ORIGINAL RESEARCH

Technical Priorities for Orthopaedic Trauma Care Development in Malawi

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Abstract

Introduction

Malawi has a high and rising incidence of musculoskeletal injuries and inadequate orthopaedic trauma care capacity, which must be urgently addressed.

Methods

We performed a scoping literature review to define essential goals and challenges to musculoskeletal trauma care delivery in Malawi pertaining to the following domains: injury prevention, prehospital care, rural health centres, district hospitals, and central hospitals. For each domain, essential goals were ratified and challenges were prioritized by a panel of experts on Malawian orthopaedic trauma care.

Results

The five highest priorities pertained to injury prevention (2), central hospital-level definitive treatment (2), and district hospital-level initial fracture management (1). We believe the next steps are to use the prioritized list of challenges to form working groups with the goal of examining and developing strategies to address each challenge. For the top priority challenges in each domain, we recommend the following: 1) Prevent road injuries by law enforcement, children's education, civic engagement, and road infrastructure development; 2) Improve pre-hospital transportation by scaling up emergency dispatch systems, fixing broken ambulances, and training public transportation workers in basic first aid; 3) Provide health workers in Rural Health Centres with basic training in musculoskeletal injury management and triage; 4) Improve diagnostic x-ray capacity at District Hospitals by fixing/replacing broken machinery and ensuring stable power supply; 5) Improve operative capacity at Central Hospitals by increasing operating theatre availability, efficiency, and utilization, and supporting specialist surgical training programmes.

Discussion

We hope that this manuscript will serve as a practical, actionable guide for policymakers, donors, health system leaders, educators and orthopaedic trauma care providers. Through this process, we also hope to create a replicable methodology and framework that can be applied to other clinical departments in Malawi, and for similar work in other low- and middle-income countries.

Keywords: orthopaedics, orthopaedic surgery, trauma, health system development, technical priorities, expert consultation, national trauma and surgery plan

Introduction

The global burden of trauma-related death and disability is rising and disproportionately affects people in low- and middle-income countries (LMICs) where trauma and surgical care capacity remains inadequate[1]. Up to 78% of injuries worldwide may be musculoskeletal in nature[2]. The absence of organized orthopaedic trauma care and rehabilitation services in many LMICs increases morbidity and mortality[2]. Trauma-related disability can have major socioeconomic ramifications for society, trapping the poorest patients and

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their families in poverty due to associated healthcare costs and reduced economic productivity[2,3].

Malawi is a low-income country in sub-Saharan Africa with a population of 18 million people, 83% of whom live in rural areas, and half the population lives below the national poverty line[4,5]. At 33 road traffic-related deaths per 100,000 people, Malawi has the world's thirteenth highest annual road injury mortality rate, underscoring a high burden of trauma[4]. Unfortunately, Malawi's health system presently lacks the essential staff, resources, and infrastructure to adequately manage the high and rising incidence of musculoskeletal injuries[4,6,7]. Foreign donors cover 52% of Malawi's current health expenditure[8], much of which is tied up in siloed, disease specific, health care programmes. The majority of health services nationwide are provided by public hospitals organized into three levels: 1) rural health centers providing basic medical and no surgical care, 2) district hospitals providing non-specialized medical and surgical care, and 3) urban central hospitals offering specialized medical and surgical care[9,10]. Most Malawians have limited access to trauma care, especially the rural poor who travel long distances and incur indirect healthcare costs in form of transportation, lost income and other related expenses[5,10]. Approximately one-third of Malawians are living with an untreated surgical condition due to lack of access to surgical care[11]. The majority of musculoskeletal injuries in Malawi are treated non-operatively due to limited surgical capacity[12].

There is a need to reduce the burden of musculoskeletal trauma in Malawi by preventing injuries and improving access to essential orthopaedic care. We therefore sought to provide evidence-based and technical expert-informed recommendations for clinicians, researchers, hospital leadership, policymakers, and donors seeking to improve orthopaedic trauma care in Malawi. Our aim in this process was to 1) present an overview of the current challenges facing orthopaedic trauma care delivery in Malawi, 2) establish the essential goals for preventative measures; pre-hospital care/transportation; care at rural health centers, district hospitals, and central hospitals; and 3) identify technical priorities for improvement of orthopaedic trauma care in Malawi.

Methods

This study was conducted in two phases. In Phase 1, we performed a scoping literature review to identify the current challenges of orthopaedic care delivery and to create a list of essential goals for orthopaedic trauma care in Malawi. We used the scoping review framework proposed by Arksey and O'Malley[13] and Levac[14]. Our literature search used a combination of keywords and MESH terms related to orthopaedic trauma care in Malawi (See Appendix A.1). Between April and June 2020, we queried PubMed, Scopus, Embase, and Hinari. Searches were performed with no date or study design restrictions and included only articles in English. All search results underwent preliminary title and abstract screening. We then performed full-text reviews for final inclusion. We included all articles pertaining to orthopaedic trauma care in Malawi at any phase of care, including preventative measures, prehospital care, rural health centers, district hospitals, and central hospitals. Articles were excluded if they were irrelevant to Malawi, did not pertain to any facet of orthopaedic trauma care, or did not present at least one clear challenge and/or goal for orthopaedic trauma care delivery. An analysis of references of included articles was also conducted to identify additional articles for inclusion via the snowballing technique (See Appendix A.2).

We performed full-text reviews of 53 peer-reviewed articles, from which we extracted and synthesized the essential goals and a list of current challenges to orthopaedic trauma care in Malawi within five domains: injury prevention, prehospital care, rural health center, district hospitals, and central hospitals. Challenges at the district and central hospitals were further classified as impacting initial management, definitive care, or rehabilitation and aftercare. Please see Appendix A.3 for further details on the data extraction process.

In Phase 2, the lists of essential goals and challenges identified in Phase 1 were evaluated by the Malawian Orthopaedic Technical Expert Group (MOTEG) – a panel of 22 experts in orthopaedic trauma care in Malawi including 16 orthopaedic surgeons, 5 senior orthopaedic clinical officers (OCOs), and 1 physiotherapist. All 22 members of MOTEG were invited and agreed to participate in Phase 2. Using a paper-based survey tool, all 22 experts 1) evaluated the proposed essential goals for each domain and were invited to suggest modifications; 2) agreed or disagreed with the inclusion of each of the identified challenges, depending on whether or not they had encountered each potential challenge in their practice; 3) assigned a priority score to each challenge between 1 and 5, with 1 indicating lowest priority and 5 indicating highest priority in urgent need of addressing. Experts were also able to suggest edits to the challenges and add challenges that may not have been identified in Phase 1. Instructions to experts and a sample survey tool are presented in Appendix B.

Edits to the essential goals and challenges, as well as any newly suggested challenges, were reviewed and synthesized by the research team. These modifications/additions were then presented to each expert individually, in person or via electronic communication, for further suggestions and evaluation. This process was repeated iteratively until all experts were in agreement with final wording and had assigned priority scores to each finalized challenge. Challenges with average priority scores ≥4 were considered "high priority", those with average priority scores ≥3 and <4 were considered "moderate priority", and those with average priority scores <3 were considered "low priority".

Results

Here we present the essential goals and highest priority challenges of each domain, as agreed by expert panel consultation. The complete list of challenges identified from Phase 1 with accompanying priority scores from Phase 2 are displayed in Appendix Tables A1-5.

Injury prevention

The essential goals of this domain within the musculoskeletal trauma system are to identify the most common causes of severe musculoskeletal injuries and how to reduce injury incidence. The following challenges were agreed upon by all expert panelists: high morbidity and mortality from road traffic accidents (RTAs), limited helmet use by bicyclists and motorcyclists, high prevalence of alcohol-related RTAs, lack of dedicated pedestrian sidewalks and poor adherence to standard traffic laws, high prevalence of fall-related injuries, lack of a uniform disaster management plan, and lack of a national injury surveillance system. High priority challenges were the high morbidity and mortality from RTAs (4.95), limited to no helmet use by bicyclists/motorcyclists (4.55), and the prevalence of alcohol-related RTAs (4.38) (Table 1).

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Table 1: Technical Priorities for Orthopaedic Trauma Care Development in Malawi

Challenge	Domain	Priority score
Road traffic accidents (RTAs) cause significant morbidity and mortality. Malawi has the world's 4th highest annual road mortality rate at 34.2 per 100,000 and the burden is increasing with more vehicles, especially informal motorcycle taxis ("kabazas").[4,7,15-17]	Injury Prevention	4.95
Limited operative capacity due to limited OR availability and/or inefficient OR utilization. Operating rooms are present in 100%, but unavailable when needed in 50% of central hospitals; only 1 out of 8 OR's at KCH are available for orthopaedic trauma. From 2010 to 2011, the number of orthopaedic procedures increased by 42% due to increased training, but has since plateaued due to lack of resources and OR staff.[10,48,50-55]	Central Hospitals – Definitive Treatment	4.77
Diagnostic X-ray is unavailable in 68% of district hospitals, usually due to broken X-ray machines.[10] An estimated 61% of the Malawian population does not have access to x-ray.[10,48]	District Hospitals – Initial Management	4.67
Limited availability of nurses, ancillary staff, surgical and anesthesia workforce, and related specialist services leads to long wait times – circulating and inpatient nurses are unavailable in 50% of central hospitals; current nurse to patient ratio is between 40:1 and 80:1.[1,10,31,43,50,61,65,66]	Central Hospitals – Definitive Treatment	4.59
Limited to no helmet use by bicyclists and motorcyclists[18,19]	Injury Prevention	4.55
Delayed presentation to hospital is common in Malawi and may result is worse outcomes.[6,15,25,28-30] 28% of pediatric patients and 34% of adult patients were found to present to the hospital late.[6] Delays in treatment and appropriate referral at the rural health center and district hospital also result in late presentation to central hospital.	Pre-Hospital Care	4.52
A&E departments are unavailable and there is a shortage of A&E trained care providers. A&E departments are unavailable to effectively triage, diagnose, and stabilize femur fracture in 60% of districts[7,10,11,31] A&E trained physicians and triage nurses are unavailable in 60% and 80% of hospitals, respectively. Usually, OCOs and MAs perform this function.[7,10,31,63,64]	District Hospitals – Initial Management	4.52
Lack of facilities for isolation of infected cases.	Central Hospitals – Definitive Treatment	4.44
Inconsistent availability of skeletal traction materials and equipment – skin traction performed in 96% , but unavailable in 40%; all hospitals reported barriers to skeletal traction, due to lack of quality tape, weights, hospital beds, functioning traction frames, and pulleys.	District Hospitals – Definitive Treatment	4.40
Although alcohol use in Malawi is assumed to be relatively low compared to other African countries, there is a high incidence of road traffic accidents (RTAs) associated with alcohol consumption – about 20% of those involved in RTAs presenting to KCH had a blood alcohol content of 0.08 or more – highest prevalence among pedestrians (41.8%) and car drivers (23.8%)[18-21]	Injury Prevention	4.38
Limited capacity for external fixation – external fixators unavailable in 60%[10]	District Hospitals – Initial Management	4.38
Limited availability of providers trained in triage and basic emergency care – tri age nurse unavailable in 50% of hospitals and only one central hospital offered routine training in prevention of bloodborne diseases to staff[7,10,31,62]	Central Hospitals – Initial Management	4.27
Providers in rural health centers receive minimal training on trauma care[40] – currently, only a short trauma course exists for nurses and medical assistants working at rural health centers.[5,27,42-44]	Rural Health Centres	4.25
A&E departments are only available in 50% of hospitals[7,10]	Central Hospitals – Initial Management	4.19
Inconsistent supply of surgical equipment and implants – IMN equipment una vailable in 25% of hospitals, but almost entirely reliant on foreign donations[10,30]	Central Hospitals – Definitive Treatment	4.19
There is limited capacity and underutilization of vital sign measurement. More than 40% of patients had no recording of temperature, pulse rate, blood pres sure; 79.5% had no recording of respiratory rate; 89.0% had no recording of oxygen saturation.[7,10,29,48,62]	District Hospitals – Initial Management	4.15
Limited availability of walking assistive devices (walkers, canes, and crutches) unavailable in 67% of district hospitals.[1,10,53]	District Hospitals – Aftercare & Rehabilitation	4.15
Limited procedure room availability for basic procedures, which are unavailable in 50% of central hospitals[10]	Central Hospitals – Definitive Treatment	4.14
Inadequate vital sign measurement – more than 40% of patients had no recording of temperature, pulse rate, blood pressure, 79.5% had no recording of respiratory rate; 89% had no recording of oxygen saturation; equipment may be present in hospital, but unavailable in the A&E department[7,10,29,48,62]	Central Hospitals – Initial Management	4.09

Table 1 Cont....

There are no standardized triage or referral protocols – may lead to over-triage and inappropriate referral to central hospitals.[2] Patients are usually seen in time order (first-come, first-serve), instead of based on illness severity[63,64]	District Hospitals – Initial Management	4.00
Colloids and blood products are unavailable in 72% and 40% of hospitals, respectively.[10]	District Hospitals – Initial Management	4.00
Inconsistent materials and equipment for provisional fracture immobilization – skin traction and casting unavailable in 20%[10,30]	District Hospitals – Initial Management	4.00
Lack of spinal injury ward and community follow-up.	Central Hospitals – Aftercare & Rehabilitation	4.00

Challenges are based on the expert opinion of MOTEG, with final wording agreed upon by all MOTEG members. Evidence in support of the challenges, as informed by the Phase 1 scoping review, is presented where applicable as literature citations

Pre-Hospital Care/Transportation

The essential goal for pre-hospital care/transportation is to ensure all patients have timely access to affordable emergency medical services and safe transportation to an appropriate healthcare facility. Challenges related to pre-hospital care/transportation that were accepted by all experts included delayed presentation to hospital and the cost of transportation to hospital posing a major barrier for patients. By expert consultation, delayed presentation to hospital and its associated poorer outcomes (4.52) was designated as high priority (Table 1).

Rural Health Centres

The essential goals for rural health centres with regards to musculoskeletal trauma care are to: 1) recognize and stabilize musculoskeletal injuries, 2) risk stratify patients based on injury, and 3) appropriately refer patients to district or central hospitals as needed. The expert panel unanimously agreed that rural health centers are challenged by lack of adequate training on orthopaedic trauma care for healthcare providers, and lack of essential medicines and other consumables. The lack of adequate orthopaedic trauma care training for healthcare providers at the rural health centers was determined to be high priority (TABLE 1).

District Hospitals

The essential goals for district hospitals are to: 1) recognize and stabilize musculoskeletal injuries, 2) risk stratify patients based on injury severity, and 3) transfer to central hospital for operative management when appropriate. The expert panel unanimously agreed on the following challenges facing district hospitals: unavailability of diagnostic X-ray, unavailability of an accident and emergency (A&E) department and a shortage of A&E-trained care providers, inconsistent availability of skeletal traction materials and equipment, limited capacity for external fixation, inconsistent availability of essential medicines, limited capacity for post-operative rehabilitation, and limited capacity for wound care. Regarding initial management of patients, high priority challenges included the unavailability of diagnostic X-ray (4.67), unavailability of an A&E department and a shortage of A&E-trained care providers (4.52), limited capacity and underutilization of vital sign measurement (4.15), lack of standardized triage or referral protocols (4.00), unavailability of colloid and blood products (4.00), and inconsistent materials and equipment for provisional fracture immobilization (4.00). High priorities for definitive treatment of injuries were inconsistent availability of skeletal traction materials and equipment (4.40), and limited capacity for external fixation (4.38). Pertaining to rehabilitation and aftercare, the limited availability of walking assistive devices (4.15) was deemed high priority (Table 1).

Central Hospitals

The essential goals for central hospitals are to: 1) recognize and stabilize musculoskeletal injuries, 2) risk stratify patients based on injury severity, 3) provide timely, safe, and equitable definitive (operative) management, 4) offer rehabilitation and social services, 5) to be a training hub for specialists and support cadres, and 6) mentor and provide outreach services to the DHs. Challenges at central hospitals that were unanimously agreed upon by all experts included limited availability/utilization of operating room (OR) capacity, limited availability of healthcare providers and ancillary staff, and lack of facilities for isolation of infected cases. Regarding initial management of trauma patients, limited availability of providers trained in triage and basic emergency care (4.27), unavailability of A&E departments in some hospitals (4.19), and inadequate vital sign measurement (4.09) were deemed high priority. For definitive treatment of injuries, high priorities were limited availability or inefficient utilization of OR capacity (4.77), limited availability of healthcare providers and ancillary staff (4.59), lack of facilities for isolation of infected cases (4.44), inconsistent supply of surgical equipment and implants (4.19), and limited procedure room availability for basic procedures (4.14). High priority for rehabilitation and aftercare was the lack of a dedicated hospital ward and community follow-up of spinal injury patients (4.00) (Table 1).

Discussion

We performed a scoping literature review to define essential goals and challenges to musculoskeletal trauma care delivery in Malawi pertaining to the following domains: injury prevention, prehospital care, rural health centres, district hospitals, and central hospitals. For each domain, essential goals were ratified and challenges were prioritized by a panel of experts on Malawian orthopaedic trauma care. This list of priorities may be used by clinicians, researchers, hospital leadership, policymakers, and donors to develop strategies that address the most urgent needs for musculoskeletal trauma care development in Malawi. In fact, we believe that the next step should be the formation of working groups to develop strategies and monitor progress towards addressing each challenge and achieving the essential goal of each domain. Below, we propose stakeholders and strategies that may be explored in order to address highest priority challenge in each domain.

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1) Prevent road injuries by law enforcement, civic education and engagement, and road infrastructure development.

Preventing RTAs is of highest priority to avert musculoskeletal injuries in Malawi. Malawi has a high and rising incidence of road traffic-related injuries, many of which are limb- and life-threatening[4,7,15-17]. Numerous studies in Malawi have documented poor adherence to recommended road safety practices, high incidence of RTAs associated with alcohol consumption, and inadequate road safety infrastructure including poor roadside lighting, few dedicated pedestrian lanes or sidewalks, and few speed bumps with raised pedestrian crossings[15,18-21]. Many MOTEG members also report a rising number of injuries caused by "kabazas", or motorcycle taxis, which are often unregistered, driven by unlicensed drivers, are overloaded with passengers and are in poor mechanical condition. To prevent RTAs in Malawi, we believe participation is required of the Malawi Police Service; the Directorate of Road Traffic and Safety Services (DRTSS), the Ministries of Health, Education, and Transport and Public Works; stakeholders with interest in trauma and/or children's health (for example: UNICEF, Raising Malawi, UK DFID); and representatives from MOTEG. The Malawian Police may consider stricter enforcement of fines for road traffic violations, enforcing seatbelt and helmet use, vehicle registration and regular maintenance, and the concept of the pedestrian "right of way", as well as suspending licenses of repeat offenders. We recommend the development and implementation of educational modules and road safety clubs in primary and secondary schools, coupled with student-led civic engagement on road traffic safety including helmet and seatbelt use and the dangers of driving while intoxicated[22,23]. The importation and use of "kabazas" must also be regulated by the government to limit their numbers and improve their safety. The government has been avoiding regulation of this industry on the basis of empowering youths to an economic activity. Curbing the industry will therefore require a strong political will, effective advocacy by healthcare providers and other stakeholders, and a balanced approach to regulation that addresses safety while preserving economic benefits of the industry. Innovative tools like SafeMotos – an Uber-like phone application to hail and evaluate motorcycle taxi drivers – has been shown to improve the safety of motorcycle taxi drivers in Rwanda and could be explored in Malawi[24]. Lastly, we believe investment in improving roadside lighting, speed bumps, crosswalks, and road infrastructure separating vulnerable road users from motorized vehicles is essential. Given that 97% of Malawian children walk to school, the areas surrounding these schools should be prioritized to ensure safety[15,18,20].

2) Improve pre-hospital transportation by scaling up emergency dispatch systems, fixing broken ambulances, and training public transportation workers in basic first aid.

In Malawi, there is no formal public ambulance service or emergency dispatch system for prehospital care. Cost of transportation to hospital can be a major financial barrier for patients[25-27]. Delayed presentation to hospital is common and worsens clinical outcomes[6,15,25,28-30]. Ambulances are available at most district and central hospitals, but only for interhospital transport and many are broken down[10,31-35]. We believe solutions to this challenge requires the participation of the Malawian Ministries of Health and Transport and Public Works; Malawi Police Service; DRTSS; private organizations and donors engaged in prehospital trauma care like Trek Medics International and the World Bank, respectively; District Health Officers; and members of MOTEG. Formal training of emergency ambulance paramedics and the development of formal ambulance services in the urban areas and along busy main highways is essential. In 2018, Trek Medics, the Malawian government, and the World Bank implemented the nation's first emergency medical system and call center covering the highway between Lilongwe and Blantyre[36]. We believe this initiative should be critically evaluated and possibly scaled nationwide, prioritizing districts with larger populations and higher incidence of musculoskeletal trauma[37]. For patients with minor injuries, motorcycle ambulances may be an effective and affordable means of transport worth exploring[38]. Emergency response and first aid training programs targeted at police, minibus drivers, community leaders, and even all drivers during their driving licensure could improve prehospital care[28,39]. Fixing, replacing, and regularly servicing many of the broken ambulances in district and central hospitals throughout Malawi is also urgently needed to improve timely transport of patients from rural hospitals to referral centers, especially those with life- or limb-threatening injuries and open fractures[10].

3) Provide health workers in Rural Health Centres with basic training in musculoskeletal injury management and triage.

Rural health centres (RHC) serve as the primary level of care in the public healthcare system. Each center is typically staffed by a medical assistant (MA) and some combination of nurses, midwives, registry clerks, drug store clerks, health surveillance assistants (HSA), and attendants. Rural health centers have no formal orthopaedic staff and offer little to no orthopaedic care, even though musculoskeletal complaints are common[5,15,25,28,29,31,40-42]. Trauma care training for medical assistants and nurses is limited to a short trauma course[5,26,42-44]. For Malawi's predominantly rural population, RHC are far more accessible than district or central hospitals and could play an important role in the delivery of primary care, basic triage, and follow-up of musculoskeletal injuries, if providers are trained appropriately.

To address this challenge, we recommend collaboration between representatives from the Malawian Ministry of Health, Kamuzu University of Health Sciences and College of Health Sciences involved in nursing and MA training; international academic partners and donors engaged in clinical education in Malawi; and members of MOTEG. Training of RHC workers in basic musculoskeletal injury management and triage should be strengthened, including management of common minor injuries, which injuries to refer, and how to recognize orthopaedic emergencies. Training would perhaps be most effective prior to starting the post at an RHC and with yearly refreshers. The clinical handbook "Orthopaedic Care at the District Hospital"[45] has been a mainstay in Malawian OCO training since its publication in 2013 and could be considered for updating and modification as a reference manual for frontline health workers, like those in RHCs. Modern educational resources like videos and standardized treatment and referral protocols displayed simply in flow charts should be considered. Regular site visits by OCOs from district hospitals could also further bolster training of RHC health workers and strengthen referral networks. Training should also be coupled with equipping RHCs with the necessary tools to enable diagnosis of musculoskeletal injuries, like diagnostic x-ray. Point-of-

care ultrasound has also been shown to be a promising tool for diagnosing fractures and a cheaper alternative to x-ray[46,47].

4) Improve diagnostic x-ray capacity at District Hospitals by fixing/replacing broken machinery and ensuring stable power supply.

The highest priority challenge at district hospitals according to the MOTEG is unavailability of diagnostic x-ray, which was reportedly unavailable when needed in 17 of 25 district hospitals and thus accessible to only 39% of the Malawian population[48]. Agarwal-Harding et al have previously described how prioritizing improvement of x-ray availability at all 4 central hospitals and the district hospitals in Dedza, Kasungu, Machinga, Mangochi, Mzimba, and Thyolo would increase estimated coverage to 75% of Malawians nationwide[48]. Addressing this challenge will, we believe, require involvement of the Ministry of Health, Ministry of Energy, biomedical engineers, Central Medical Stores Trust leadership, radiologists and radiology technicians representing public and private/charity hospitals, international donors, and members of MOTEG. This process will likely require training and deployment of Malawian biomedical engineers and external donor financial support. Donation of equipment should be carefully coordinated to ensure that machinery is durable and can be serviced appropriately in the future. The WHO compendium of innovative health technologies for low-resource settings lists some diagnostic x-ray systems that may be appropriate for the Malawian context, but would likely require external donor support to purchase[49]. There is also an urgent need to improve sustainable power supply to district hospitals to ensure that x-ray machinery can be consistently used and is not damaged by the frequently interrupted and fluctuating power supply. This may require purchasing or servicing generators and voltage stabilizers at district hospitals, as well as expanding the national energy grid and exploring renewable, sustainable sources of power, like solar or wind power, for remote district hospitals.

Improving diagnostic x-ray capacity is essential for district hospitals, however many other high priority challenges were identified by the MOTEG. We believe that district hospitals must have the resources to diagnose and temporarily stabilize musculoskeletal injuries, provide high quality nonoperative care, and appropriately refer patients in need of surgery. This will require the development and implementation of standardized protocols, regular training and recertification of OCOs, and sustainable supply chains of essential resources like plaster and traction pins. A well-functioning district hospital network will prevent central hospitals from being overwhelmed by inappropriate or late referrals that decrease central hospital operative capacity. Eventually, we believe district hospitals should scale up postoperative aftercare and rehabilitation of patients who are managed operatively at central hospitals, further freeing up beds and increasing operative capacity at central hospitals.

5) Improve operative capacity at Central Hospitals by increasing operating theatre availability, efficiency, and utilization.

The highest priority challenge at central hospitals, according to the MOTEG, is limited operative capacity due to limited operating theatre availability, lack of surgical personnel, and limited resources[10,50-55]. Central hospitals must offer comprehensive operative management for simple and complex orthopaedic pathologies. This could be accomplished by improving operating room workflow; increasing training opportunities for surgeons, nurses, anesthetists, and ancillary staff; and improving resource supply chain. This would require participation of the Ministry of Health; Kamuzu University of Health Sciences; MOTEG, particularly orthopaedic department heads from each central hospital, and leadership from Beit Cure International Hospital and Lilongwe Institute of Orthopaedics and Neurosurgery; nursing, anesthesia, and hospital leadership representatives from each central hospital; international organizations and academic institutions engaged in orthopaedic capacity building.

We recommend the implementation of quality improvement projects at each central hospital to examine current operating theatre utilization and workflow. A classic operations management approach using process diagrams could help identify bottlenecks, and we recommend continuous monitoring of five operating theatre utilization indicators: procedure start time, finish time, turnover time, total daily case number, and cancellation rate and cause. Colleagues in Ethiopia used these metrics to identify a high surgical cancellation rate of 35.8%, which was largely attributable to inadequate preoperative patient preparation, which led to late start times, and decreased operating room availability[56]. Similarly at each central hospital in Malawi, workflow bottlenecks may differ but should be documented and addressed by the working group and its representatives at each hospital. Our MOTEG has already identified that lack of nurses, ancillary staff, and anesthetists is a high priority challenge that presents a bottleneck to operative capacity. MOTEG members at Queen Elizabeth Central Hospital have observed that appropriate training of operating room personnel has strengthened the surgical team and helped foster a collective team identity and motivation to improve quality of care. The upcoming launch of clinical services at the autonomous Lilongwe Institute of Orthopaedics and Neurosurgery presents a unique opportunity to address many of the challenges plaguing operative capacity at Kamuzu Central Hospital, streamline workflow, recruit staff, and institute regular quality assurance protocols.

With regards to essential resources, central hospitals are still heavily reliant on foreign donations for basic orthopaedic equipment[10,31]. The new Global Surgery Initiative by Johnson & Johnson in Malawi aims to improve supply of orthopaedic equipment and provide training to surgeons. This certainly has the potential to dramatically improve operative capacity, but only if integrated into functioning hospital systems and with measures taken to ensure sustainable supply chains in future when this support ends. We recommend using this opportunity to standardize and streamline procurement of surgical implants and equipment, decreasing costs by bulk order coordination, and avoiding inappropriate procurement from entities outside the hospitals. Malawian hospitals must, unfortunately, continue to rely on foreign donation to support orthopaedic resource procurement, but there must be a plan in place for increased financial and operational investment by the Ministry of Health and Malawian government. To that end, we propose the creation of a Road Traffic Injury Fund (RTIF) in Malawi, supported by a small levy raised on fuel and alcohol prices. Botswana, Lesotho, Namibia, South Africa, and Swaziland have all successfully implemented fuel tax levy funds to support road injury victims and generally improve trauma care[57]. Malawian citizens would contribute to the RTIF every time they buy petrol or alcohol, and the RTIF would cover medical costs of hospitalization, treatment,

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and rehabilitation for all Malawian drivers, passengers, and pedestrians injured on the road. We believe such a fund could greatly support the expansion and modernization of trauma care in Malawi and would be of net benefit to the Malawian economy by averting significant road injury-related disability[58,59]. Involvement of trauma care providers and clinical leadership in guiding the allocation of these funds would, we believe, ensure funds are spent efficiently on appropriate and high quality capacity improvements.

Improving operative capacity in Malawian public hospitals is vital, and greater investment in infrastructure, staff training, and essential resource procurement is needed in district and central hospitals to ensure safe surgeries are performed, appropriate to the hospital level. However, we believe central hospital capacity improvements must be prioritized before operative capacity is further expanded in the district hospitals. Although procedural capacity improvements like skeletal traction (4.40) and external fixation (4.38) were determined to be high priority by MOTEG, central hospital operative capacity (4.77) and training of the current and future surgical workforce (4.59) were higher priority. We therefore recommend a two-staged approach to expanding orthopaedic surgical capacity in Malawi. Stage 1 would involve increased investment in central hospital capacity building (infrastructure, staff, implants, optimizing utilization, and training of specialists and associated staff), district hospital diagnostics (x-ray) and basic operative capacity (open fracture debridement, safe amputation, and appropriate fracture immobilization), training of OCOs and rural health center workers on basic MSK trauma care, standardizing and enforcing referral protocols, and improving prehospital/interhospital transportation. Stage 2 would involve decentralizing management of certain high volume, lower acuity injuries to select district hospitals, with appropriate training and supervision from the central hospitals to ensure safe surgical care.

Limitations

This study has limitations. First, it is possible that we missed some important challenges. We attempted to control for this by performing a current literature review and allowing experts to add challenges that were not captured by the scoping review. Nevertheless, this analysis represents a snapshot in time and our hope is that this will lead to future and continuous analysis of these challenges. Second, most MOTEG members practice in central hospitals, so their responses may not represent the opinions of all orthopaedic care providers in Malawi. We chose to include experts who could adequately opine on the full spectrum of orthopaedic care, from injury prevention to definitive surgical treatment and rehabilitation. Although the opinions of RHC workers and OCOs in district hospitals were not included, Malawian MOTEG members have worked in the public health system including the district hospitals prior to specialist training. We believe MOTEG members are therefore able to provide opinions regarding challenges in each domain, with the perspective of leaders who can understand interactions between each level of care. Only one physiotherapist was included in MOTEG, and although many of the other MOTEG members were qualified to opine on the challenges of rehabilitation of injured patients, inclusion of more physiotherapists may have strengthened the study. Third, although MOTEG members were given the opportunity to suggest modifications to the challenges, they were not able to qualify or justify their priority scores. This information could perhaps be assessed in the future and may be useful for policymakers.

Conclusion

Orthopaedic trauma care delivery in Malawi is a complex, multifaceted system that includes injury prevention, pre-hospital care/transportation, rural health centers, district hospitals, and central hospitals. Through this study, we elucidated the current challenges, established the essential goals at each level of care, and identified the technical priorities for orthopaedic trauma care delivery in Malawi. The five highest priorities pertained to injury prevention (2), central hospital-level definitive treatment (2), and district hospital-level initial fracture management (1). For the top priority challenges in each domain, we recommend the following: 1) Prevent road injuries by law enforcement, children's education, civic engagement, and road infrastructure development; 2) Improve pre-hospital transportation by scaling up emergency dispatch systems, fixing broken ambulances, and training public transportation workers in basic first aid; 3) Provide health workers in Rural Health Centres with basic training in musculoskeletal injury management and triage; 4) Improve diagnostic x-ray capacity at District Hospitals by fixing/replacing broken machinery and ensuring stable power supply; 5) Improve operative capacity at Central Hospitals by increasing operating theatre availability, efficiency, and utilization, and supporting specialist surgical training programmes. We hope that this manuscript will serve as a practical actionable guide for policymakers, health system leaders, educators, and orthopaedic trauma care providers. The next steps are to use this prioritized list to form working groups with the goal of examining and developing strategies to address each challenge. Through this process, we also hope to create a replicable methodology and framework that can be applied to other clinical departments in Malawi, and for similar work in other LMICs.

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Technical Priorities for Orthopaedic Trauma Care Development in Malawi
Appendix

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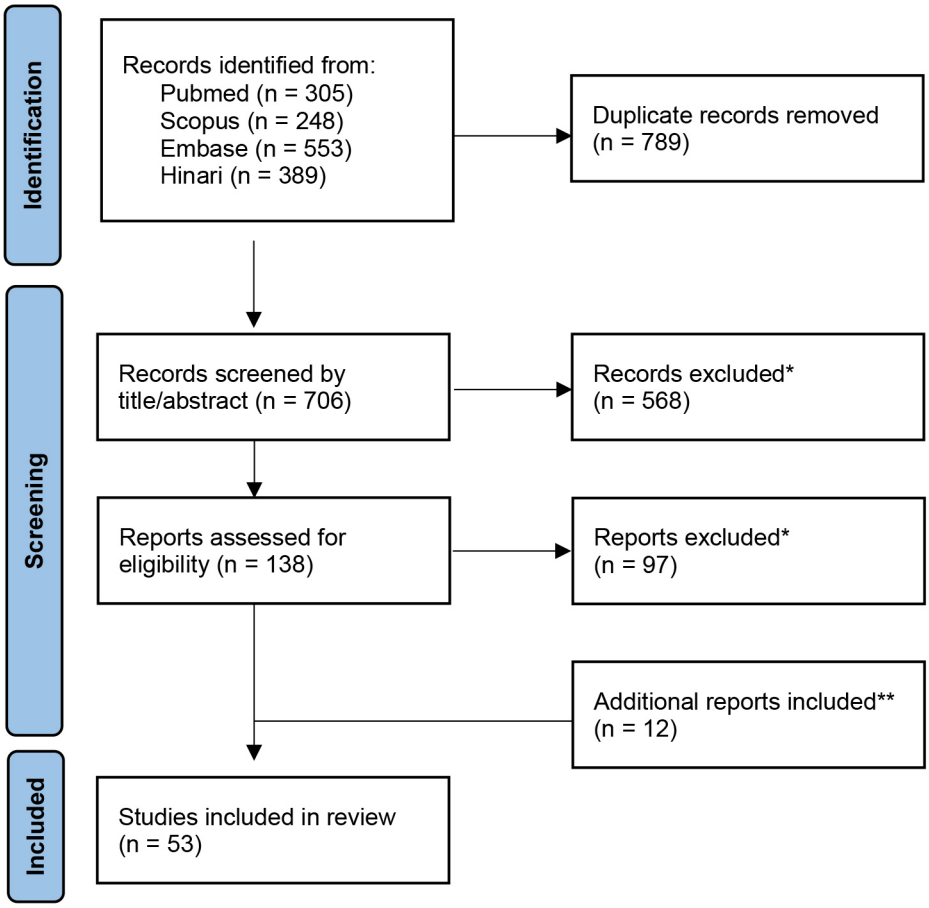
Appendix A.1: MESH Terms

(Orthopaedic OR Orthopedic OR Orthopaedics OR Orthopedics OR Trauma OR Traumatology OR Fracture OR Fractures OR Break OR Breaks OR Bone OR Bones) AND Malawi AND (low-resource OR low-income OR developing OR undeveloped OR underdeveloped OR lmic OR lmics OR lic OR lics OR resource poor OR limited resource OR disadvantaged OR Challenge OR Challenges OR health system OR health systems OR healthcare OR tertiary hospital OR tertiary hospitals OR problem OR problems OR road traffic OR road accident OR road accidents OR road collision OR road collisions)

Appendix A.2: Article screening flow diagram



* We included all articles pertaining to orthopaedic trauma care in Malawi at any phase of care, including preventative measures, prehospital care, rural health centers, district hospitals, and central hospitals. Articles were excluded if they: 1) were not specific to Malawi, 2) presented information not relevant to orthopaedic trauma care, 3) did not present a clearly discernible challenge or essential goal to orthopaedic trauma care delivery.

** We reviewed the references of all articles that underwent full-text review, and further included any articles that met the inclusion criteria.

Appendix A.3: Data extraction methods

All included manuscripts underwent data extraction in order to identify essential goals and current challenges to orthopaedic trauma care delivery in Malawi. First, a framework of five domains – injury prevention, prehospital care, rural health center, district hospitals, and central hospitals – was developed by the authors prior to data extraction in order to provide a structure for the identification and categorization of the goals and challenges. Similar frameworks for evaluating musculoskeletal trauma systems including injury prevention, prehospital care, and hospital care have been published elsewhere.[1] The rural health center, district hospital, and central hospital domains were based on the structure of the Malawian public health system. Additional sub-domains of initial management, definitive care, and rehabilitation/aftercare have also been previously defined when examining capacity of Malawian district and central hospitals.[2]

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Next, three authors (KM, KN, KJAH) performed open readings of five randomly selected manuscripts that had passed the title/abstract screen. This was done to confirm that all authors performing full-text reviews were able to uniformly apply the inclusion and exclusion criteria as well as identify text that presented a goal or challenge within the five-domain framework. Two authors (KM and KN) then performed all full-text reviews with the first author (KJAH) serving as a tie breaker for inclusion/exclusion. Text from included manuscripts that presented a potential challenge or goal was extracted by the full-text reviewers (KM and KN) and reviewed by KJAH, who at regular intervals performed separate readings of a subset of included manuscripts in order to assess adequate capture of challenges and goals and agreement between the full-text reviewers.

The challenges and goals were then synthesized by KM, KN, and KJAH in an iterative process resembling an immersion/crystallization approach taken for qualitative analysis.[3] Through iterative cycles of reading and reflection, similar themes were identified across extracted text and was consolidated and synthesized into goals and challenges. The initial list of essential goals and challenges for each domain was reviewed and further refined by the first author (KJAH) and two senior authors (LC, LNB), who have extensive experience providing clinical orthopaedic care in Malawi as well as profound familiarity with and contribution to the scientific literature on this subject. The list of essential goals and challenges was thus further refined for clarity prior to presentation to the Malawian Orthopaedic Trauma Expert Group (MOTEG) in Phase 2.

1. Dworkin M, Agarwal-Harding KJ, Joseph M, Cahill G, Konadu-Yeboah D, Makasa E, et al. Indicators for the evaluation of musculoskeletal trauma systems: A scoping review and Delphi study. PLoS ONE 2023;18(8): e0290816.

2. Agarwal-Harding KJ, Chokotho L, Young S, et al. Assessing the capacity of Malawi's district and central hospitals to manage traumatic diaphyseal femoral fractures in adults. PLoS ONE 2019;14:e0225254.

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Appendix B.1: Instructions provided to MOTEG members in Phase 2

Please evaluate the following lists of challenges and essential goals to orthopaedic trauma care in Malawi. To edit the essential goals, please add any edits to the "Suggestions" box next to the essential goal. You will evaluate the challenges in three steps:

1) Indicate whether or not you have encountered the potential challenge in your practice.

2) Assign a priority score to each challenge from 1 to 5, with 1 indicating of lowest priority and 5 indicating most urgent and highest priority.

3) Circle the one challenge that you believe is most essential to address.

You may also choose to edit challenges by adding any edits to the "Suggestions" box next to the potential challenge. Any additional challenges that were not identified in the literature review, but that you have identified in your own personal experience, can be added at the bottom of each table.

Appendix B.2: Sample of paper-based survey tool used in Phase 2

The following is the survey presented to all MOTEG panelist for evaluation of the goals and challenges of Injury Prevention. Identical structure was used to evaluate goals and challenges of the other four domains: pre-hospital care/transportation, rural health centres, district hospitals, and central hospitals.

Injury Prevention

Essential Goals	Suggestions		
To identify the most common causes of musculoskeletal injuries and to reduce the injury incidence.			
Potential Challenge	Is this a Challenge? (Yes/No)	Priority Score (1 – 5)	Suggestions
1) Road traffic accidents cause significant morbidity and mortality. Malawi has the world's 4th highest annual road mortality rate at 34.2 per 100,000 and the burden is increasing with more vehicles.[3-6,13,14]			

2) Although alcohol use in Malawi is assumed to be relatively low compared to other African countries, there is a high incidence of road traffic accidents (RTAs) associated with alcohol consumption – about 20% of those involved in RTAs presenting to KCH had a blood alcohol content of 0.08 or more – highest prevalence among pedestrians (41.8%) and car drivers (23.8%)[18-21]			
3) Falls are a very common mechanism of injury, particularly within the pediatric population – 44% of all injuries in children are due to falls[6,14]			
4) Poor lighting along roads and inadequate use of reflective devices by pedestrians and cyclists leads to increased risk of traumatic injuries [6,20,21]			
5) Limited to no helmet use by cyclists[20,21]			
6) No dedicated pedestrian lanes or sidewalks, few raised pedestrian crossings and speed bumps at accident prone points and poor adherence to standard traffic laws – despite the fact that 97% of students walks to school[6,18,20]			
7) There is no uniform disaster management plan.[5] This could impair responses to natural disasters and public health emergencies, such as the 2019 Cyclone Idai, 2009 Karonga earthquakes, and 2020 COVID-19 pandemic.			
8) There is no national injury surveillance system, which would allow for more directed preventive measures.[2] DHIS2 has few indicators for injury and orthopaedics.			
9) There is inadequate investment in trauma-related clinical research in Malawi that could better direct policies at all levels of care[2]			
Additional Challenges			

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Appendix C.1: Complete list of essential goals and challenges with accompanying average priority scores

Challenges are based on the expert opinion of MOTEG, with final wording agreed upon by all MOTEG members. Evidence in support of the challenges, as informed by the Phase 1 scoping review, is presented where applicable as literature citations.

Table C1: Average expert priority scores for potential challenges related to injury prevention

Injury Prevention	
Potential Challenge	Priority Score
Road traffic accidents (RTAs) cause significant morbidity and mortality. Malawi has the world's 4th highest annual road mortality rate at 34.2 per 100,000 and the burden is increasing with more vehicles.[4,7,15-17]	4.95
Limited to no helmet use by cyclists[18,19]	4.55
Although alcohol use in Malawi is assumed to be relatively low compared to other African countries, there is a high incidence of road traffic accidents (RTAs) associated with alcohol consumption – about 20% of those involved in RTAs presenting to KCH had a blood alcohol content of 0.08 or more – highest prevalence among pedestrians (41.8%) and car drivers (23.8%)[18-21]	4.38
Poor lighting along roads and inadequate use of reflective devices by pedestrians and cyclists leads to increased risk of traumatic injuries [15,18,19]	3.85
There is no uniform disaster management plan.[7] This could impair responses to natural disasters and public health emergencies, such as the 2019 Cyclone Idai, 2009 Karonga earthquakes, and 2020 COVID-19 pandemic.	3.85
Falls are a very common mechanism of injury, particularly within the pediatric population – 44% of all injuries in children are due to falls[15,17]	3.77
No dedicated pedestrian lanes or sidewalks, few raised pedestrian crossings and speed bumps at accident prone points and poor adherence to standard traffic laws – despite the fact that 97% of students walks to school[15,18,20]	3.77
There is no national injury surveillance system (NISS), which would allow for more directed preventive measures.[31] DHIS2 has few indicators for injury and orthopaedics.	3.62
There is inadequate investment in trauma-related clinical research in Malawi that could better direct policies at all levels of care[31]	3.00

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Table C2: Average expert priority scores for potential challenges related to pre-hospital care/transportation

Pre-Hospital Care/Transportation	
Potential Challenge	Priority Score
Delayed presentation to hospital is common in Malawi and may result is worse outcomes.[6,15,25,28-30] 28% of pediatric patients and 34% of adult patients were found to have delayed presentation.[6]	4.52
There is no formal ambulance service to transport patients safely from the scene of injury to hospital. Ambulances are available at almost all district and central hospital, but are broken down and functioning ones are used only for transport between hospitals.[10,31-33]	3.86
There is no formal emergency dispatch system.[34] Most patients have no way of calling for emergency medical services, despite the presence of mobile phone infrastructure that covers 93% of the population.	3.73
Roads are poorly maintained. In 2011, while Malawi was ahead of its sub-Saharan counterparts with regards to new paved road construction, the Malawian government spent about 24% less than what was needed to sustain the current road infrastructure.[34]	3.65
There is no formal emergency medical service with BTLS/ATLS trained first responders to perform field triage. Based on KCH trauma registry, the increased relative mortality risk during mass casualty incidents (MCIs) was due to inadequate prehospital care and triage, rather than in-hospital care.[31,32,35]	3.59
The cost of transportation to hospital is a major barrier for patients. 56.3% can get to rural health center on less than $1 USD, compared to 27% for district hospitals and 9.5% for central hospitals.[25-27]	3.52

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Table C3: Average expert priority scores for potential challenges related to rural health centers

Rural Health Centers	
Potential Challenge	Priority Score
Providers in rural health centers receive minimal training on trauma care[40] – currently, only a short trauma course exists for nurses and medical assistants working at rural health centers [5,27,42-44]	4.25
There is a lack of essential medicines and other consumables – 27% of patients did not receive one or more of the drugs they were prescribed. Paracetamol was prescribed to 30% of patients, but only available to 59% of those to whom it was prescribed.[1,40] Consumable supplies like Plaster of Paris and dressing supplies are frequently out of stock.	3.86
Rural health centers have no formal orthopaedic staff. Muscular or skeletal pain may be one of the most common diagnoses made in rural health centers[39] and about 40-70% of patients present first to a rural health center. [5,15,25,28,29,31,41,42]	3.71
There is no standardized patient flow through health center i.e. registry clerk to nurse to MA[40]	2.78

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Table C4: Average expert priority scores for potential challenges related to district hospitals

District Hospitals	
Potential Challenge	Priority Score
Diagnostic X-ray is unavailable in 68% of district hospitals, usually due to broken X-ray machine[10] 61% of the Malawian population does not have access to x-ray.[10,46]	4.67
A&E departments are unavailable and there is a shortage of A&E trained care providers. A&E departments are unavailable to effectively triage, diagnose, and stabilize femur fracture in 60% of districts[7,10,11,31] A&E trained physicians and triage nurses are unavailable in 60% and 80% of hospitals, respectively. Usually, OCOs and MAs perform this function.[7,10,31,60,61]	4.52
Inconsistent availability of skeletal traction materials and equipment – skin traction performed in 96% , but unavailable in 40%; all hospitals reported barriers to skeletal traction, due to lack of quality tape, weights, hospital beds, functioning traction frames, and pulleys.	4.40
Limited capacity for external fixation – external fixators unavailable in 60%[10]	4.38
There is limited capacity and underutilization of vital sign measurement. More than 40% of patients had no recording of temperature, pulse rate, blood pressure; 79.5% had no recording of respiratory rate; 89.0% had no recording of oxygen saturation.[7,10,29,48,62]	4.15
Limited availability of walking assistive devices (walkers, canes, and crutches) unavailable in 67% of district hospitals.[1,10,53]	4.15
There are no standardized triage or referral protocols – may lead to over-triage and inappropriate referral to central hospitals.[2] Patients are usually seen in time order (first-come, first-serve), instead of based on illness severity [63,64]	4.00
Colloids and blood products are unavailable in 72% and 40% of hospitals, respectively.[10]	4.00
Inconsistent materials and equipment for provisional fracture immobilization – skin traction and casting unavailable in 20%[10,31]	4.00
Inconsistent availability of essential medicines[1] – antibiotics[10,53], inpatient pain control[10], DVT prophylaxis[10,53,55,67,68] – antibiotics are present in most (76%) hospitals, but often in limited supply or variety; morphine, ibuprofen, and acetaminophen/ paracetamol are unavailable in 40%; heparin unavailable in all hospitals.	3.95
Limited capacity for post-operative rehabilitation and physical therapy – unavailable in 60% due to lack of equipment and trained staff [1,10,33]	3.90
Laboratory testing is unavailable in 40% of district hospitals due to lack of necessary equipment, reagents, or other supplies.[10]	3.86
Limited capacity for wound care – sterile cotton wool unavailable in 20% and gauze and bandages unavailable in 60%[10] – 20% of lower extremity fractures are open fractures[50,59]	3.84

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There is no electronic trauma registry at all district hospitals.[7,15,29,30,69]	3.67
Lack of discharge planning, mental health counseling, or social work – Patients experience tremendous financial challenges and psychological trauma following injury, along with job loss, food insecurity, and limited funds for school fees[1,10,31,33,55,58]	3.63
Limited availability and training of nurses and ancillary staff – circulating nurses unavailable in 32% of hospitals and inpatient nurses unavailable in 64%[10,31,50,61]	3.55
There is a lack of communication between providers and patients, with a lack of patient involvement in decision-making and inconsistent informed consent procedures.[17,70]	3.35
Insufficient capacity for transport between health facilities, which affects ability to scale up of operative service at central hospitals. Ambulances are available at almost all district and central hospital, but are often broken and awaiting repair or unavailable due to no fuel or insufficient stock of supplies to safely transport patients	3.33
There are no standardized treatment algorithms for common injuries such as femoral shaft or ankle fractures[17,58]	3.19
Limited access to outpatient pain control, given that many patients cannot afford to buy medications.[1,33,58]	3.06
Relative underutilization of inpatient beds at the DH compared to CH – 92% of hospitals reported inpatient beds were present and 80% had beds available for newly admitted patients with musculoskeletal injuries[10]	2.12
Mortality rates are high for immobilized patients in skeletal traction, possibly due to the lack of patient evaluation for and prophylaxis against DVTs and PEs.[53,55,67]	2.10

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Table C5: Average expert priority scores for potential challenges related to central hospitals

Central Hospitals	
Potential Challenge	Priority Score
Limited operative capacity due to limited OR availability and/or inefficient OR utilization. Operating rooms are present in 100%, but unavailable in 50%; only 1 out of 8 OR's at KCH are available for orthopaedic trauma. From 2010 to 2011, the number of orthopaedic procedures increased by 42% due to increased training, but has since plateaued due to lack of resources and OR staff.[10,50-55]	4.77
Limited availability of nurses, ancillary staff, surgical and anesthesia workforce, and related specialist services leads to long wait times – circulating and inpatient nurses are unavailable in 50% of central hospitals; current nurse to patient ratio is between 40:1 and 80:1 [1,10,31,43,50,61,65,66]	4.59
Lack of facilities for isolation of infected cases.	4.44
Limited availability of providers trained in triage and basic emergency care – triage nurse unavailable in 50% of hospitals and only one central hospital offered routine training in prevention of bloodborne diseases to staff[7,10,301,62]	4.27
A&E departments are only available in 50% of hospitals[7,10]	4.19
Inconsistent supply of surgical equipment and implants – IMN equipment unavailable in 25% of hospitals, but almost entirely reliant on foreign donations[10,31]	4.19
Limited procedure room availability for basic procedures, which are unavailable in 50% of central hospitals[10]	4.14
Inadequate vital sign measurement – more than 40% of patients had no recording of temperature, pulse rate, blood pressure, 79.5% had no recording of respiratory rate; 89% had no recording of oxygen saturation; equipment may be present in hospital, but unavailable in the A&E department[7,10,29,48,62]	4.09
Lack of spinal injury ward and community follow-up.	4.00
No cervical spine immobilization and clearance protocol. 30.6% of patients at QECH had no records of cervical spine examination and immobilization details[29]	3.91
Lack of cleanliness and sanitation in overcrowded hospital wards[1,58]	3.90
Limited availability of walking assistive devices (walkers, canes, crutches) and wheel chairs are unavailable in 50% – sometimes patients buy their own walking aids from carpenters[1,10,53]	3.86
Inconsistent supply of materials and equipment for skeletal traction – unavailable in 25% of hospitals, but all report barriers to providing skeletal traction to patients with femoral shaft fractures due to lack of equipment (drills, traction pins, weights, hospital beds).	3.77
Laboratory testing (basic chemistry panel, urea/electrolytes, full blood count) unavailable in 75%[10,62]	3.68
Lack of postoperative physical therapy, including guided joint range of motion, hand and gait training, which leads to inferior results, stiff joints, prolonged recovery and longer hospital stays.	3.67
Insufficient and inconsistent supply of blood for trauma cases and major surgery. Reliance on third party suppliers, with occasionally inadequate supply.	3.64
Lack of capacity in prosthetics and orthotics services. Inferior results after surgery, long waiting times for a prosthesis.	3.60
Inconsistent supply of suturing materials – unavailable in 50%[10,31]	3.57

Inpatient hospital beds are unavailable at 75% of hospitals. This is especially concerning at district hospitals, because the standard of care here is nonoperative. This means that patients are often immobilized in skeletal traction for months while they recover from their injury. The insufficient number of beds becomes a bottleneck for more patients receiving treatment.[10]	3.55
Lack of discharge planning, mental health counseling, or social work – Patients experience tremendous financial challenges and psychological trauma following injury, along with job loss, food insecurity, and limited funds for school fees[1,10,33,55,58]	3.33
Lack of access to essential medicines for DVT prophylaxis – LMWH unavailable in all hospitals and aspirin unavailable in 50%[1,10,53,55,67,68]	3.33
Lack of sufficient knowledge of anatomy, injury characteristics, and ideal treatment principles ; limited opportunities for continuing medical education for providers[53,58,70, 71]	3.32
There are no standardized treatment algorithms for common injuries, no formal training related to injury stratification[53,58,71]	3.05
There is a lack of communication between providers and patients, with a lack of patient involvement in decision-making and inconsistent informed consent procedures.[1,58]	3.05
Colloids available in none of the central hospitals[10]	2.76
Lack of transparency with regards to provision of care – patients view the process as unfair and corrupt [1,53,58,70]	2.62
Electrocardiogram (ECG) is unavailable in 50% of hospitals[10] – unavailable to 51% of Malawians[49]	2.50
Lack of post-discharge follow-up[1,50]	2.48
Diagnostic x-ray is unavailable when needed in 50% of central hospitals, and of inadequate quality to safely treat a femoral shaft fracture in 75% of central hospitals.[10]	2.45
Patients lack access to outpatient pain control[33,58]	2.29
High post-operative complication rates, due to the lack of patient evaluation for pressure ulcers, DVTs, and Pes[1,53,55,67]	1.81

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