	**3.2 What was done to treat it?**	Description of treatment[1point]	
13		Assess if ABCD was done at **baseline** and **if a comparison** can be made after treatment A- A- Spo2, or airway patency or ability to speak [1 point]	
14			
15		B- B – RR, or breath sounds [1 points]	
16		C- C - Capillary refill, or PR,BP, and warmth of extremity or temperature [2 points]	
17		D- AVPU or GCS [1 point]	
18	**4. How did the patient respond to treatment (outcome)**	Or if a comment is made in notes on progress of patient during or at transfer to final hospital [1 point]	
19	***Triage category**	Red, Orange, Yellow, Green, Blue or equivalent of these[1point for any described]	
20	TOTAL		
21	NOTES		
22	* Sasser SV, Documenting care, uniform prehospital data, chapter 6. In Sasser S, Varghese M, Kellermann A, Lormand JD, Pre-hospital trauma care systems. Geneva: World Health Organization, 2005. [Other: http://apps.who.int/iris/bitstream/10665/43167/1/924159294X.pdf accessed on 30th November 2018]		

26	APPENDIX 002		
27	***ADEQUACY OF TRAUMA PATIENT HOSPITAL DOCUMENTATION		
28	**Items**	**Description grid** (Score 1 point per response)	**Score**
29	Identification	Name Age, Sex,[3points]	
30	Time	Time to EMD/or Triage time[1point]	
31		Time to Treatment(Consultation at EMD)[1point]	
32		Time out of EMD[point]	
33	Triage	Triage category assigned(RED, Orange, Yellow, Green, Blue) or equivalent of these[1 point]	
34	S- Subjective assessment	i.e. Chief complain, mechanism of injury, last meal, Allergy[4 points]	
35	O - Objective assessment [ABCD] and Secondary survey, tests,	A- A -SPO2, patency - feel air on back of hand, or able to speak[1 point]	
36		B- B-RR, equal chest movement, breathing sound on auscultation or chest resonance[2]	
37		C – C-PR, BP, Temperature or Sweatiness or Warmth of extremity [3 points]	
38		D- D-AVPU or GCS [1 point]	
39		Secondary survey documentation(Head, ENT, Chest, Abdomen, GUS, extremities)[6]	
40		Adjunct tests [Blood- grouping, ABG, FAST, CXR, C-Spine X-ray] [1 point]	
41	Assessment	Diagnosis[1point]	
42	Plan	Initial management [Airway, Breathing, Circulation, Oxygen and or intubation for GCS<8] [[1 point as appropriate to assessment and diagnosis]]	
43	TOTAL		
44	NOTES		

45 ***References

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47 2 Committee on trauma. Advanced trauma life support for doctors: student course manual. 9th edition. Chicago, IL: American College of Surgeons, 2012. [Other: https://www.44c.in.ua/files/book11.pdf accessed on 30th November 2018]

48 3 Wallis LA, Gottschalk SB, Wood D, et al. The cape triage score-a triage system for South Africa. South African Medical Journal 2006;96(1):53-6.

49 4 National Confidential Enquiry into Patient Outcome and Death. Severely injured patient study. 2007. [Other: https://www.ncepod.org.uk/2007report2/Downloads/A&E%20patient%20care%20questionnaire.pdf accessed 30th November 2018]

50 5 Boonmak P, Thanapaisal C, Techa-atik P, et al. Trauma Care Audit Using Srinagarind Hospital's Audit Filter. J Med Assoc Thai 2008;91(11):1714.

Table 2: Presence of emergency department's core services

	Emergency deparment core services	P Marina	GPH	Nyangagbı	Mahalpye	MNH	KCMC	Tumbi	Mbeya
2	Number of Emergency bay beds								
3	Emergency bay surge capacity (number of beds and and of patients on floor capacity for Mass casuality preparation)								
4	Number of functional wheeled trolleys								
5	Number of functional wheel chairs								
6	Number of functional ECG Monitors								
7	Number of functional ventilators								
8	Number of Ultrasound scan machine/POCUS								
9	Presence of Mobile X-ray machine(Yes +/No -)								
10	Presence of CT scanner(Yes +/No-)								
11	Presence of Chemistry analyzer(Yes +/No -)								
12	Presence of hematology analyzer(Yes +/No -)								

Table 3: assessment of presence of basic equipment & consumables for Airway(A) and Breathing (B)

	Variables at A&E	P Marina	GPH	Nyangagb	Mahalpye	MNH	KCMC	Tumbi	Mbeya
2	number of oxygen concentrator[where applicable]								
3	Number of Oxygen cylinders(include size*L--, number---)								
4	Central oxygen supplying system(mention If combinned, wall and cylinders) [present + or absent -]								
5	Oropharyngeal airway[present +, absent -, irregular supply - Irr]								
6	Number Suction unit – powered								
7	number of suction unit – non powered								
8	Suction tubes(*P) [present +, absent -, irregular supply - Irr]								
9	Suction tubes(*A) [present +, absent -, irregular supply - Irr]								
10	Yankauer or stiff suction tip [present +, absent -, irregular supply - Irr]								
11	Number of Bag-valve-mask(if less than 10 count, more mention >10)								
12	Nasogastric tubes(*P) [present +, absent -, irregular supply - Irr]								
13	Nasogastric tubes(*A)[present +, absent -, irregular supply - Irr]								
14	Laryngoscope (*P)[present +, absent -]								
15	Laryngoscope (*A)[present +, absent -]								
16	Magill forceps(*P)[present +, absent -]								
17	Magill forceps(*A)[present +, absent -]								
18	Endotracheal tube (*P) [present +, absent -, irregular supply - Irr]								
19	Endotracheal tube (*A) [present +, absent -, irregular supply - Irr]								
20	Hard neck collars [present +, absent -, irregular supply - Irr]								
21	Number of Spine boards								
22	Number of functional Pulse-oximeter								
23	Number of functional Pulse-oximeter								
24	Pulse-oximeter probes (pediatric) [present +, absent -]								
25	Pulse-oximeter probes(Adults) [present +, absent -]								
26	Number of ventilator machines								
27	Underwater drain kit A&E(EMD)-(*P)[present +, absent -, irregular supply - Irr]								
28	Underwater drain kit in A&E(EMD) -(*)[present +, absent -, irregular supply - Irr]								
29	Largebore needle suitable for needle thoracostomy[present +, absent -, irregular supply - Irr]								
30	Cricothyroidotomy set (*EMD OT, #EMD- Rx Bays) [Present +. Absent -]								
31	Tracheostomy set(*EMD OT, #EMD- Rx Bays)								
32	Number of Emergency trolleys(*P)								
33	Number of Emergency trolleys(*A)								
34	Emergency trolleys maintenance protocol[present +, or absent -]								
35	*P- pediatric *A - adult								
36	irregular - irr, AE -availabe in EMD, AH- available in Hospital								

Table 4: Assessment of presence of basic equipment & consumables for circulation (C)

	Circulation at A&E	P Marina	GPH	Nyangagbwe	Mahalpye	MNH	KCMC	Tumbi	Mbeya
2	Presence of cannular (18 or larger)								
3	Presence of cannular (20-22)								
4	Presence of cannular (24)								
5	Presence of Intraosseous needles -pink[present (+,- absent, irregular supply - Irr)								
6	Presence of Intraosseous needles - yellow(+. -)								
7	Presence of Intraosseous needles - green (+, -)								
8	Presence of IVF crystalloids (+,-)								
9	Number of rapid infusion equipment								
10	Number of fluid warming equipment								
11	Number of basic surgery sets (EMD OT)								
12	Number of cut down sets(EMD OT)								
13	Number of Kramer splint (and wool, or padded)								
14	Presence of a dedicated emergency operation theater(+,-)	2							
15	Presence of foley catheters(*P)								
16	Presence of foley catheters(*A)								
17	Number of functional BP machines & cuffs / monitors mobile units,(*P)								
18	Number of functional BP machines & cuffs)/ monitors mobile units,(*A)								
19	**Presence of Blood transfusion capacity								
20									
21									
22	*P- pediatric *A - adult								
23	EMDOT - emergency department operating theater								
24	(Present +, Absent -, irregular,AE-avaiabe in EMD, AH- available in Hospital))								

Table 5: Assessment of presence of human resource & skills

	Assesment variables [present +, or absent - 'for services or consumables' OR mention numbers for professional categories or if appropriate for equipment]	P Marina	GPH	Nyangagb	Mahalpye	MNH	KCMC	Tumbi	Mbeya
2	Number of doctor(General MD and interns) at EMD								
3	Number of Emergency Specialists at EMD								
4	Number of nurses(RN) at EMD								
5	Number of General surgeons								
6	Number of Anesthesiologists								
7	Number of Nurse-anesthetists								
8	Radiology services								
9	Number of Intensive care nurses								
10	Number of dedicated emergency theaters								
11	Number of adult ICU beds								
12	Number of neonatal ICU beds								
13	Occupational therapy services								
14	Physiotherapy services								
15	Social work services								
16	Dietitian services								
17	Orthotic/prothetic services								

Table 6: Assessment of trauma surgery procedures

	TYPE AND NUMBER OF OPERATIONS UNDERTAKEN (CODE theathers -- General Surg-1, MOI- 2, 3 EMD - 4, Cardiac - 6)	DEC	FEB	APRIL	JUNE	AUGUST	OCTOBER
2							
3							
4							
5							
6							
7							
8							
9							
10							

Table 7: Assessment of trauma deaths among mortuary admissions

	Hospital file/Serial No	Date	Admission point (EMD, inter hospital transfer, OPD Clinics, wards, pre-hospital etc)	Age	Gender	Mechanism of injury- if apply(*NA-not apply)	Pathology report	Diagnosis
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

Table 8: Assessment of organisation of trauma care

	Assesment Item(respond as present or absent, if present describe as requested)	P Marina	GPH	Nyangagbwe	Mahalpye	MNH	KCMC	Tumbi	Mbeya
2	Presence of trauma team(describe team composition)								
3	Presence of trauma team activation protocol (describe ativation criteria)								
4	Presence of ongoing in-house trauma training(mention conveners								
5	If answer to the above is yes, how many times did the trauma training(mentioned above) run in the past year								
6	Presence of Quality Improvement initiatives (i.e. mortality and morbidity-meetings, review meetings etc)								
7	If yes mention 1) which one of the initiative is conducted(reviews, mortality and morbity etc, 2) how many times per quarter(3 month) and 3)who are the members names and positions								
8	Presence of protocol for hand-over of polytrauma patients(if present describe, mention which form number)								
9	Presence of protocol for transferring polytrauma patients between specialists or facilities								

Table 8: Assessment provider's skill form #001

1	Participant Identification (001,003, etc)	1	2	3		
2	Start time---------- end time----------					
3	Designation(General, Emergency, etc)					
4	Courses undertaken/Year(ATLS,TCN,ATCN,ERTC etc)					
5	Randal, a front seat un-restrained passenger was thrown out of the car after head-on collision. Half an hour later he was picked up by road patrol and rushed to a nearby specialist's hospital, he was found semi-conscious, BP 80/50, with noisy breathing, pulse rate of 110/min, and his trousers soaked with blood.Considering primary survey (Airway Breathing Circulation and Disability), what would you do to manage him? **(within your capacity)**					
6	Asses C spine by:					
7	Manage C spine by:					
8	Asses Airway by:					
9	Manage Airway by:					
10	Asses Breathing by:					
11	Manage Breathing by :					
12	Assess the Circulation and presence of shock by:					
13	Manage 'C' by:					
14	Assess level consciousness'D' by:					
15	Manage' D' by:					
16	Manage' E' by:					
17	Describe triaging process- what are considerations in assigning triage categories to trauma patients					
18	Total (1 Score for each correct response)					

Table 9: Assessment of provider's skill form #002

1	**Participant Identification (001,003, etc)**	1	2	3		
2	**Start time------ end time----------**					
3	Designation,(i.e Intern, Registrar, Resident etc.)					
4	Courses undertaken/Year(ATLS,PTC,ESS, ERTC etc)					
5	Randal, a front seat un-restrained passenger was thrown out of the car after head-on collision. Half an hour later he was picked up by road patrol and rushed to a nearby specialist's hospital, he was found semi-conscious, BP 80/50, with noisy breathing, pulse rate of 110/min, and his trousers soaked with blood.Considering primary survey (Airway Breathing Circulation and Disability), what would you do to manage him?					
6	Asses C spine by:					
7	Manage C spine by:					
8	Asses Airway by:					
9	Manage Airway by:					
10	Asses Breathing by:					
11	Manage Breathing by :					
12	Assess the Circulation and presence of shock by:					
13	Manage 'C' by:					
14	Assess level consciousness'D' by:					
15	Manage' D' by:					
16	Manage' E' by:					
17	Describe triaging process- what are considerations in assigning triage categories to trauma patients					
18	Total (1 Score for each correct response)					

Appendix 3

Approval letters - Post Graduate

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

11 November 2014

TO WHOM IT MAY CONCERN

Surname	:	Mwandri
First Name	:	Michael Bartholomew
Student Number	:	214584705
Degree	:	Doctor of Philosophy in Surgery (PhD)

Title of Study: Trauma care in Sub-Saharan Africa: Challenges and opportunities in Botswana and Tanzania for implementing Afrocentric Systems.

This letter confirms that the abovementioned student is registered for the academic year 2014 in the School of Clinical Medicine at the University of KwaZulu-Natal.

Yours sincerely

[redacted]

Veronica Jantjies
Administrative Officer
Postgraduate, Higher Degrees & Research
School of Clinical Medicine

Postgraduate, Higher Degrees & Research
School of Clinical Medicine, NRMSM Campus
Postal Address: P/Bag X3, Congella, Durban, 4013, South Africa
Telephone: +27 (0) 31 260 4745 **Facsimile:** +27 (0) 31 260 4723 **Email:** jantjies@ukzn.ac.za **Website:** www.ukzn.ac.za

Appendix 4

Approval letters - Ethics

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

20 May 2015

Dr Michael Mwandri
Private Bag 713
University of Botswana
Gaborone
mwanrister@gmail.com

PROTOCOL: Trauma Care in Sub-Saharan Africa: Challenges and Opportunities in Botswana and Tanzania for implementing Afrocentric systems: Degree Purposes (PhD) - School of Clinical Sciences (Surgery). BREC REF: BE487/14.

EXPEDITED APPLICATION

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application received on 07 November 2014.

The study was provisionally approved pending appropriate responses to queries raised. Your responses received on 18 May 2015 to queries raised on 24 December 2014 have been noted by a sub-committee of the Biomedical Research Ethics Committee. ***Please note that BREC has granted approval to conduct research in the sites from which permission and ethical approval were obtained for Botswana. Provisional approval remains for pending site permissions from Botswana and Tanzania site permissions and approval from REC.***

This approval is valid for one year from **20 May 2015.** To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2015), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be **RATIFIED** by a full Committee at its meeting taking place on **09 June 2015.**

We wish you well with this study. We would appreciate receiving copies of all publications arising out of this study.

Yours sincerely

[redacted]

Professor J Tsoka-Gwegweni
Chair: Biomedical Research Ethics Committee

UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI
RESEARCH OFFICE
Biomedical Research Ethics Administration
Westville Campus, Govan Mbeki Building
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Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604769 - Fax: 27 31 2604609
Email: BREC@ukzn.ac.za
Website http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

15 March 2019

Dr Michael Mwandri
University of Botswana
mwanrister@gmail.com

Dear Dr Mwandri

PROTOCOL: Trauma Care in Sub-Saharan Africa: Challenges and Opportunities in Botswana and Tanzania for implementing Afrocentric systems: Degree Purposes (PhD) - School of Clinical Sciences (Surgery). BREC REF: BE487/14.

RECERTIFICATION APPLICATION APPROVAL NOTICE

Approved:	20 May 2018
Expiration of Ethical Approval:	19 May 2019

I wish to advise you that your application for Recertification received on 27 February 2019 for the above protocol has been **noted and approved** by a sub-committee of the Biomedical Research Ethics Committee (BREC) for another approval period. The start and end dates of this period are indicated above.

BREC condones the lapse period of certification.

If any modifications or adverse events occur in the project before your next scheduled review, you must submit them to BREC for review. Except in emergency situations, no change to the protocol may be implemented until you have received written BREC approval for the change.

The committee will be notified of the above approval at its next meeting to be held on 09 April 2019.

Yours sincerely

[redacted]

Prof V Rambiritch
Chair: Biomedical Research Ethics Committee

cc: hardcastle@ukzn.ac.za

UNIVERSITY OF
KWAZULU-NATAL
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Email: BREC@ukzn.ac.za
Website http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

12 June 2019

Dr Michael Mwandri
University of Botswana
mwanrister@gmail.com

Dear Dr Mwandri

PROTOCOL: Trauma Care in Sub-Saharan Africa: Challenges and Opportunities in Botswana and Tanzania for implementing Afrocentric systems: Degree Purposes (PhD) - School of Clinical Sciences (Surgery). BREC REF: BE487/14.

RECERTIFICATION APPLICATION APPROVAL NOTICE

Approved:	20 May 2019
Expiration of Ethical Approval:	19 May 2020

I wish to advise you that your application for Recertification received on 02 May 2019 for the above protocol has been **noted and approved** by a sub-committee of the Biomedical Research Ethics Committee (BREC) for another approval period. The start and end dates of this period are indicated above.

If any modifications or adverse events occur in the project before your next scheduled review, you must submit them to BREC for review. Except in emergency situations, no change to the protocol may be implemented until you have received written BREC approval for the change.

The committee will be notified of the above approval at its next meeting to be held on 09 July 2019.

Yours sincerely

[redacted]

Prof V Rambiritch
Chair: Biomedical Research Ethics Committee

cc: hardcastle@ukzn.ac.za

Telephone: (267) 363200
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TELEGRAMS: RABONGAKA
TELEX: 2818 CARE BD

MINISTRY OF HEALTH
PRIVATE BAG 0038
GABORONE

REPUBLIC OF BOTSWANA

REFERENCE NO: PPME 13/18/1 IX (112) 7 November 2014

Health Research and Development Division
Notification of IRB Review: New Application

Dr Michael Mwandri
Private Bag 00708
Gaborone

Dear Dr Mwandri

PERMIT: TRAUMA CARE IN SUB-SAHARAN AFRICA; CHALLENGES AND OPPORTUNITIES IN BOTSWANA AND TANZANIA FOR IMPLEMENTING AFROCENTRIC SYSTEM

Your application for a research permit for the above stated research protocol refers. We note that your proposal has been reviewed and approved by the University of Botswana Research Ethics Committee.

Permission is therefore granted to conduct the above mentioned study. This approval is valid for a period of 1 year effective 7 November 2014

This permit does not however give you authority to collect data from the selected site without prior approval from the management. Consent from the identified individuals should be obtained at all times.

The research should be conducted as outlined in the approved proposal. Any changes to the approved proposal must be submitted to the Health Research and Development Division in the Ministry of Health for consideration and approval.

Furthermore, you are requested to submit at least one hardcopy and an electronic copy of the report to the Health Research, Ministry of Health within 3 months of completion of the study. Approval is for academic fulfillment only. Copies should also be submitted to all other relevant authorities.

Yours sincerely

[redacted]

P. Khulumani
For Permanent Secretary

MINISTRY OF HEALTH RESEARCH DIVISION
2014 -11- 07
P/BAG 0038
GABORONE
REPUBLIC OF BOTSWANA

1

THE UNITED REPUBLIC OF TANZANIA

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NIMR/HQ/R.8a/Vol. IX/1971

Ministry of Health and Social Welfare
6 Samora Machel Avenue
P.O. Box 9083
11478 Dar es Salaam
Tel: 255 22 2120262-7
Fax: 255 22 2110986

08th June 2015

Dr Michael Mwandri
Temeke Municipal Hospital
Temeke Municipal Council,
P O Box 45232, DAR ES SALAAM

CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: Trauma care in sub Saharan Africa: Challenges and Opportunities for implementing Afrocentric Systems in Tanzania, (Mwandri M I *et al*), has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health & Social Welfare and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine. NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Sites: Four major public consultant hospitals: Muhimbili, KCMC, Bugando and Mbeya, Tumbi, and Dodoma regional hospitals. Two private hospitals: Aga Khan –Dar es Salam and ALMC-Selian Arusha

Approval is for one year: 08th June 2015 to 07th June 2016.

Name: Dr Julius J Massaga

Signature [redacted]
Ag CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Dr Margaret E Mhando

Signatu [redacted]
Ag CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, SOCIAL WELFARE

CC: RMO
DED
DMO

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NIMR/HQ/R.8c/Vol. II /827

21st August 2017

Dr. Michael Mwandri
Temeke Municipal Hospital
P.O. Box 45232
Dar es Salaam

APPROVAL FOR EXTENSION OF ETHICAL CLEARANCE

This letter is to confirm that your application for extension on the already approved proposal: Trauma care in sub-Saharan Africa: Challenges and opportunities for implementing Afrocentric Systems in Tanzania (Mwandri M. *et al*) has been approved.

The extension approval is based on the progress report dated 29th July 2017 on the project, Ref. NIMR/HQ/R.8a/Vol. IX/1971 dated 08th June 2016. Extension approval is valid until 7th June 2018.

The Principal Investigator must ensure that other conditions of approval remain as per ethical clearance letter. The PI should ensure that progress and final reports are submitted in a timely manner.

Name: Prof. Yunus Daud Mgaya

[redacted]

Signature
CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Prof. Muhammad Bakari Kambi

[redacted]

Signature
CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, COMMUNITY DEVELOPMENT, GENDER, ELDERLY & CHILDREN

UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

4 November 2014

Dr TC Hardcastle
School of Clinical Medicine
College of Health Science

Dear Dr Hardcastle

PhD: "Trauma care in Sub-Saharan Africa: Challenges and opportunities in Botswana and Tanzania for implementing Afrocentric Systems." Student: Dr Mwandri, student number: 214584705

I am pleased to inform you that the abovementioned study has been approved for submission to the university ethics committee.

Please note:

- The Academic Leader: Research must review any changes made to this study
- The study may not begin without approval of the Research Ethics Committee
- A copy of the full ethics approval letter should be forwarded to the Postgraduate Office.

May I take this opportunity to wish the student every success with the study.

Yours sincerely

[redacted]

for Dr VS Singaram
Academic Leader Research
School of Clinical Medicine

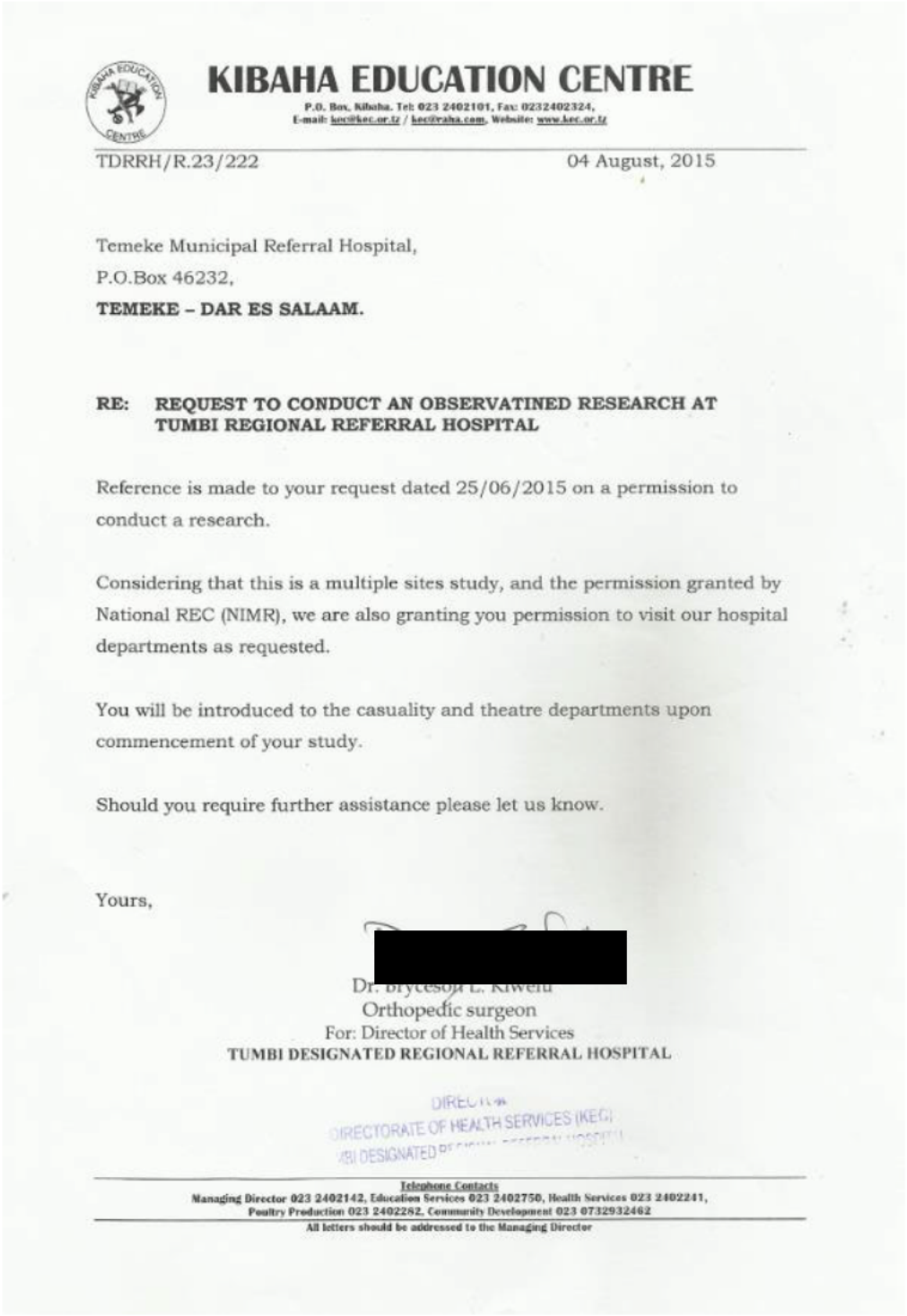
C. Dr MB Mwandri

Biomedical Research Ethics Committee
Westville Campus

Postgraduate, Higher Degrees & Research
School of Clinical Medicine, NRMSM Campus
Postal Address: P/Bag X3, Congella, Durban, 4013, South Africa
Telephone: +27 (0) 31 260 4745 **Facsimile:** +27 (0) 31 260 4723 **Email:** jantjies@ukzn.ac.za **Website:** www.ukzn.ac.za

Appendix 5

Support letters from hospitals



KIBAHA EDUCATION CENTRE

P.O. Box, Kibaha. Tel: 023 2402101, Fax: 0232402324,
E-mail: kec@kec.or.tz / kec@raha.com, Website: www.kec.or.tz

TDRRH/R.23/222 04 August, 2015

Temeke Municipal Referral Hospital,
P.O.Box 46232,
TEMEKE – DAR ES SALAAM.

RE: REQUEST TO CONDUCT AN OBSERVATINED RESEARCH AT TUMBI REGIONAL REFERRAL HOSPITAL

Reference is made to your request dated 25/06/2015 on a permission to conduct a research.

Considering that this is a multiple sites study, and the permission granted by National REC (NIMR), we are also granting you permission to visit our hospital departments as requested.

You will be introduced to the casuality and theatre departments upon commencement of your study.

Should you require further assistance please let us know.

Yours,

[redacted]

Dr. Bryceson L. Kiwelu
Orthopedic surgeon
For: Director of Health Services
TUMBI DESIGNATED REGIONAL REFERRAL HOSPITAL

DIRECTORATE OF HEALTH SERVICES (KEG)

Telephone Contacts
Managing Director 023 2402142, Education Services 023 2402750, Health Services 023 2402241,
Poultry Production 023 2402282, Community Development 023 0732932462
All letters should be addressed to the Managing Director

MUHIMBILI NATIONAL HOSPITAL

Cables: "MUHIMBILI"
Telephones: +255-22-2151367-9
FAX: +255-22-2150534
Web: www.mnh.or.tz

Postal Address:
P.O. Box 65000
DAR ES SALAAM
Tanzania

In reply please quote:
Ref: MNH/TRC/2015/594

Date: 5th August, 2015

TO
MICHAEL MWANDRI

RE: PERMISSION TO CONDUCT RESEARCH AT MNH NO: 594

You have been granted permission to conduct research at MNH

Name of Researcher	Michael Mwandri
Research Title	Trauma care in sub Saharan Africa: Challenges and Opportunities for implementing Afrocentric Systems in Tanzania.
Type of Research	Cross-sectional study
Supervisor	Dr. Timothy Craig Hardcastle
Valid Between	7th August, 2015 – 29th January, 2016 (6months)

Please note that;

1. Your are expected to present a copy of your final report to the **HTRCU**.
2. Publication of your findings needs permission from the management of **MNH**

Sincerely,

[redacted]

DR. Faraja Chiwanga
Ag: Head, Teaching, Research and Consultancy Coordination Unit

K.C.M.C

KILIMANJARO CHRISTIAN MEDICAL CENTRE

An institution of the Good Samaritan Foundation

P. O. Box 3010, Moshi, Tanzania

Tel: 255-027-2754377/ 80 Fax: 255-027-2754381

Email: kcmcadmin@kcmc.ac.tz Website: http://www.kcmc.ac.tz

Our Ref No: KCMC/P.1 VOL III/44 05.01.2016

Dr. Michael Mwandry,
P.O BOX 42,
SANYA JUU,
MOSHI.

RE: **REQUEST TO CONDUCT FOR RESEACH AT KCMC:**

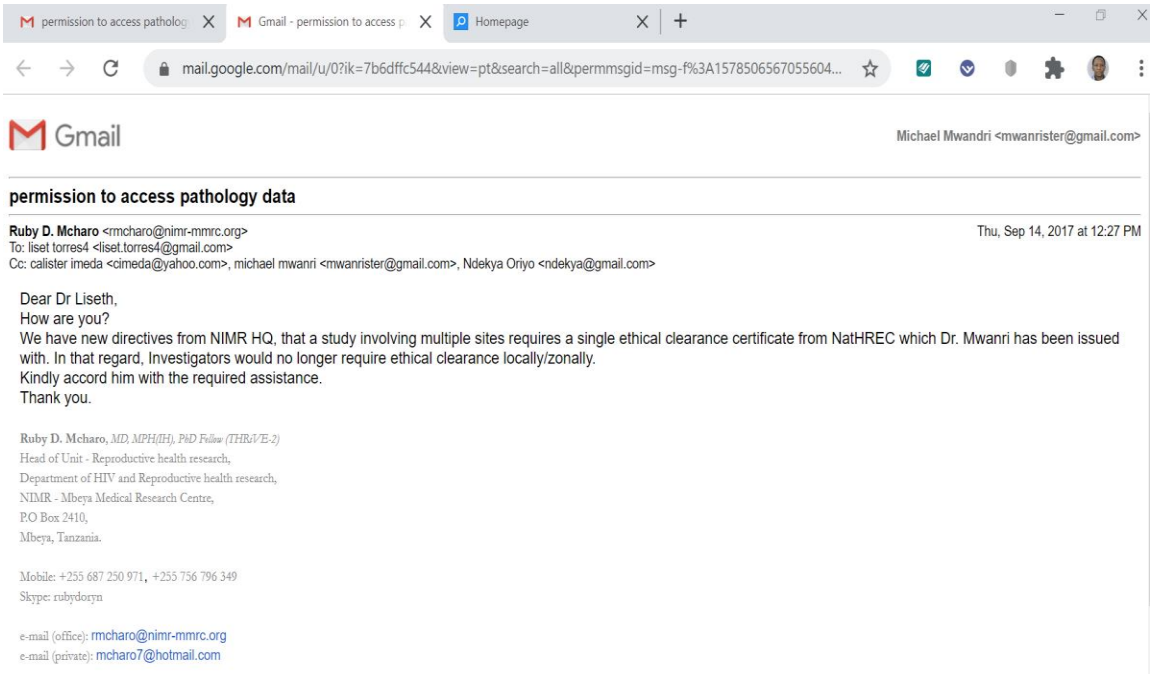
We acknowledge the receipt of your letter dated 20th December 2015 regarding the above heading.

Please be informed that, permission is granted for you to conduct research at KCMC in Casuality Department.

Yours,

[redacted]

G. Chikira
For: **EXECUTIVE DIRECTOR**



permission to access patholog | Gmail - permission to access p | Homepage

mail.google.com/mail/u/0?ik=7b6dffc544&view=pt&search=all&permmsgid=msg-f%3A1578506567055604...

Gmail

Michael Mwandri <mwanrister@gmail.com>

permission to access pathology data

Ruby D. Mcharo <rmcharo@nimr-mmrc.org> Thu, Sep 14, 2017 at 12:27 PM
To: liset torres4 <liset.torres4@gmail.com>
Cc: calister imeda <cimeda@yahoo.com>, michael mwanri <mwanrister@gmail.com>, Ndekya Oriyo <ndekya@gmail.com>

Dear Dr Liseth,
How are you?
We have new directives from NIMR HQ, that a study involving multiple sites requires a single ethical clearance certificate from NatHREC which Dr. Mwanri has been issued with. In that regard, Investigators would no longer require ethical clearance locally/zonally.
Kindly accord him with the required assistance.
Thank you.

Ruby D. Mcharo, *MD, MPH(IH), PhD Fellow (THRiVE-2)*
Head of Unit - Reproductive health research,
Department of HIV and Reproductive health research,
NIMR - Mbeya Medical Research Centre,
P.O Box 2410,
Mbeya, Tanzania.

Mobile: +255 687 250 971, +255 756 796 349
Skype: rubydoiryn

e-mail (office): rmcharo@nimr-mmrc.org
e-mail (private): mcharo7@hotmail.com

PLOT 1836 HOSPITAL WAY
TELEPHONE: 3621400
FAX: 3973776

RE PUBLIC OF BOTSWANA

PRINCESS MARINA HOSPITAL
P. O. BOX 258
GABORONE
BOTSWANA

REF: PMH 5/79(147a)

29 April 2015

Dr. Michael B Mwanri
University of KwaZulu Natal

Dear Dr. Mwanri

Trauma Care in Sub-Saharan Africa: Challenges and Opportunities in Botswana and Tanzania for Implementing Afrocentric Systems.

The Research and Ethics Committee (REC) of Princess Marina Hospital met and discussed your request to do the study with aforementioned title. Full approval is granted.

Please you are requested to observe the following:

1. You must get permission from head of department in the unit that you intend to do your research.
2. You must at all times get consent from individuals that you are using as subjects in your study.
3. You will not change any aspect of your research without permission from the Research and Ethics Committee (REC).
4. You need to report any unforeseen circumstances including the termination of the study to the REC.
5. You must allow the REC access to the study at anytime for purposes of auditing.
6. This permit is valid for one year; from 29April 2015 to 30 April 2016.
7. At the end of the study you should give the research and ethics committee a hard copy and soft copy of your report.

Thank you

Sincerely,

[redacted]

Gladness O. Tlhomelang
Secretary Research and Ethics Committee

Life HEALTH CARE Gaborone Private Hospital

8448 Mica Way, Gaborone, Botswana
Private Bag BR130, Gaborone, Botswana
Telephone 09267 3685600
Facsimile 09267 3901998
www.gaboroneprivatehospital.co.za

5th February 2015

Dr M Mwandri
Lecturer, Department of Surgery
School of Medicine
University of Botswana
Private Bag 00713
GABORONE

Dear Dr Mwandri

RE: REQUEST TO CONDUCT RESEARCH IN GABORONE PRIVATE HOSPITAL

TITLE OF STUDY: ***TRAUMA CARE IN SUB SAHARAN AFRICA: CHALLENGES AND OPPORTUNITIES IN BOTSWANA AND TANZANIA FOR IMPLEMENTING AFROCENTRIC SYSTEMS***

Your request to conduct the above study in Gaborone Private Hospital has been granted, subject to the following conditions:

1. The source data has to be codified, so that no patient's name may appear in any document.
2. The data may not be used for any purpose other than that stated, i.e; for academic study or research purposes.
3. The data may not be passed to any third party without written consent/permission from Gaborone Private Hospital.
4. On completion of the study, a complete copy of the research shall be availed to Gaborone Private Hospital for the institution's custody.
5. Any revision of any aspect of the study should be with written consent from Gaborone Private Hospital Management. Management shall be deemed for this purpose to be the Hospital Manager or Hospital Superintendent.

Yours sincerely

[redacted]
HOSPITAL MANAGER

[redacted]
Dr A D I Sibiya
HOSPITAL SUPERINTENDENT

MAHALAPYE DHMT

FAX:
TELEPHONE:

P.O. BOX 49 MAHALAPYE

Republic of Botswana

REFERENCE NO: MH/DHMT/1/7/7

25th Feb 2015

To: Dr Michael Mwandri
P.O. Box 00708
Gaborone

Dear Sir

Protocol Title: Trauma Care in Sub-Saharan Africa: Challenges and Opportunities in Botswana and Tanzania for Implementing Afrocentric Systems.

Notification of IRB Review: New Application

Approval Status: Approved

Risk Determination: Low risk

The Mahalapye DHMT thanks you for submitting the documents for the above captioned protocol for evaluation. The application was reviewed and awarded an approval. This approval is valid for **a period of 1 year effective 07 Nov 2014.** The research should be conducted as outlined in the approved proposal. Please notify the Mahalapye IRB when you start collecting data. Any changes to the approved proposal must be submitted to the Mahalapye IRB and the Health Research and Development Division in the Ministry of Health for consideration and approval.

Furthermore, you are requested to submit at least one hard copy to The Mahalapye IRB within three months of completion of the study or notify its publication.

Thank you for your commitment in protecting human subjects in Research in the Mahalapye DHM

Yours faithfully you have any questions/queries, please contact DrS. T. Tshitenge at stephane.tshitenge@mopipi.ub.bw. Tel +267 3554762, + 267 71550036 or Mr M Ralethaka (Mahalapye DHMT IRB Secretary) at amralet@yahoo.com. Cell: 71922235

Thank you for your commitment in protecting human subjects in Research in the Mahalapye DHMT.

Yours faithfully

[redacted]

Dr Stephane Tshitenge
Mahalapye DHMT IRB CHAIR

Appendix 6

Turnitin Summary

As per UKZN rules the non-published aspects of this thesis were submitted to Turinitin via the University Login and a Plagiarism Screen was undertaken on: 06-Dec-2020 4:49 PM CAT:

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Paper ID: 323126317

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