Trauma Incidence and Emergency Medical Services in Malawi

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Acknowledgements

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Ethics Approval

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Acronyms

AVPU	Alert, Voice, Pain, Unresponsive scale
ER	Emergency Room
EMT	Emergency Medical Technicians
DHO	District Health Officer
DRTSS	Directorate of Road Traffic and Safety Services
KCH	Kamuzu Central Hospital
GSC	Glasgow Coma Score
HMIS	Health Management Information System
LMIC	Low or Middle Income Country
MACRA	Malawi Communications Regulatory Authority
MOH	Ministry of Health
MOTPW	Ministry of Transport and Public Works
MRA	Malawi Roads Authority
NHRSC	National Health Sciences Research Committee
QECH	Queen Elizabeth Central Hospital
RTC	Road Traffic Crash
SSA	Sub-Saharan Africa
TR	Trauma Registry

Executive Summary

Globally, Road Traffic Crashes (RTC) account for around 1.35 million deaths annually, with this burden falling heavily on low- and middle-income countries. This is especially true for Sub-Saharan Africa and countries like Malawi, which is in the top 20 countries in terms of fatalities from RTCs (WHO, 2018). Further, deaths occur mostly in the economically active age-groups of the population, leading to important economic consequences for these countries (WHO, 2018).

Sustainable Development Goal (SDG) 3.6, calls for a halving of the number of global deaths and injuries from road traffic crashes. While preventive measures can decrease the number of RTCs, it is also important to invest in post-crash care to save more lives (Soro and Wayoro, 2017). Yet, in Sub-Saharan Africa (SSA), where the problem is most acute, very few countries have developed

systematic and sustainable Emergency Medical Services (EMS) systems at scale (World Bank, 2021).[1]

Malawi is a prime example of this precarious road safety situation, showing both high numbers of annual RTCs (WHO, 2018) and having a weak emergency response system, including pre-hospital care (Mulwafu, 2017). To address this challenge and in an attempt to decrease victims of RTCs in Malawi, the Government of Malawi developed an Emergency Response Pilot (the EMS Pilot), to be implemented along the busiest stretch of Malawi's largest road, the M1, between Lilongwe and Blantyre. This pilot is funded by the World Bank through the Southern Africa Trade and Transport Facilitation Program – Phase 2 (SATTFP2), and it is being implemented by the Ministry of Health (MoH). The EMS Pilot is being implemented in two Central and four District Hospitals and it includes the provision of 12 ambulances, a central dispatch center, capacity building of medical personnel in trauma care as well as a Trauma Registry (TR), to collect data on trauma cases, care and outcomes.

Given the importance of understanding the implementation and impacts of this pilot project, as well as the burden of trauma more broadly, in order to inform potential scale-up to the rest of the country, the Development Impact Evaluation Group (DIME) at the World Bank partnered with the MoH to conduct an impact evaluation of the EMS pilot project. As part of this work and in collaboration with the MoH and local researchers from the College of Medicine, University of Malawi, the DIME team supported in setting up and expanding high quality trauma data collection, in the form of a Trauma Registry, in five of the six pilot health facilities and five comparable health facilities along the M1 road that were not part of the pilot.[2] The process of setting up the TR also provides crucial learning and may help inform trauma registry implementation endeavors for policy makers in similar contexts.

This report shares data insights and makes recommendations based on the findings from the TR data. The Malawi TR was operational in 10 district and central hospitals in Malawi for 35 months (August 2018–June 2021) and collected data on 118,013 patients. It provides detailed data on patient demographics, trauma causes, care, medical outcomes, and road traffic injuries.

The TR data was collected with several objectives in mind, including 1) providing an understanding of the trauma burden in Malawi, 2) acting as a baseline for the EMS pilot project in order for the team to conduct a rigorous impact evaluation, and 3) supporting the improved functioning of the EMS system in the longer term through insights on the trauma burden, care and outcomes.

The EMS pilot is still ongoing; consequently, the impact evaluation has not been completed since it will require the pilot to be fully implemented and operational for a period of time in order to evaluate the impacts. Therefore, **the goal of this report is 1) to provide insights into the current situation and overall burden of trauma and RTCs in Malawi, 2) to share what we have learned about how to effectively run a digital trauma registry in a low-resource setting, and 3) to highlight lessons learned from the implementation of the EMS pilot.** These insights can provide valuable information to improve our understanding of trauma and road traffic injuries in the country as well as the practicalities around rigorous data collection and setting up of an EMS system, which can help in the framing and targeting of future policy in the sector. This report provides a few key findings and recommendations:

Burden of Trauma

1. Like data from other TRs in the region, the Malawi TR shows **marked gender and age patterns in the incidence of trauma, with overrepresentation of males and younger adults.**
2. **RTCs make up almost half of admitted trauma cases recorded (48%).** While falls make up 46% of all trauma cases recorded, they are only 22% of hospital admissions.
3. Almost **half (49%) of RTC victims are non-motorized road users** such as pedestrians and cyclists.
4. **84 % of patients** who were passengers of motor vehicles such as cars, buses, and trucks **report not having worn a seatbelt.** And **52% of patients** who were drivers or passengers of motorbikes **report not wearing a helmet.**
5. Patients report major delays between the time of injury and the time they reach the hospitals as well as delays in care after arrival in hospital. Focusing on cases where the patient arrived within 24 hours of the trauma, **RTC cases have around 1.4 hours between the time of trauma and the time of arrival.** All serious trauma cases (including RTCs) arriving within 24 hours of the trauma have a median time to arrival of 2 hours, but non-RTC serious cases have a median time to arrival of 4 hours.

[1] The report defines EMS as prehospital care that is formalized and provided by emergency care professionals, whereby there is an established entity, agency or system facilitating the coordinated, timely, and safe provision of emergency care and transportation to the most appropriate healthcare facility.

[2] One of the pilot facilities, Kamuzu Central Hospital, already had a high-quality trauma registry in place, and therefore additional data collection was not implemented as part of this work.

6. For admitted cases, 29% arrive by private vehicle, 21% use commercial vehicles such as taxis, 16% come using public modes such as minibuses, and **only 6% use an ambulance.**

Implementation of Trauma Registries

7. **Digital Data collection is feasible** in this setting. The upfront costs might be slightly higher, but the data quality is better. Initial skepticism from counterparts disappeared as the TR was set up and functioned well for almost three years.
8. **Stakeholder engagement and coordination** at both the centralized level and individual facility level is critical for effective and complete data collection.
9. **Pre-testing, piloting, training, frequent data quality checks and feedback** to data collection teams are critical components for high-quality data collection.
10. TR coordinators and hospital management found the **TR data useful for reporting and planning purposes**.
11. TR data analysis demonstrates the **potential of trauma registries to inform both preventive policies and clinical care**.

Process of EMS Pilot Implementation

12. The implementation of the EMS call center and ambulance dispatch could have benefitted from greater focus on **change management within the implementing agency**, to emphasize efforts at building an overall understanding of how core elements of an EMS system are unique and different from previous use of ambulance services in Malawi.
13. Recognition was needed at an earlier stage of the need for an active and engaged **ICT specialist** to support throughout the process of systems engineering and planning for the **technology, communications and related protocols** needed to enable a core part of the EMS system, the dispatching of ambulances. This could have increased efficiency, effectiveness and speed of system rollout.
14. An in-depth **analysis of operational and financial data** collected during the pilot can usefully inform the level of resources and personnel requirements for call center management and EMS pre-hospital care considerations, towards elevating EMS as part of critical care planning and budgeting.
15. **More effective public communications campaigns** are vital to increase local awareness on the proper use of the new emergency number (*118), the relevance of formal post-crash care for road trauma, and to reduce the misuse of the toll-free number.

Recommendations

1. The data demonstrate the burden of road traffic crashes for health facilities and the need to implement additional policies that can decrease RTCs, which will help to alleviate resource needs within health facilities.
2. There is a need to target policies and infrastructure to improve road safety for the most vulnerable users — pedestrians and cyclists.
3. The data collected shows the scope for increased seat belt and helmet use to reduce RTC-related trauma in Malawi, through both increased enforcement of related road laws and public safety advocacy.
4. Investment in a comprehensive communications campaign and use of existing data to help guide and evaluate the effectiveness of the campaign will be important.
5. There should be increased use of all the different data that are collected by the EMS systems and within health facilities in order to help guide operations and lead to higher effectiveness.
6. A continuation and a refinement of the TR, including greater detail on care delivered and patient outcomes, could contribute to the evidence base regarding trauma care in Malawi. Streamlining of the variables collected (by identifying the most important ones) and integration into existing data collection practices in health facilities can help support sustainability.
7. Increased investment in digital data collection in health facilities could help to improve the quantity and quality of data collected and increase the usefulness of the data for policy planning and health facility operations.

SECTION I

Introduction

Road traffic crashes are the eighth leading cause of death globally, with approximately 1.35 million people dying annually (WHO, 2018). Low- and middle-income countries (LMICs) carry the majority of the burden, accounting for 93% of these fatalities, and vulnerable road users (pedestrians, cyclists, motorcyclists) make up a high share of deaths, especially in these countries (WHO, 2020; World Bank, 2021). There are also important economic consequences of RTCs, given that they especially impact the prime working-age groups, and RTCs are the leading cause of death worldwide among those aged 15–29 years (Boniface et al., 2016; WHO, 2020). In addition to the large mortality burden, approximately 50 million people per year sustain injuries resulting in long term disability due to RTCs. Yet investments in road safety interventions and emergency medical care are non-existent or inadequate (World Bank, 2021). In particular, Sub-Saharan Africa represents the largest group of countries (by population) with no effective pre-hospital emergency care systems in place. More data-driven regional evidence to improve mortality and morbidity

is needed in this area to support both reductions in RTCs and improvements in outcomes from RTCs (World Bank, 2021).

Post-Crash Care

The Global Plan for the Decade of Action for Road Safety 2011–2020, initiated by the United Nations, identified improved "post-crash response" as one of the five pillars within the overall framework for its activities. While the main goal to be pursued by policymakers should be to prevent road traffic injuries, the reality is that road crashes will continue to occur. Therefore, it is also important to look at policies that can mitigate the consequences of crashes and improve the quality of life for those people that are injured, in conjunction with policies to decrease the number of crashes. In this light, as described by the WHO, "the aim of post-crash care is to avoid preventable death and disability, limit the severity of the injury and the suffering caused by it, and ensure the crash survivor's best possible recovery and reintegration into society" (WHO, 2006). The relatively high mortality rate due to RTCs in LMICs points towards weaker health care and trauma care systems in these countries, that are especially in need of investments in emergency care (Reynolds et al., 2017). Yet, many developing countries lack adequate emergency medical response systems and the disparities in injury outcomes between high-income countries and low-and middle-income countries directly relate to the level of post-crash and pre-hospital care received immediately at the accident scene, and subsequently in a health-care facility.

Impact of RTCs and Post-Crash Care in Malawi

Fatalities and injuries from road traffic crashes represent a significant and growing economic and social cost in Africa, particularly along major trade corridors. Africa has one of the highest road traffic death rates in the world, with 26.6 deaths per 100,000 people (WHO, 2018). This rate far exceeds the global rate of 18.2 traffic deaths per 100,000, with the best performing countries at rates below 3 per 100,000. In Malawi, the death rate from RTCs is estimated to be 31 per 100,000, and in 2016 alone there were an estimated 5,601 deaths in Malawi due to RTCs (WHO, 2018).

Even though around half of all road traffic deaths occur almost immediately at the scene of the crash, the outcome for the survivors at the crash site could be affected by the quality of the medical care that they receive. However, the ability to provide rapid emergency medical care for serious trauma in developing

countries is often limited. An assessment of the capacity of trauma care and emergency medical assistance to respond to motor vehicle crashes conducted in Malawi in 2014 found very little pre-hospital care, lack of a coordinated emergency response system, and poor capacity in hospitals to provide adequate trauma care (Malwafu et al. 2017). Further, in-hospital care was found to be especially sub-optimal in district hospitals, mainly due to scarce human resources, unavailability of basic and necessary equipment and lack of training in trauma care (Malwafu et al. 2017). As of 2017, there was also no national emergency access telephone number in Malawi, an important component of a successful post-crash response.

Road safety will only continue to grow as a problem if it is not addressed. As more resources are channeled towards improving road infrastructure, these upgrades often lead to higher road speeds, which can increase the number of injuries and deaths from RTCs (Job and Sakashita, 2016). At the same time, rigorous evidence on effective interventions is lacking for all aspects of the road safety agenda, and it is paramount to both study and implement a broad range of policies and interventions, from preventive measures that reduce the frequency and severity of crashes, to improved post-crash strategies that can decrease mortality and morbidity through post-crash response and medical treatment.

There are particularly large gaps in the evidence base with respect to post-crash trauma care and emergency care, in Malawi like in the majority of SSA countries. Many SSA countries have, in the recent past, started to pay more attention to and build out emergency health care services, to respond to higher prevalence rates of non-communicable disease as well as injuries, which are increasingly burdening these health systems. However, very few of the SSA countries have found a model for their Emergency Medical Service (EMS) system that is operationally and financially sound and sustainable (World Bank, 2021).

This report shares the results of a research project that set out to help fill this knowledge gap, through an impact evaluation of a new EMS pilot in Malawi. At this point in time, the EMS pilot has not yet reached its full capacity and we cannot assess and share the impact of this new system. However, the data that has been collected, through this project, can shed light on the epidemiology of trauma in Malawi, lessons learned regarding trauma data collection and experiences and insights of starting a public EMS system in a low-resource setting.

Section II of this report provides background on the operational project and an overview of the impact evaluation that was originally designed. Section III covers the trauma registry set up and data collection process. Section IV provides quantitative analysis based on data collected using the trauma registry. Section V provides limitations related to the data collection, including details on data collection during COVID-19, and identifies the challenges, successes and lessons learned with a focus on implementation logistics, stakeholder engagement strategies and data monitoring and quality assurance. Section VI shares insights on the process of implementing the EMS pilot in Malawi by bringing together data and experiences from the TR, the EMS monthly reporting, the call center data collection and close collaboration with the EMS management team. Section VII concludes with a discussion and a focus on policy implications.

SECTION II

Background

The DIME ieConnect *Health Impacts of Emergency Response and Post-Crash Medical Care, Malawi*, impact evaluation (IE) project was designed to support and evaluate a new Emergency Medical Services (EMS) pilot in Malawi, which was planned and being implemented under the Southern Africa Trade and Transport Facilitation Program (SATTFP). The goal of this IE was to evaluate the impact of the EMS pilot on trauma cases in general and RTC victims in particular. To evaluate and support the new EMS pilot a digital multi-site Trauma Registry (TR) was set up to collect data on trauma cases and outcomes from ten district and central hospitals across the country. This report provides insights from analysis done on data collected through this TR, which ran for almost three consecutive years and collected data on over 118,000 trauma patients. It also shares insights and learnings on the process of the implementation of the TR and the EMS pilot.

Malawi Health Care System

Health services in Malawi are delivered to the public through different providers including, public, private for profit and private not for profit organizations. The public sector includes all facilities run by the MOH, which is the largest provider of health care services in the country. The publicly run health care system includes 4 central hospitals and 26 district hospitals. Among the smaller facilities, there are 360 health centers and 98 dispensaries, clinics and health posts. The Christian Health Association of Malawi (CHAM) is the second largest provider of health care and provides approximately 29% of all health services in Malawi through their 170 different level health facilities. Health care services are organized in three different levels: primary, secondary and tertiary care. Tertiary health care facilities are the central hospitals, which are meant to provide specialist health services and referral services for difficult and emergency cases from the lower levels of care within the region. The Health Sector Strategic Plan II (HSSP II) identifies some of the greatest challenges in the health system to be 1) only 76% of the population lives within an 8 km radius of a health facility; 2) there is a regular shortage of essential medical products and technologies; and (3) overall, there is a 45% vacancy rate for medical personnel (MOH, 2017).

HSSP II also states that, prior to the new EMS pilot, EMS services in the country were weak and uncoordinated, and mostly focused on emergency referrals rather than pre-hospital care and emergency transportation to a health facility. Furthermore, prior to the EMS pilot, Emergency Medical Technicians (EMT) training for paramedics was not available in the country, and there was no national emergency number dedicated to medical emergencies. The third Health Sector Strategic Plan is currently being developed, and this HSSP is set to include a section dedicated to Emergency Care.

Southern Africa Trade and Transport Facilitation Project — EMS Pilot

In Malawi, and Tanzania, the World Bank is financing the Southern Africa Trade and Transport Facilitation Program – Phases 1 & 2 (SATTFP), with the objective of facilitating the movement of goods and people along a North-South Trade Corridor, while supporting improvements in road safety and health services along the corridor. The objectives of the SATTFP shall be realized through a sequential improvement in the physical, institutional and social infrastructure and the strengthening of the management of the corridor. The project in Malawi (Phase 2) was approved in April 2015 and began implementation in May

the same year. The project initially had an end date of 31st December 2021, but with approved additional financing from the World Bank, the timeline has been extended by two years until 31st December 2023.

Improvements in the corridor are expected to lead to higher speeds and reductions in travel time, and without accompanying attention to road safety, such interventions can result in increases in crashes and fatalities from RTCs. To forestall this potentiality, several road safety components are integrated into large transport programs like this one. In this case, among other efforts, a post-crash intervention was developed — The Malawi EMS Pilot. This program sub-component is focused on improving health services and emergency medical response. The pilot project is being implemented along 310km of the major highway in Malawi (the M1) between Lilongwe and Blantyre and includes six health facilities: Kamuzu Central Hospital, Dedza District Hospital, Ntcheu District Hospital, Lisungwi Community Hospital, Balaka District Hospital and Queen Elizabeth Central Hospital. The pilot involves the following components:

- Creation of a central call and ambulance dispatch center, and activation of an emergency access telephone number;
- Training of 500 community first responders from village health committees in communities adjacent to the EMS pilot area;
- Training of paramedics and ambulance drivers;
- Procurement and management of 12 ambulances and other EMS equipment;
- Design and roll out of an information campaign announcing the new emergency number and educating the public in how to use it;

- Renovation and improvement of the Trauma Care Centers in the six hospitals that are part of the EMS Pilot, this includes:
  - Procurement of equipment, consumables and laboratory equipment for each of the hospitals;
  - Increasing capacity with refresher training on Advanced Trauma Life support.
- Collecting data on trauma cases, care and outcomes, through the set-up of a multi-site Trauma Registry (TR);

In Malawi, there are gaps in the trauma care system, but also in the data infrastructure which would allow policymakers to better understand the scope of these problems. Previous attempts to establish trauma registries in Malawi have been largely based at referral hospitals (e.g., Queen Elizabeth Central Hospital and Kamuzu Central Hospital) with several more limited registries in single district hospitals over a limited period. Hence, broader trends with respect to trauma in Malawi, especially outside of the larger cities of Lilongwe and Blantyre, have not previously been comprehensively measured. This has limited the ability of policymakers to quantify the size of Malawi's trauma problem, and hampered their efforts to develop, target, and evaluate policy interventions in this area. Therefore, a new multi-site trauma registry was included as an element in the EMS pilot, with the objective to collect more and better data on trauma in Malawi.

The implementation of the EMS pilot started in May 2015. The first step was to appoint a Project Steering Committee, with the responsibility to provide oversight, strategic leadership and conduct performance monitoring of the EMS pilot implementation progress. A project implementation plan was also developed, and finalized, in October 2016.

Implementation of activities started with training of ambulance drivers, first responders and EMS providers in 2017. Twelve mini-van ambulances and related medical equipment were bought and delivered to Malawi in the second half of 2018. In the same year, the Malawi emergency number, *118, was created and a call and dispatch center was set up. Dispatchers were trained in answering and handling emergency calls as well as in how to dispatch ambulances, using a dispatching software. The TR also started operating in 5 out of 6 EMS hospitals.

A live trial of the EMS pilot began in May 2019. In order to get the system running well and address any operational challenges, the EMS pilot started operating with 6 of the 12 new ambulances. The goal of this limited roll-out was to test the new system and work on improving its management until it was ready to operate at full scale with all 12 ambulances.

In early 2020, one ambulance was used to travel around Blantyre and meet with the public and share information about the EMS services. This public-facing communication activity (known as a "roadshow") showed some success locally in educating the public about the new EMS system and emergency number. However, the roll-out of a large-scale communication campaign to the public is still needed. Renovation of the Trauma Care Centers at the six EMS hospitals is expected by late 2022.

Emergency Medical Services Pilot Impact Evaluation

While program components similar to those in the Malawi EMS pilot have been implemented in other contexts before, there is limited evidence on the effectiveness of the implementation of this specific combination of EMS services in low income, high RTC incidence settings such as Malawi. Therefore, an IE was developed to generate evidence related to EMS services in this context. The planned IE meant to evaluate the impact of the EMS pilot on intermediate outcomes such as health status of trauma patients at the arrival to hospital and timeliness of treatment of trauma patients as well as outcomes such as treatment and next-day condition (if admitted). The broad, long term, objective of the IE was to evaluate the impact of the program on health outcomes of trauma patients and to enable policy makers to calculate the cost effectiveness of an EMS system. Additionally, evidence was meant to inform decisions of expansion of the system, or, alternatively, provide information on whether other strategies might be more effective to reduce the burden of road traffic injuries. Finally, given the limited evidence on trauma broadly, another goal was to produce high-quality data on trauma that could help provide insights on trauma causes and care in Malawi. The main strategy for this study was to collect detailed data on trauma cases coming into the six health facilities that are part of the EMS pilot using the TR that was planned as an integral part of the EMS pilot project.

To note, since one of the EMS health facilities, Kamuzu Central Hospital, already had a well-functioning trauma registry in place, we focused on the remaining five facilities where there was no data on trauma being collected. The TR was started prior to the intervention in order to have a comparison period before the intervention to study how outcome variables changed after the intervention was implemented. Additionally, in order to set up a rigorous research project, and knowing that other factors affecting trauma outcomes could occur at the same time, we also selected five control units. In other words, we include an additional five health facilities in the TR as 'comparison facilities.' These facilities are also located along the M1 highway but are not part of the EMS pilot. Including both intervention and control units, the TR was set up in a total of ten central and district hospitals in Malawi. This strategy allowed for a difference-in-differences design for the impact evaluation. In addition, by collecting detailed trauma registry data in major facilities all along the main highway in the country, we could provide a more comprehensive analysis of trauma and road traffic crashes in Malawi.

During the course of 35 months (August 2018–June 2021) the TR collected a total of 118,013 observations. Since implementation of all the project components is still ongoing, an impact evaluation of the EMS pilot is not possible at this time. Once all components are fully functional for a period of time, additional data collection could allow for evaluation of the pilot. Nevertheless, there are several important and policy-relevant learnings and insights coming out of these data. These include insights on setting up high-quality trauma registries that could support better data collection in the future, as well as analyses that provide information on the current status of trauma in Malawi. Additionally, the study allowed a more in-depth look at the process of implementing this type of EMS project, and some of the learnings from this can be applicable more broadly to these types of projects. Some of these have been discussed in specialized academic publications, and this report helps to bring together the learning from these publications and the study into one report.

This report shares the results from the analysis of the epidemiology of trauma in adults, including trauma care, trauma outcomes and trauma related to RTCs, in Malawi. It also covers insights about how to effectively run a digital trauma registry in a low-resource setting, including challenges and lessons learned. Lastly, the report also shares learning insights from the implementation of the EMS pilot.

SECTION III

Trauma Registry Data Collection Process

For the IE designed to evaluate the impact of the EMS pilot, a digital, multi-site trauma registry was planned as the main data source. A trauma registry is a systematic collection of data on trauma cases, including their cause, management, treatment, and outcome. In high resource settings, TRs are considered an essential element of a well-functioning trauma care system, as they can feed into quality improvement processes, improved clinical management and care, injury prevention initiatives and policy development (Nwomeh et al. 2006).

In collaboration with the Ministry of Health (MoH), this TR was set up in ten central and district hospitals. The TR planning began in February 2018, different stages of piloting were conducted in June–August 2018, full-scale data collection began September 2018 and concluded at the end of June 2021 **(Table 1).** The aim of the TR was to collect detailed data on every trauma patient arriving to the health facility in order to understand the circumstances and outcomes of their trauma. This included demographics, information on the trauma, health data collected from the patient, and outcome data from the trauma.

Table 1. Trauma Registry Implementation and Activity Timeline

Malawi Trauma Registry Timeline		
Year	**Month**	**Activity**
2018	January	Planning of TR started. Workshop with stakeholders; MOH, DHOs, DMOs, other district and central hospital representatives, external researchers, MRA, DRTSS and Malawi Police
	February–May	Development and programming of Trauma Registry (TR). Field visits to all hospitals
	June	Field testing of TR at Dedza District Hospital with two data clerks
	July	Stakeholder Meeting to discuss the drafted TR and plans for implementation
	August	Training of data collection teams, over a two-week period. Classroom training and 'on the job training'/shadowing. Two weeks of piloting of data collection
	September	Trauma Registry Launch
	November	High Frequency Checks on the incoming data started
		Data Validation 1. Validating one week of data against HMIS data
2019	June	Data Validation 2. Validating one week of data against HMIS data
	July	Re-training 1. 'On the job training'
	December	Data Dissemination event to Stakeholders
2020	February	Data Validation 3. Validating one week of data against HMIS data
	April	COVID safety protocols were implemented
	April	Data Validation. Validating two days of data against HMIS data to assess the impact of COVID-19 on the TR data collection
	July	Publishing of paper: Implementation of a multi-center digital trauma registry: Experience in district and central hospitals in Malawi, in The International Journal of Health Planning and Management
2021	June	TR stopped operating
	September	Dissemination Event to Stakeholders

The World Bank DIME research team, MOH and other government agencies worked in close collaboration in the development, implementation and maintenance of the TR. To commence the project, a one-day workshop was held in Lilongwe, Malawi in January 2018, including the following stakeholders: MOH staff, District Health Officers (DHOs) and District Medical Officers (DMOs), other district and central hospital representatives, external researchers, as well as the Malawi Roads Authority (MRA), the Directorate of Road Traffic and Safety Services (DRTSS) and the Malawi Police.[3] The main objectives of the workshop were to ascertain the status of data related to road traffic crash trauma and trauma more broadly from the stakeholders, to learn

about current best practices and desired data collection practices from stakeholders that would collect and use the data in order to ensure ownership, and to explore feasible ways of setting up the trauma registry based on the context and best practices discussed and other relevant feedback from stakeholders. A second meeting, with the same stakeholders, was held in July 2018 to discuss the logistics of the implementation of the TR.

Over the course of 35 months (August 2018–June 2021) the TR collected detailed data on trauma, trauma care and outcomes from 118,013 patients. All hospitals in the TR were located along the main national road in Malawi, the M1, running from north to south across almost the entire country. The EMS pilot is being implemented in six hospitals located on the southern segment of the M1, between Lilongwe (the capital city) and Blantyre (the commercial hub). The TR was implemented in five out of those six, as one hospital already had a well-functioning trauma registry. Another five hospitals were chosen for the IE to be part of the TR, in order to act as "controls", meaning they were similar to the EMS pilot intervention facilities but did not receive the intervention. They were also located along the M1, but north of Lilongwe. These five facilities shared certain key features with the five facilities that are part of the EMS pilot. These features include: location within 20 km distance from the M1 and a high volume of trauma patients from RTCs on the M1. The hospitals included in the TR were (from north to south): Rumphi District Hospital, Mzuzu Central Hospital, Mzimba District Hospital, Kasungu District Hospital, Dowa District Hospital, Dedza District Hospital, Ntcheu District Hospital, Lisungwi Community Hospital, Balaka District Hospital, and Queen Elizabeth Central Hospital (**Figure 1**).

[3] At this point in time the EMS Management Team had not yet been formed.

Figure 1. Health Facilities Included in the TR

Note: The above map shows all the health facilities that are included in the trauma registry. The purple line represents the M1 highway segment. The green lines represent other roads in Malawi.

Based on consultations during the initial stakeholder meetings, it was agreed that the DHOs would select trauma coordinators for their respective hospitals, typically clinical officers or medical doctors in the participating health facilities, who would lead the TR teams. They were responsible for making sure that all trauma cases that arrived at the hospital were registered (including during nights and weekends); developing rosters for the trauma registry team; sending the data to the central server once a week; serving as the contact person and reporting any issues with the trauma registry; and serving as an expert on the trauma registry (which also required that they personally enter at least 5 cases per week). The responsibilities of the rest of the team members, including clinicians, data clerks and hospital attendants, were to collect data in collaboration with clinicians and nurses, to keep the tablets safe and secure, and to collect data on all trauma cases that arrived at the hospital. The TR teams, at each of the ten facilities, were composed of two clinicians and three data clerks.

Trauma patients were defined as those who had sustained one or multiple injuries to any body region or regions, irrespective of severity. Data was collected on all trauma cases that present at the hospital, excluding cases in which the injury occurred more than 30 days ago. Only those injured patients who came to the hospital for the first time since the injury happened were entered into the registry, i.e., follow-up visits were excluded. The TR collected data on patient demographics, mode of transport to hospital, geographic location of trauma, time of trauma, time of hospital arrival and time attended, setting, intent and cause of trauma, vital signs, AVPU (Alert, Voice, Pain, Unresponsive) scale, Glasgow Coma Score (GCS), Kampala Trauma Score, and details on up to three injuries.

Responses were based on self-reporting from the patient to the data clerk, for all parts of the TR except medical data (including vital signs), which were entered after a clinical staff member's assessment. Data collection was initiated by the data clerk when patients were waiting to be seen by the clinical staff. Demographic information, time, location and type of trauma was entered at this point; vital signs, AVPU scale and GCS score could also be entered if they were taken by the a trained data clerk or the nurse registering the patient's arrival at the hospital. The medical information that was filled in after the patient had been attended to by clinical staff included information about the injury, outcome on day one, vital signs, AVPU and GCS scores, if not yet recorded. If the patient was admitted overnight, the clerk visited the patient the next day to collect information about vital signs, AVPU, GCS score, treatment received and outcome for day two. All data was collected and immediately entered into the TR using an Android tablet, while on or offline. The data was submitted weekly to the research team by connecting the tablet to the internet and sending the data to a secure server.

SECTION IV

Analysis of the trauma registry data

The objective of this quantitative analysis of the TR data was to learn more about the epidemiological patterns and care of injuries in Malawi, with a specific focus on causes of serious trauma and RTCs. In this section we share the results from this analysis.

In total, 118,013 trauma cases were recorded in the TR over 35 months. **Figure 2** shows the distribution of cases by hospital, where each bar represents a hospital, in all cases but one. Queen Elizabeth Central Hospital (QECH) has two distinctly different entrances for trauma cases, AETC, for adults (15 years and above) and A&E for children below 15 years of age. These two departments are shown as two different bars in the graph. In all other hospitals included in the TR, adult and pediatric trauma were seen in the same department at the hospital. **Appendix 1** includes the breakdown of cases per facility per month.

We present the rest of the analysis focusing on specifically the data collected from September 2018–March 2020. We exclude the first month of data collection because it was a live-pilot phase of

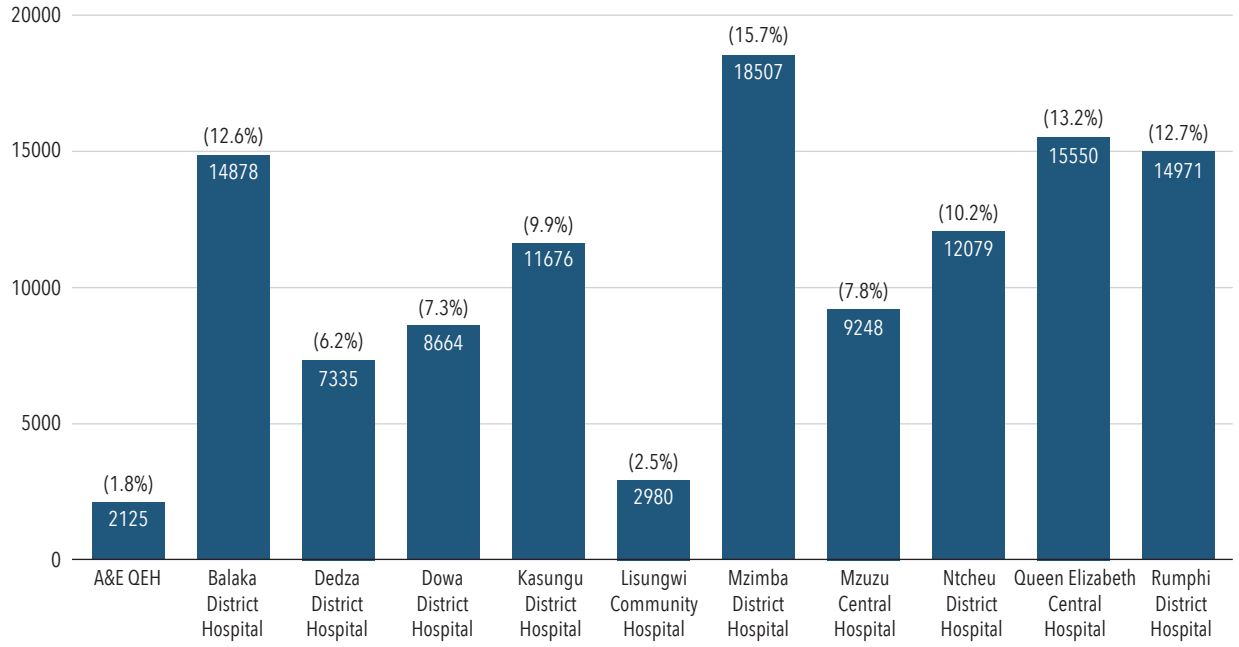


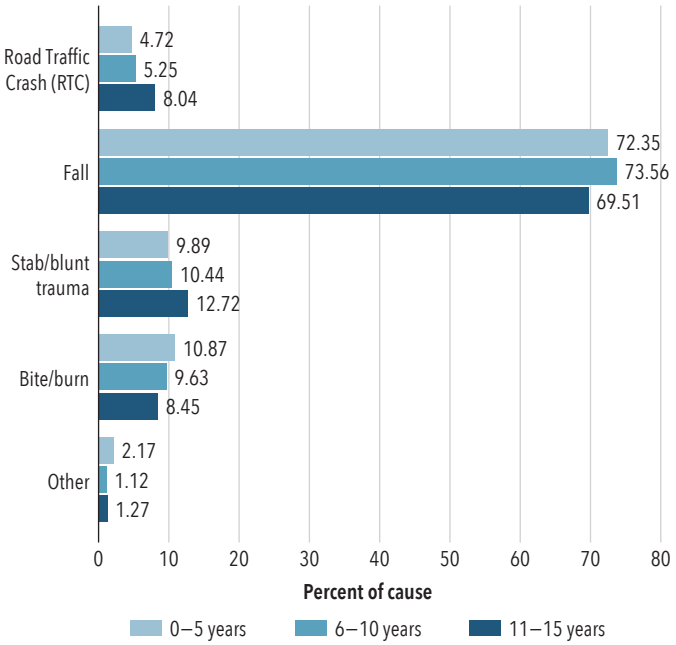
Figure 2. Number of Trauma Registry Cases by Facility

data collection. We also do not include data since April 2020 for this analysis, when the COVID-19 pandemic began to affect health system utilization and data collection (see section V for a discussion on data collection during COVID-19).

The analysis focuses on patients above the age of 15. The main reason for this is that pediatric patients experience a very different epidemiology of trauma, with an overwhelming percent of cases being dominated by falls, and only a very small percent of cases due to RTCs (**Figure 3**). Given the different epidemiology, adult and pediatric trauma is generally analyzed separately (Sawe et al. 2021b). The analysis therefore focuses on adults given the particular interest of this project in road traffic crash victims. Additionally, data was collected in QECH A&E for children under age 15 for a much shorter period of time, and we did not want this limitation in data availability to affect the analysis.[4]

[4] Data collection in QECH A&E began later, due to additional time needed to meet all bureaucratic requirements and ensure full buy-in from all stakeholders. Data collection ended in April 2020 due to COVID-19. When the pandemic first started, the team discussed with each facility if they wanted to continue data collection and determined that it posed no additional risk as compared to their typical work in the health facility. QECH A&E was the only one that expressed a desire to cease data collection at this time, and therefore the data collection was stopped.

Therefore, once we remove the 15 months of data post-COVID-19 and the data on cases below age 15, the total number of cases in the analysis is 49,241 (see **Figure 4** for caseload by month for this limited sample of adult cases). The results presented summarize the findings that have been included in the academic paper "Epidemiology of adult trauma injuries in Malawi: Results from a multi-site trauma registry" (Chokotho et al. 2021).



Other includes: Drowning, foreign object, lightning, blast, gunshot, unknown

Figure 3. Cause of Trauma for Pediatric Patients

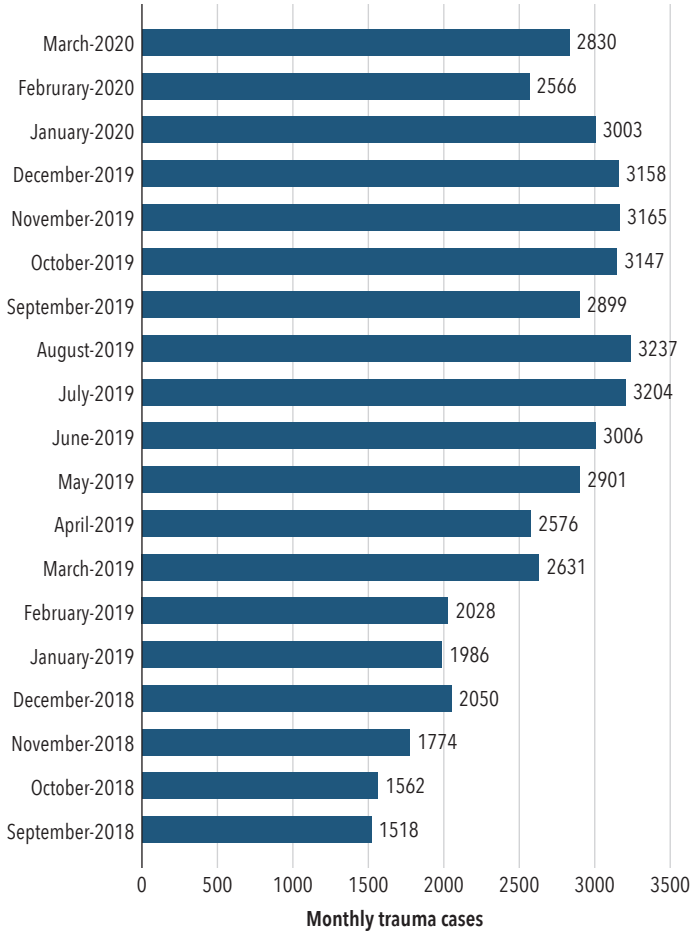


Figure 4. Monthly Caseload in Trauma Registry

Note: This figure shows the total number of adult trauma cases above age 15 reported (shown on the horizontal axis) each month of the study (as shown on the vertical axis).

Demographic Information

Figure 5a shows the demographic correlates of trauma cases in the sample. Injuries are most common for younger adults. Two-thirds of trauma patients are male, with greater gender differences at younger ages. The most common occupations observed in the trauma registry are farmers (26%), students (16%), manual laborers (14%), small businessmen (12%), and housewives (12%). Most trauma cases occur among patients with primary education (47%), followed by secondary education (40%) and no education (5%).

Injury Details

The analysis examines mechanism of injury, type of injury, disposition, injury severity and timeliness of care for non-admitted and admitted trauma cases, using hospital admission as a proxy for severity.

The most common mechanisms of injury are falls (45.8%), followed by RTCs (19.5%), blunt trauma (15.5%), stabs and cuts (10.7%) and bites (5.8%) (**Figure 6**). The most common diagnosis across all trauma cases are soft tissue injuries (42%), followed by fractures (27%), lacerations (12%), bite/stab/abrasion/burn (10%), contusion (4%), dislocations (2%), and head/spine/internal (1%).

For admitted trauma cases (which are also some of the more severe cases, demonstrated by the need to remain at the health facility), the most common mechanism of injury was RTCs (48%), falls (22%), blunt trauma (12%) and penetrating wounds (11%). The most common type of injuries for admitted patients

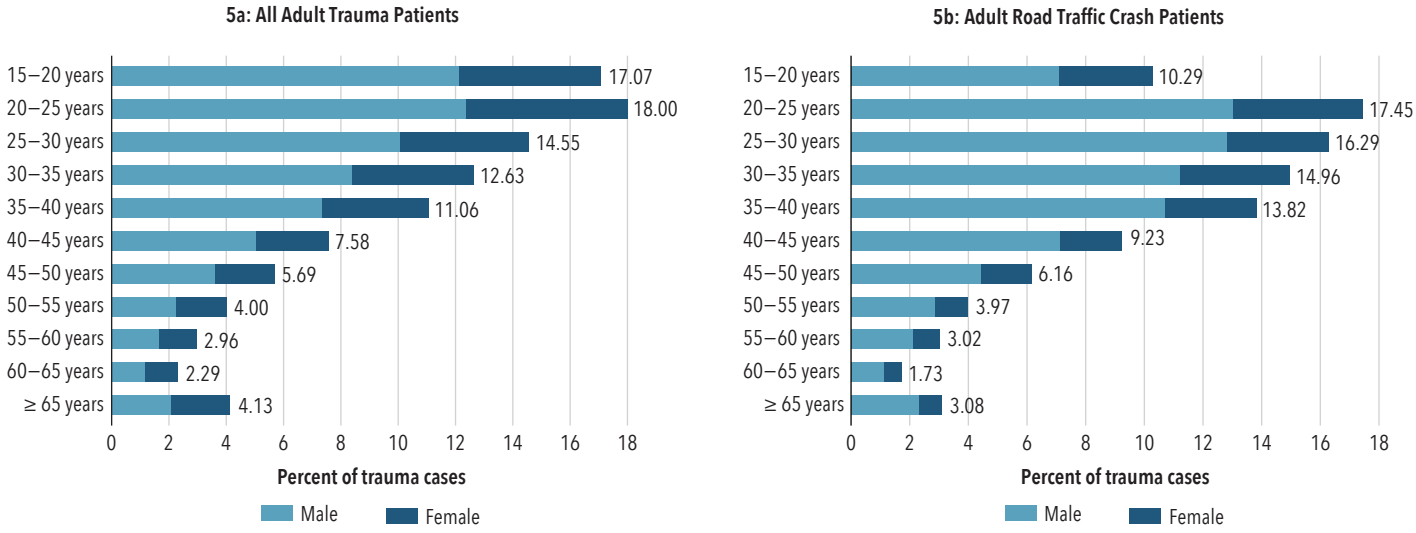


Figure 5. Age and Gender of Trauma Patients

Note: The above graphs show the age groups on the vertical axis and the percent of trauma cases from each age group on the horizontal axis.

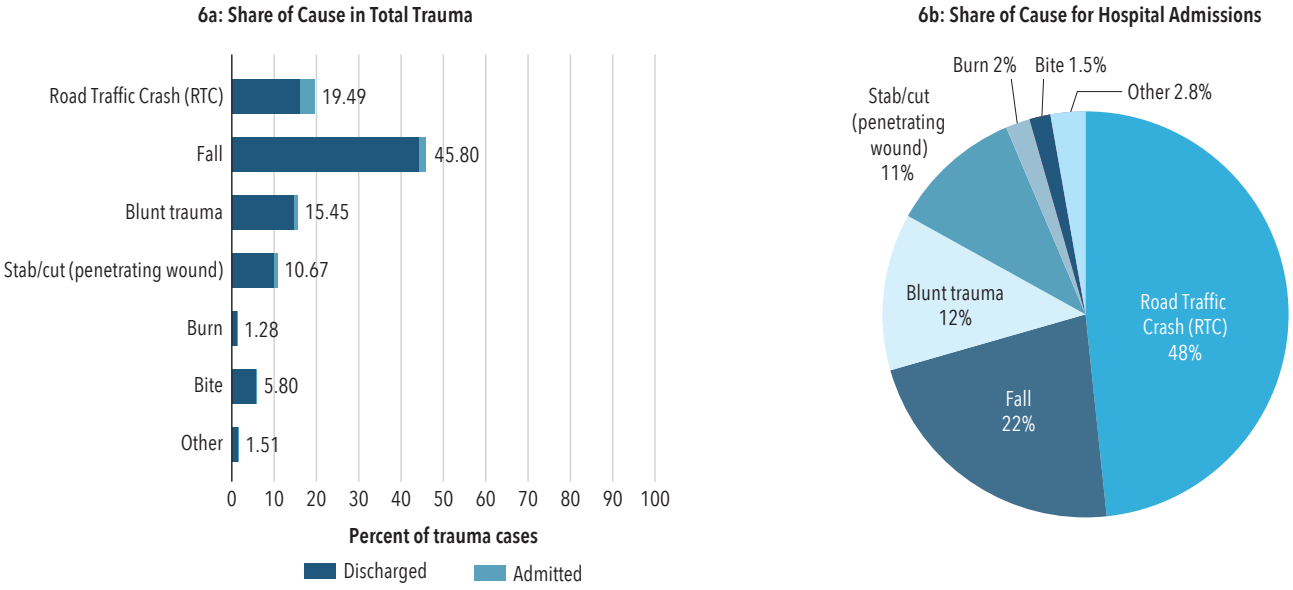


Figure 6. Share of Trauma Causes

were fractures (35%), followed by soft tissue injuries (20%), and lacerations (13%). 71% of injuries were to the extremities, while 7.14% were to head and neck, and 8.33% to the face, 3.19% to the thorax, 1.54% to the abdomen, and 7.01% external.

Geographic Location of Trauma

In the trauma registry, data is recorded on the location of where the trauma occurred. The trauma registry recorded cases from all 28 districts in Malawi. The districts in the map refer to the district where the trauma occurred (**Figure 7**). For 24,523 trauma cases (50% of total trauma), the setting of the trauma was the patient's home, for these cases, the district of the patient's home was used as the trauma district. It is important to note that the geographic concentration of trauma cases is largely driven by the location of the ten health facilities where data was collected. The map in the center shows the number of road traffic crashes for each district. Darker color represents the district with a higher number of RTCs.

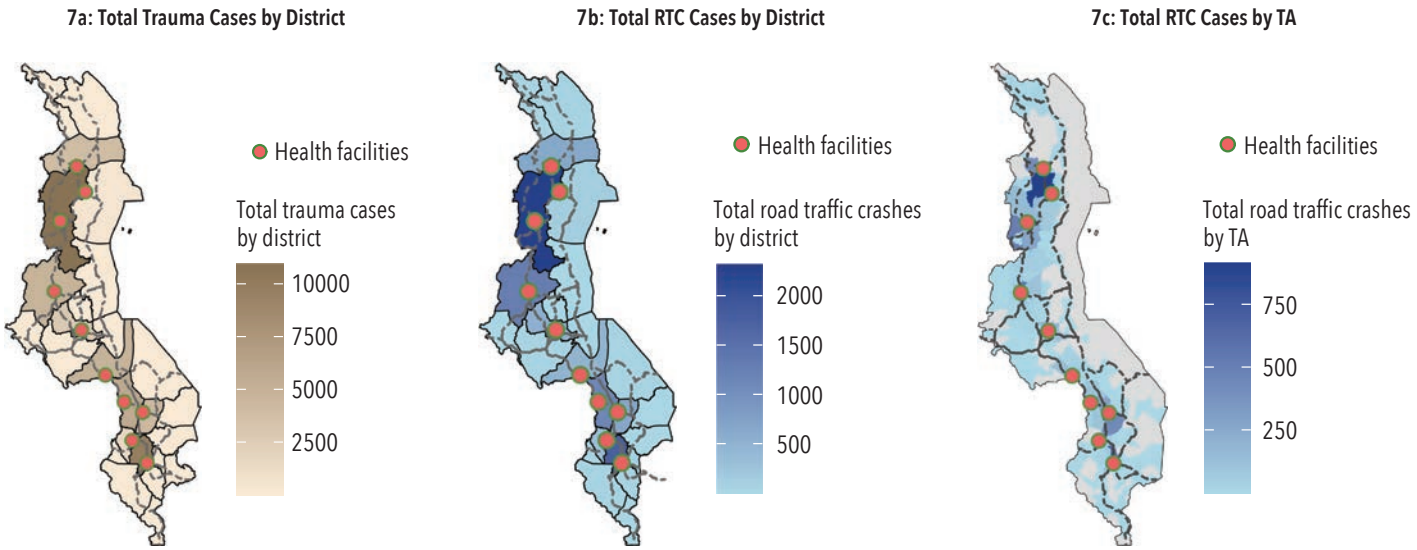


Figure 7. Geographic Information on Trauma in Malawi

Note: The above panel shows total number of trauma cases by district (a) with 48,747 trauma cases (1% cases were missing information on district); the total number of RTC cases by district (b) for 9,489 RTC cases (1% cases were missing information on district); and the total number of RTC by TA (c) for 8,565 RTC cases (7% of RTC cases were missing or had incomplete information on TA in the trauma registry.)

The districts with the highest number of trauma cases are: Mzimba 10,954 (22%), Blantyre 9,832 (20%), Ntcheu 5,544 (11%), Dedza 4,696 (9%), Kasungu 4,599 (9%), Balaka 4,114 (8%) and Rumphi 3,855 (8%). For each of these districts, RTCs make up on average 18.4% of their case load, with Dedza as low as 10% and Kasungu as high as 28%. We can further break down the geographic location of RTCs by "traditional authorities" (TA), which are smaller geographic areas (Figure 7c). This is available for 93% of RTC cases. Again, the geographic concentration is largely driven by the location of the health facilities where data is collected. Nevertheless, we see an important concentration of crashes in the north of the country on the M1.

Time to Hospital Care

Median time elapsed between occurrence of trauma and patient arrival at hospital is 8 hours 59 minutes (Interquartile Range, IQR, 1 hour 50 minutes, 23 hours 50 minutes). Yet, around one quarter of the patients come to the facility more than 24 hours after the trauma, signaling that this timing is not only a reflection of transport needs for accessing care but also behavioral trends in delays to seek care. When we limit the analysis to those patients arriving within 24 hours after the trauma, the median time to arrival is three hours.

Separately, we examined timeliness of treatment for the subset of severe trauma cases that represent urgent need for care based on four serious characteristics (patients who were admitted to hospital, patients with AVPU < 4, patients with GCS < 8, and patients whose self-reported pain level was severe or extreme). We again focus on those that arrive within 24 hours of the trauma. **Figure 8** shows the arrival times across all trauma, RTCs, and severe trauma, focusing on cases arriving within 24 hours of trauma. Severely injured patients arrive after a median time of 2 hours, and RTC patients arrive after a median time of 1 hour 40 minutes. If we only look at the non-RTC severe cases, though, the median time to arrival is 4 hours.

Figure 8 also shows the time to receive care post-arrival. For RTCs, patients are seen by a clinician within a median 35 minutes after arrival. For minor trauma, patients are seen approximately an hour after their arrival. Severely injured patients are seen within 10 minutes of their arrival.

For admitted trauma cases, the most common modes of transport to hospitals are private (29%) and commercial vehicles such as taxis (21%), public modes such as minibuses (16%), and ambulances (6%). In contrast, ambulances are the most-used mode of transport for referral cases between facilities (39%).

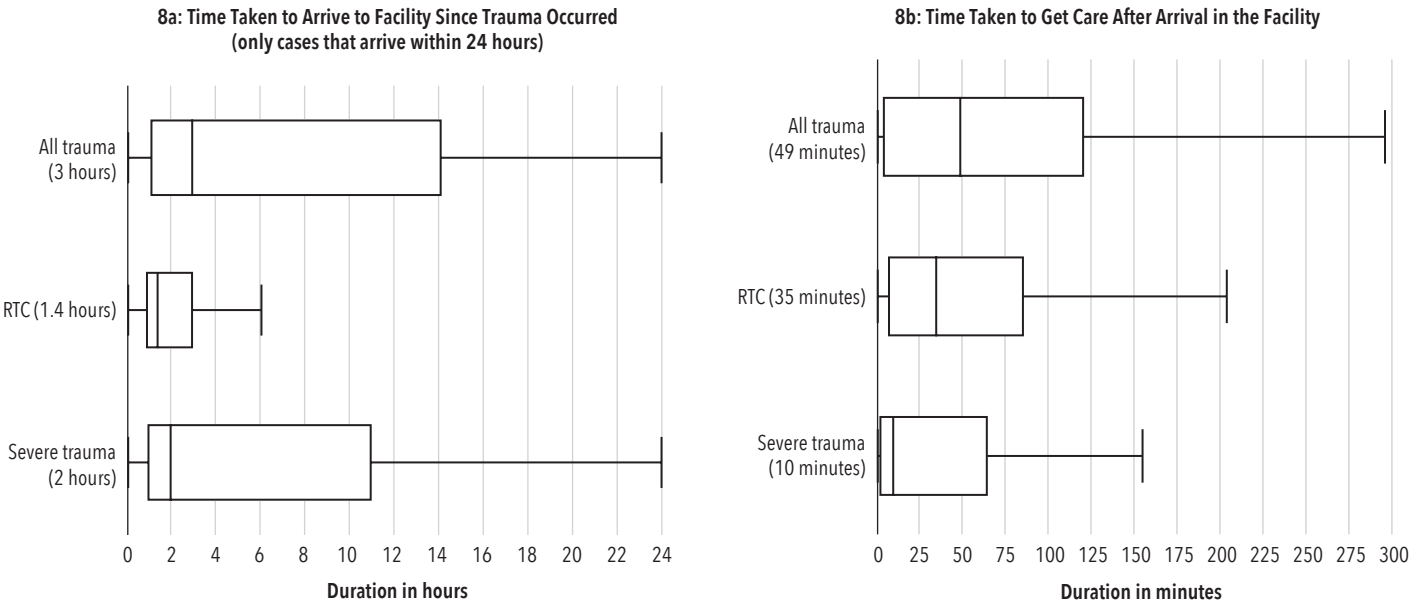


Figure 8. Time Elapsed from Occurrence of Trauma to Hospital Arrival and Care

Note: The left panel shows the distribution of duration of arrival to the facility since trauma only for cases that arrived in the facility on the same day as the trauma occurred (i.e., within 24 hours). The vertical axis represents the distribution of arrival for all trauma, road traffic crashes and all severe trauma arrived in the facility within 24 hours of the trauma. The panel on the right shows the duration to get care since arrival to hospital. The vertical axis represents the distribution of arrival for all trauma, road traffic crashes and all severe trauma. In both figures the horizontal axis represents the duration time. The line inside each box represents the median duration of time, from trauma to arrival, and to care. All referred trauma cases are excluded.

Disposition

There are three separate measures that help in assessing the severity of a case. These include the GCS score, the AVPU scale and the pain score provided by the patient. The large majority of cases coming to the health facilities are not severe, with a GCS score of 12 or above, a measure of "Alert" (4) on the AVPU scale, and a pain score of none to moderate (**Figure 9**).

The trauma registry also records the final outcome of the trauma case in the casualty department on the day they visit the hospital. 92% (45,374) of all trauma were treated and sent home the same day, 6.5% (3,232) of cases were admitted to another ward, 0.14% (74) were taken to the operating theatre, 0.04% (19) were taken to the ICU, 0.09% (42) of patients died in the casualty department, 0.49% (242) were referred to another facility, 0.4% (177) were dead on arrival.

Out of 3,325 patients who were admitted to a ward, admitted to operating theatre, or taken to the ICU, 1,636 (49%) were still in the hospital 24 hours later. Of those no longer in the hospital, 842 patients were discharged (79%), 119 transferred to another hospital (11%), 29 (2.9%) died, 17 (1.5%) ran away and 54 (5%) was unknown. The next day status was missing for 628 (18%) of the patients who were admitted to ward, ICU or operating theatre. Out of the patients who stayed overnight and were still in the hospital 24 hours later, 89% (1,459/1,629) reported being in moderate or severe pain on day 1, which went down to 70% (1,156/1,629) as reported on day 2. This demonstrates improvements in the condition of over 20% of patients reporting moderate or severe pain.[5]

[5] The pain level data was not available for seven of the patients who were admitted to the hospital and were found 24 hours later.

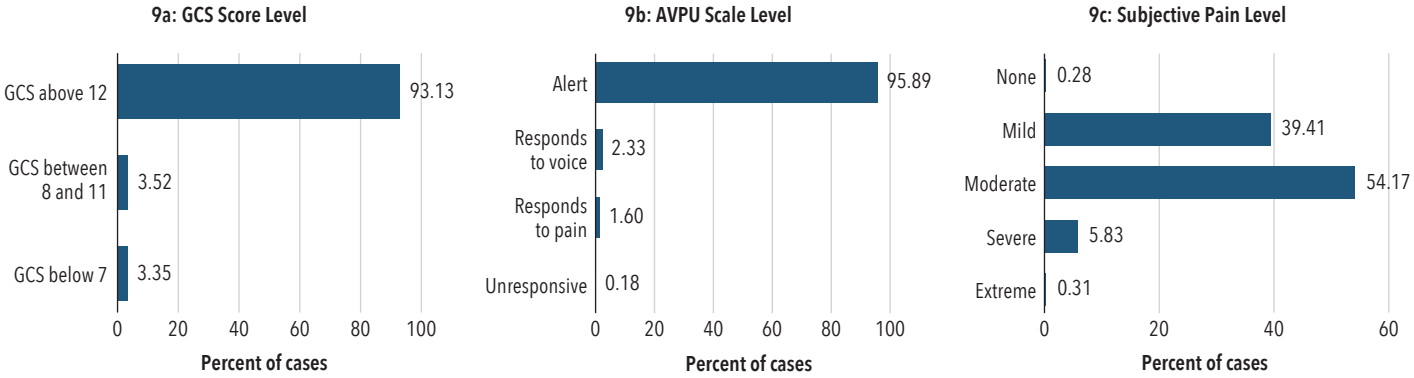


Figure 9. Different Measures of Severity

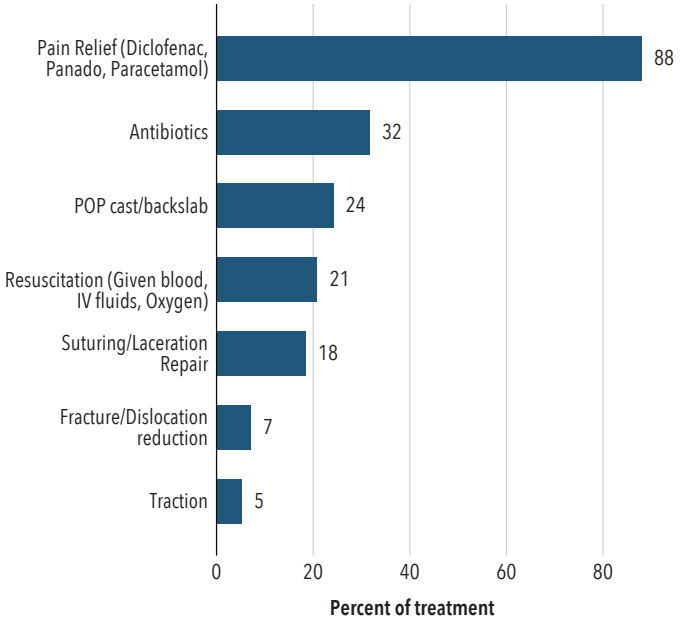


Figure 10. Top Seven Treatments Given to Incoming Trauma Patients.

Note: The above figure shows the different treatments (shown on the vertical axis) and the percentage share of trauma cases that the treatment was given. It is important to note here that multiple treatments could be given to one patient so this will not sum up to 100%.

The treatment provided was collected for 1,636 patients who stayed in the health facility overnight. The trauma registry recorded all types of treatment that were given to the patient. Pain relief was given in most of the admitted trauma cases, and antibiotics were given in just over a third of cases (**Figure 10**).

Trauma Due to Road Traffic Crashes

Since RTCs represent almost half of all trauma cases requiring hospital admission, they are examined in more detail here. The percent of trauma cases that are RTCs in each facility varies from 11% to 28%, with Kasungu, Lisungwi and Mzuzu seeing the highest percent of RTCs (**Figure 11**). **Table A1** in Appendix 1 shows the detailed breakdown of the number of trauma cases, RTCs and admission by hospital. The demographic distribution of RTC patients is similar to the distribution for all trauma patients, though it is much more concentrated in the ages of 20–40 (**Figure 5b**). Given these are the prime working ages, this demonstrates the large economic opportunity cost that RTCs represent. RTCs are also even more highly concentrated in men, compared to all trauma.

The analysis shows that 1.3% (133/9,595) of RTC patients were dead on arrival at the facility and 18% required admission to hospital. Soft tissue injuries are observed in 45% of RTC patients followed by fractures (20%), contusions (11%) and lacerations (11%) (**Figure12**). Importantly, head, spine and internal injuries make up a much larger percent of RTC cases as compared to all cases, and these are some of the most serious injuriesthat require significant care.

We find that non-motorized users (pedestrians and cyclists) make up approximately half of all RTC trauma patients (49%) (**Figure 13**).

For motorized RTCs, we find limited adherence to safety practices, where 84% of patients who were passengers of

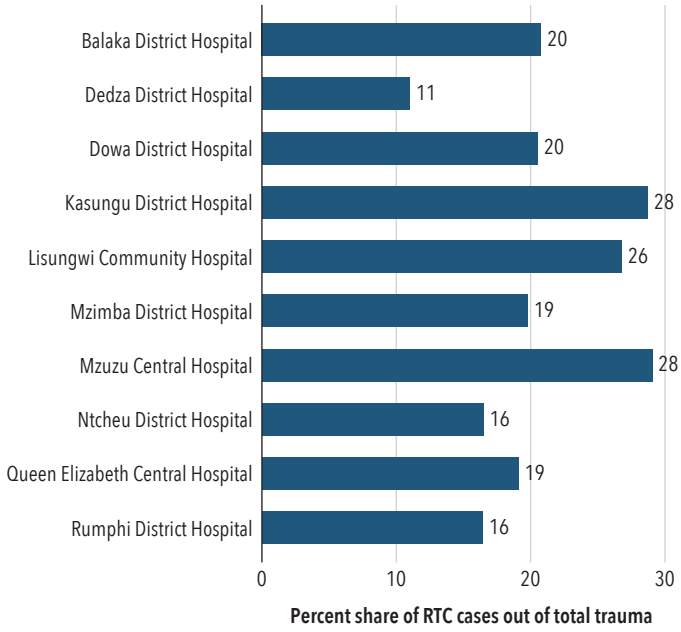


Figure 11. Percent of Road Traffic Crash Patients by Facility

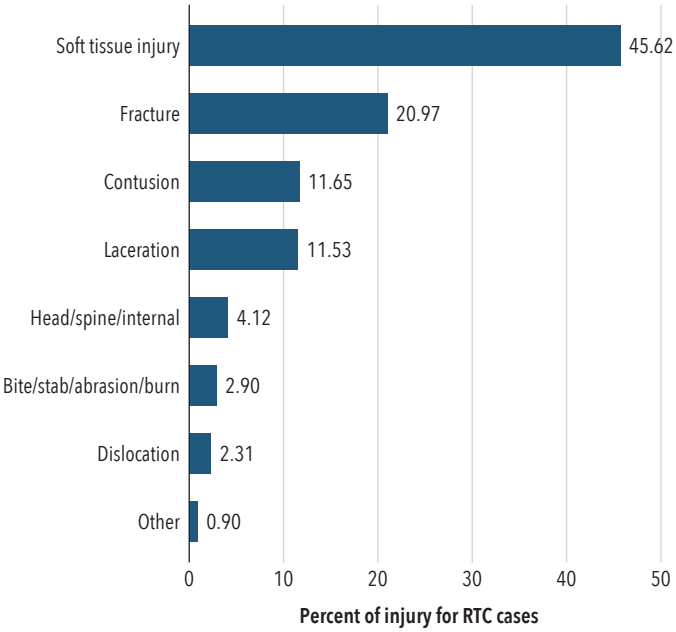


Figure 12. Type of Injuries for RTCs

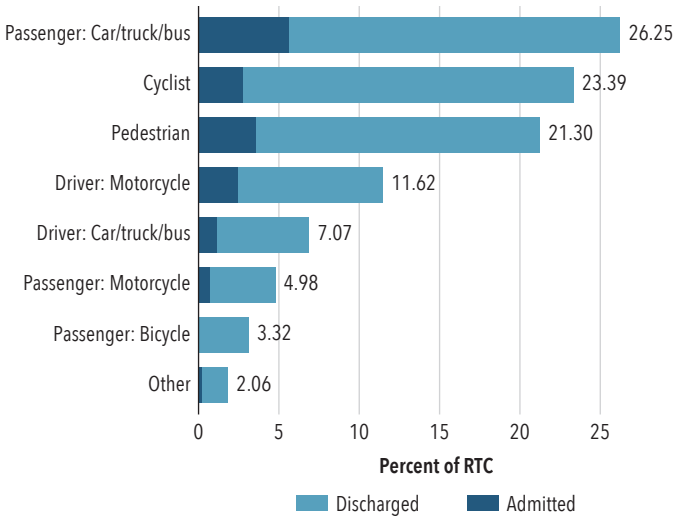


Figure 13. Role on the Road for RTC Injuries

Note: The above figure represents the types of road users on the vertical axis and their percentage share in the trauma registry's road traffic crashes on the horizontal axis. The light grey region represents share of road users that were discharged the same day, the dark grey region represents share of road users that required hospital admission after the injury.

motor vehicles such as cars, buses, and trucks report not having worn a seat belt, and 52% of patients who were drivers or passengers of motorbikes report not wearing a helmet.

Among admitted road traffic crash patients, passengers of car/bus/trucks make up a third (32%) of the road users in RTC cases, followed by pedestrians (20%) and cyclists (16%). Overall, 50% of admitted pedestrians were struck by private vehicles or trucks, 23% by public transit vehicles, 17% by motorcycles and 4% by bicycles.

We present geographic variation in pedestrian crashes in the regions surrounding the facilities by looking at the share of RTCs involving pedestrians out of the total RTCs recorded in each facility from the 10 hospitals. Queen Elizabeth Central Hospital (45%), Dedza District Hospital (20%), Balaka District Hospital (18%), Ntcheu District Hospital (17%), Mzuzu Central Hospital (17%) and Kasungu District Hospital (16%) each have more than 15% of the RTC caseload involving pedestrians (see **Appendix 1** for total number of RTC for each hospital). There is a clear need for a focus on pedestrian interventions in Blantyre where almost half of RTC victims coming to QECH are pedestrians.

Figure 14 shows the peak hours of road traffic crashes as recorded in the trauma registry. There are two peaks of RTCs consistent across all the road users coinciding with morning and evening rush hours, one between 6:00–10:00, and a second peak between 16:00–20:00. Non-motorized users (pedestrians and cyclists) have a higher share of RTCs happen during those peaks and almost none in the night hours. By contrast, cars, trucks, and buses have a higher share of crashes happening between 22:00–6:00, possibly due to lower visibility, fatigue, or speeding. Presence of alcohol was confirmed in 6.7% (45/678) of all drivers of cars, trucks, buses and suspected for an additional 2% (15/678).

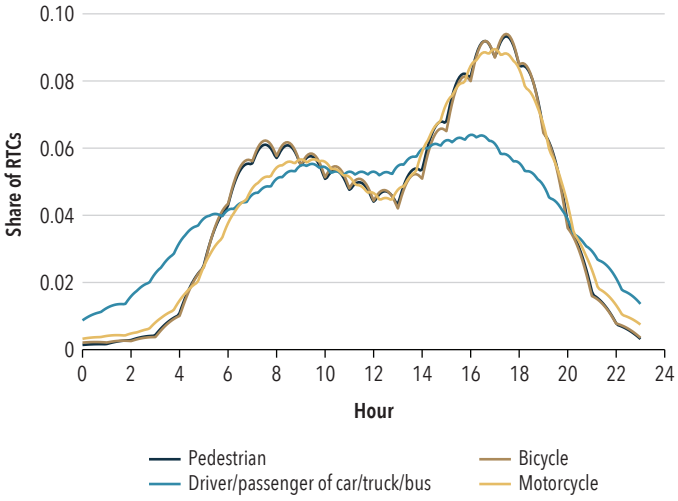


Figure 14. Distribution of RTC by Road Users and Time of Day

Note: In the above figure, each line represents a road user type recorded in the trauma registry. The figure represents the share of road traffic crashes recorded in each hour of a 24-hour day (on the horizontal axis) for each road user type

SECTION V

Challenges and Actions for Successful Trauma Registry Implementation

Actions for Successful Implementation

Like other trauma registries in similar contexts, key challenges for the TR implementation and data collection were institutional support, implementation logistics and data quality.

- **Institutional Support:** Data will only be useful if used and, data will only be collected if it fits naturally into the daily work routines. However, challenges in this process included busy schedules and many competing priorities in the health care system, and it was therefore not always easy to reach consensus.
- **Implementation Logistics:** Each hospital functions differently from the next, and they all run on very limited resources and staff. In addition, in several instances the institutional environment was complex, such as at referral hospitals, with multiple entry points for trauma patients, multiple ongoing research projects, and high patient volumes. Therefore, it was important to

develop a TR that was flexible enough to be able to function in any hospital, and easy to learn how to operate and implement into the daily routines.

- **Data Quality:** An important aspect in working with trauma data is ensuring the quality of the data, which is an ongoing process. Often trauma registries, especially in low-resource settings, can suffer from quality issues including missing variables or a large number of cases that are not entered at all, as well as issues with incorrect information entered.

Actions taken by the team to address these challenges can be divided into 3 categories: 1) Planning & stakeholder involvement, 2) Implementation support, and 3) Data quality assurance activities **(Table 2).**

Planning and Stakeholder Involvement

The team worked closely with end-users of the data at all levels, including clinicians, DMOs, DHOs and MOH, as well as the staff tasked to collect the data. Ultimately, this process was a crucial step in deciding what data to collect and how to execute the data collection. The MOH, the World Bank DIME research team and other government agencies worked in collaboration on the development, implementation and maintenance of the TR. To commence the project, a one-day workshop was held in Lilongwe, Malawi in January 2018, bringing together all relevant stakeholders. A second meeting, with the same stakeholders, was held in July 2018 to discuss the logistics of the implementation of the TR. These engagements were critical in achieving consensus and ensuring that the data collected in the TR would be relevant for policymakers.

The initial and ongoing consultation and collaboration through the workshops, field visits, frequent communication and several rounds of receiving feedback and incorporating it into both the registry tool itself and into registry processes were important for establishing support and engagement. These forms of ongoing engagement were especially important when there was a need to iteratively test and adapt different approaches to solve data collection or data quality challenges.

Table 2. Principles for Successful Trauma Registry Implementation

Principles for success	Actions taken	Detailed explanation
Trauma Registry Planning and Stakeholder involvement	Key stakeholder meeting and communication	Several events (stakeholder consultations) and consistent communication and feedback throughout the process of planning, developing and implementing the TR
	Develop a TR fit for context	Study of the context and current best practices for data collections through discussions and feedback from stakeholders (on all levels) and field visits
	Make data available useful	Key stakeholders to feedback on the draft tool and data feedback loops, continuously
Trauma registry implementation support activities	Pre-testing TR	Drafted TR tool was pre-tested in one central and one district hospital, with trained HMIS data clerks
	Piloting TR	Pilot testing of TR tool, data management process and data feedback loops, in one central and one district hospital
	Data collection team	One TR coordinator (clinician), one ER clinician and three data clerks from each hospital, selected by the DHO
	Training	Two days: One-day classroom training (including role play) & one day 'on the job training'/shadowing
	Refresher training	After 11 months; informed by the data collection and data quality seen during that period. With two main objectives: 1) to improve data quality in key variables like vital signs, cause and intent of trauma and 2) to train new data clerks that had been added or replaced
Data quality assurance activities	Ongoing support and communication	Each TR Coordinator had a main point of contact within the Trauma Registry Monitoring team, who aimed to respond to any request within 24 hours by phone or WhatsApp
	Field visits	Two supervisory visits to all hospitals in the first six months, and then as needed
	Digital Data Collection	The digital data collection reduced data entry errors and increased data completeness. It allowed for hard-coded controls, automated skip patterns and immediate quality checking of the data, including feedback to the data collections teams
	Dashboard on Dropbox paper	Weekly sharing of descriptive statistics at the facility level
	Weekly High frequency checks	High frequency checks flagging potential issues and mistakes in the data, including checks on missing data, notable outliers and logically inconsistent answers
	Three data validation exercises	Comparison of TR data with regular HMIS data

Source: Croke et al 2020.

Implementation Support

To overcome the challenges generated by heterogeneity across health facilities, several visits were made to all ten hospitals, to see the infrastructure and to discuss with DHOs, medical and HMIS staff. As the TR was developed, pre-testing and piloting of the TR was extensive and allowed feedback to change the TR as needed. Testing was done in both a central hospital and a district hospital, acknowledging that the way these different levels of facilities work is different and therefore piloting should be done at both levels to ensure success. As change is constant, the research team continued to make support visits, respond to requests from data collection teams and make necessary changes to the TR throughout the entire data collection.

Data Quality Assurance Activities

With the help of several different strategies, the quality of the data in the TR improved over time. Improvements in data quality included an increase in monthly capture rates, completeness of important variables and improvements in correctness of data, in terms of outliers and inconsistencies. Data quality was ensured through frequent in-person and digital communication with trauma data collection teams, weekly updates and sharing of an online data dashboard showing results from ongoing data analysis, and through the activities of the team, which conducted ongoing visits and refresher trainings. Even as data quality constantly improved, ongoing supervision was key in both improving and maintaining data quality over time. Three additional activities were extremely important for quality assurance: 1) the digital nature of the data collection, 2) high frequency checks, and 3) data validation.

Digital Data Collection

A digital data collection tool had many advantages. First, it reduced data entry errors, i.e. when entering data collected on paper into a digital database. Second, it enabled hard-coded controls on what input is allowed, which also limited data entry mistakes. Third, it helped to ensure completeness of data as fields can be made mandatory to ensure data clerks or clinicians enter data for all of them. Fourth, it helped the data collector with skip patterns, making sure that only the questions valid for the situation at hand were being answered, which led to less contradictions in the data. Fifth, it allowed for immediate management and initial basic analysis of data, which could serve to improve the tool itself and facilitate learning of data collectors and thereby continuously improve the trauma registry, the tool itself and the data it collected.

High Frequency Checks

The research team conducted weekly high frequency checks on the incoming data to flag potential issues, including outliers and errors in the data entry. These issues were then reported back to all trauma coordinators and the data clerk who had made the mistake. The high frequency checks included checks on missing data in important variables, such as vital signs, or notable outliers and logically inconsistent answers, such as when the diagnosis indicated that a patient was very badly injured but the recorded outcome was "treated and sent home."[6] There were 15 different checks and the research team conducted all of them once a week.

Looking at the monthly number of entries in the TR over all months the TR was running, there were lower numbers of entries during the first 6 months of the TR, which later increased and stabilized at a higher level (**Figure 15**). This increase is believed to be due to improvements in the TR operations, TR clerks' understanding of the TR itself and how to operate it, and the consistent high frequency checks and weekly check-ins with the clerks.

Data Validation

In addition to high frequency checks for outliers and inconsistent responses, the research team also conducted three data validation exercises to examine the completeness of the data. In government health facilities in Malawi, paper registers are used to register patients. These are part of the Health Management Information System (HMIS) in the country, and they capture basic demographic and medical information. The HMIS data is

[6] Note that this type of inconsistency does not always indicate a mistake, since there might be a specific reason for someone that was indicated as badly injured to be sent home. The flags were meant to indicate data points that should be double checked and corrected if a mistake could be confirmed.

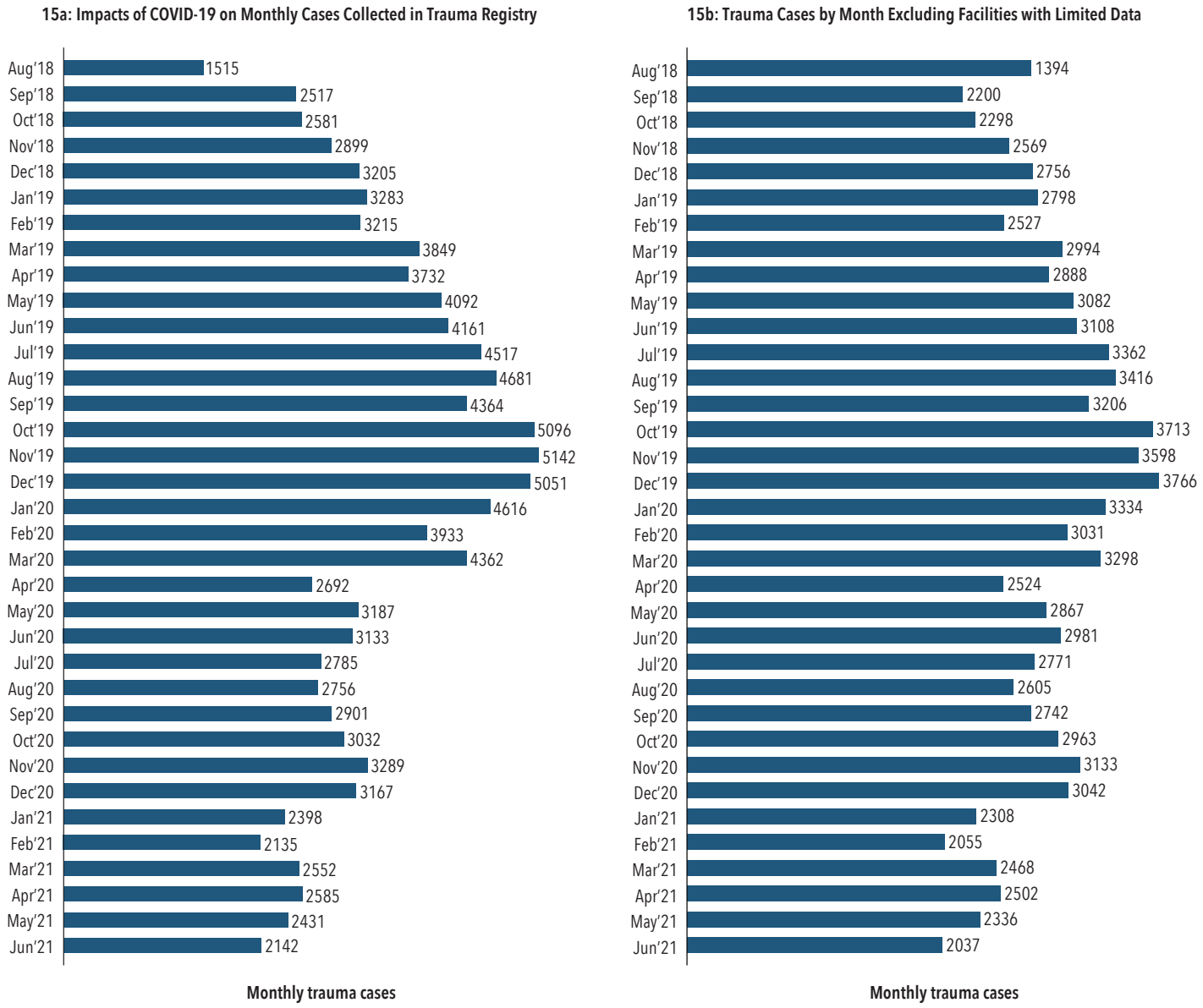


Figure 15. Trauma Cases by Month

then aggregated in each hospital and fed into the national HMIS data system. In the national HMIS data system, information about trauma cases is entered as code 47a ("Trauma") or 47b ("Road Traffic Accident"). The research team used this HMIS data to compare and validate the TR data. The number of entries in the TR was validated by comparing to the number of entries in these paper registers in all participating facilities. While there were challenges with comprehensiveness of this HMIS data, the comparison provided a good indication of the coverage of the trauma registries. Data validation exercises took place on three occasions, November 2018, June 2019 and February 2020. **Table 3** provides the outcome of the last validation in February 2020, showing the cases in the HMIS data, the trauma registry and the percent coverage.[7]

Additional Challenges

The shortage of health care staff in Malawi posed a challenge for the Trauma Registry data collection as it became clear that, when a staff member is absent there is seldom anyone available to

[7] Note that in some health facilities, the number of cases captured in the trauma registry exceeded the number of cases in the HMIS data. For a number of reasons, there can be cases where not all patients coming into a facility are registered in the paper record and therefore the HMIS data can be an undercount of patients.

Table 3. Data Validation February 2020

Hospital	Date collected	Dates of data*	Total trauma cases, HMIS	Total trauma cases, registry	Registry coverage (%)
QECH	16.07.19	24–30 June	282	251	89%
Balaka	17.07.19	24–30 June	61	114	187%
Ntcheu	18.07.19	1–7 July	166	94	57%
Dedza	24.07.19	15–21 July	22	94	427%
Lisungwi	18.07.19	24–30 June	19	17	89%
Dowa	05.07.19	24–30 June	40	56	140%
Kasungu	04.07.19	24–30 June	52	88	169%
Mzuzu	10.06.19	13–19 May	86	72	84%
Mzimba	03.07.19	24–30 June	116	132	114%
Rumphi	02.07.19	24–30 June	84	45	54%
Total			**928**	**963**	**104%**

*Represents the range of dates within which the number of trauma cases from the Trauma Registry and HMIS was collected for comparison

cover for this person. An example of this became apparent during the February 2020 data validation (**Table 3**) when Rumphi District Hospital, which generally performed well in the TR data collection, showed a capture rate of only 54% for the incoming trauma cases. After further investigation, it became clear the clinician working in the Orthopedic hospital entrance, which is one of two entrances for trauma cases at Rumphi District Hospital, had been absent during the dates used for data validation. This resulted in cases being missed during that time. It was not uncommon for us to find this to be the case when we observed a lower number of entries than expected at a specific facility.

Further, while regular HMIS data should be collected at every department in all facilities, we do find that this is not always the case, i.e. the routine for data entering is not always established. This was for example the case at one of the trauma entries at Dedza District Hospital (**Table 3**), which we believe is the reason for 400% more trauma cases being reported through the TR than the regular HMIS data. While all hospitals had some challenges with the data collection at times, the teams worked through them and continued the data collection, which generally improved over time. However, in the case of Dedza District Hospital, the research team and the Dedza DHO agreed to stop data collection after two years, due to poor data quality.

A number of factors, including the large volume of patients at the hospital, affected the quality of data collected in Dedza, and it was decided that data collection funds could be more effectively spent elsewhere given the unreliable nature of the data coming from this facility (see Appendix 1 for monthly cases recorded in the TR at Dedza District Hospital). Before stopping the TR, the research team tried several different interventions in order to help the situation, such as liaising with the Dedza DHO and the hospital's TR coordinator, changing the TR coordinator, giving additional training for the data collection team in this facility as well as frequent site visits. Despite the shorter period of data collection in this facility, it was still a valuable learning experience in terms of the challenges that can arise with data collection. In particular, we learned that when the data collection is not an established routine task, the TR data trends were often more erratic. This required additional follow-ups, check-ins and support to the coordinator, to keep the TR data collection performing well. Nevertheless, the two years of data collected in the facility can still provide useful information.

Impact of COVID-19 on Trauma Registry Data Collection

The first COVID-19 case in Malawi was confirmed on the 2nd of April 2020 after which the country had a relatively small first wave between June and September 2020. The first wave was followed by two larger waves in December 2020–March 2021 and June–August 2021.[8] The Government of Malawi (GoM) implemented restrictions to decrease the spread of the virus,

[8] https://covid19.health.gov.mw/

such as closing schools, but a full lock-down has never been implemented in the country. While this report does not cover a comprehensive analysis of the impact of COVID-19 on the TR data collection (or on the epidemiology of trauma in Malawi), it is evident that the data collection was affected by the onset of the COVID-19 pandemic in Malawi, which will be described in this section.

In order not to contribute to any further spread of COVID-19 through the running of the TR, the data collection team contemplated stopping the registry. However, after a discussion with stakeholders and TR coordinators in April 2020, it was decided that the TR should continue. Since the majority of the data collectors working on the TR were already health facility staff, working in the facilities seeing patients or collecting standard data, continuation of the TR did not increase exposure risk. In two cases, external staff helped to collect TR data, one at QECH in what is known as "Room 8" and one at Mzuzu Central Hospital. These two data clerks did stop working on the TR data collection, in late April 2020 in order to ensure their safety. This led to significant reductions in the number of cases collected at these two facilities, as seen in Appendix 1. Furthermore, safety protocols were implemented to ensure any risks associated with the TR were minimized.

Trauma Registry COVID-19 safety protocol:

- Everyone working on the TR should wash hands with **soap** and water — often!
  - Always wash hands before and after start using the TR tablet
- Wipe the TR tablets with spirit, regularly
- The patients should be seen by a **clinician first and then the data clerk** — this way if the patient is showing any signs of COVID-19 the clerks should not interact with the patient at all.
- Clerks should stop taking Vital Signs, for all patients — this shall be done by clinicians.
- If the patient is showing signs of COVID-19 the TR will be shortened to only include a few questions, to be filled in by the clinician, not the clerk.
  - An updated version of the TR included a question asking *"Is the patient showing signs or symptoms of being infected by COVID-19? Based on the clinician's assessment"*.
    - **If yes**, then the TR is shortened to only ask questions about the following: hospital, mode of transport, demographics (shortened), time of arrival & time of trauma, cause of trauma, VS and outcome day 1.

Due to the COVID-19 safety protocols that were implemented in April 2020 (as above) the completion rate of some variables in the TR is lower after April 2020.

Additionally, while the TR continued in facilities, from the onset of the pandemic in Malawi, in early April 2020, the number of monthly entries declined. The majority of the decline in cases in the TR is driven by the removal of full-time TR staff for COVID safety reasons as well as the stop of data collection in Dedza and QECH A&E (see comparison of **Figure 15a** and **15b**). Nevertheless, there are still some declines in cases during this period even after removing the facilities/units where data collection was stopped (**Figure 15b**). Our analysis on the reasons for the decline in number of cases in the TR is only observational and includes the following:

- **Trauma Cases might have been missed by the TR.** With additional burden on the clinicians to enter more of the data, due to the new COVID-19 protocols, some cases may have been missed during busy periods.
- **Lack of staff due to illness.** Some hospitals were more affected by COVID-19 than others and at times data collection had to stop or was minimal. However, data was always picked back up again when staff had recovered from illness and returned to work.
- **Less trauma cases at the hospitals.** Less trauma cases presenting at hospitals as it is considered a risky environment; therefore, people may choose to not come in for what they view as less severe trauma.
- **Lower trauma incident rates during COVID-19.** Due to government-implemented restrictions people might have moved around less, leading to a drop in the trauma incidence rate.

SECTION VI

EMS Pilot, Challenges and Lessons Learned

Status of EMS Pilot

Implementation of the EMS pilot, with the oversight of the Project Steering Committee, started after the EMS Pilot Project Development Plan was finalized by MOH in late 2016.

As of November 2021, many of the components in the plan have been undertaken and implemented, while others are still underway. Training of ambulance drivers, EMT staff, first responders and EMS providers was conducted in 2017. Procurement of 12 mini-van ambulances and related medical equipment was completed, and they were delivered to Malawi late 2018. In the same year, the Malawi emergency number, *118, was created and a call center was set up. Dispatchers were trained in answering and handling emergency calls as well as in how to dispatch ambulances, using an online dispatching software. In 2019, shortly before the launch of the EMS pilot in May 2019, an Operations Manager and a Call Center Manager were appointed. Around

the same time an Operations Manual was also developed. Since May 2019 the EMS pilot has been operational as a 'Live Trial' with 6 ambulances, out of 12 that were procured. The goal of the live trial is to test the system, identify bottlenecks and solve remaining system challenges, with the intention to eventually deliver more effective emergency medical services once the full-scale system starts operating. In early 2020, a 'roadshow' with one of the ambulances, in and around Blantyre, showed some success in educating the public about the new EMS system, and emergency number. However, apart from this, communication campaigns to the public regarding the availability and proper use of the new EMS system have been limited, with a large-scale awareness campaign yet to be undertaken. It is therefore likely that the public is not yet aware of the EMS services, the emergency number or when and how it should be used. Further, renovation of the Trauma Care Centers at the six EMS hospitals is expected to be complete by late-2022.

Currently, while the TR data indicates that the burden of road crash and other trauma is substantial, only about ten ambulances per month are being dispatched through the EMS.[9] The dispatch center is receiving 11,000–16,000 calls/ month, the majority of which are either prank calls, dropped calls where the caller hangs up prior to a dispatcher responding, non-urgent calls, or calls that remain unattended due to high call volumes or insufficient call center staffing. This high number of non-emergency calls places an **operational and financial** strain on the EMS pilot system and remains a risk factor to its long-term sustainability. Further, an analysis of the incoming calls to the EMS call center shows that less than 1% of the incoming calls are true emergency calls (**Figure 16**).

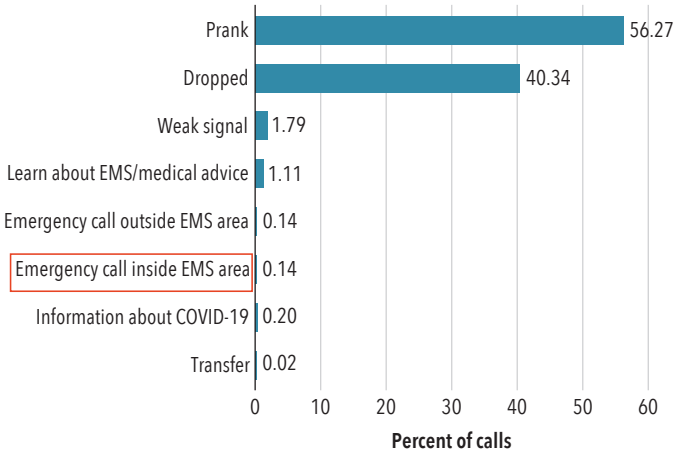


Figure 16. Type of Calls to Dispatch Center

[9] This is according to the monthly reporting on the EMS pilot, with data generated through the dispatch system.

Lessons Learned based on Challenges Faced by the EMS Pilot

As part of the process of implementing the impact evaluation and collecting data on trauma, the team also collected qualitative information on the EMS pilot rollout to be able to tie activities and events to the quantitative data as well as provide insights from a process perspective. Insights from the process evaluation data can be useful for the potential expansion of EMS delivery in Malawi, as well as to provide helpful information for other health sector professionals that are considering similar approaches to implementation of post-crash care capacity in resource constrained contexts. We focus below on five of the main lessons learned.

Change Management within the Implementing Agency

Firstly, a government-run EMS system with a central dispatch is new in Malawi, and the design requirements for this type of service system were not well understood and adopted from the outset within some parts of the implementing agency. This might have been inhibited by initial resistance to a new model of pre-hospital care and ambulance operations.

Secondly, the goal of the EMS pilot was "*to build a single functional system, with central coordination*", that "*operates the same way in all EMS districts.*" However, many of the EMS components have been treated as free-standing activities, rather than planned and integrated as part of a wider system where the activities are interdependent with clear linkages between call intake technologies, communication platforms, and patient care data management. This mindset and disconnect hampered the progress and success of the EMS pilot.

Thirdly, as the EMS system potentially leads to the need for a new cadre in the health system to fulfil EMS staffing requirements, in this scenario it is important that respective roles are well defined. This should include details on the overall management structure, key personnel, their responsibilities and mandate, remuneration and other financial and non-financial incentives, as well as roster guidelines and templates. For example, an observed challenge was that staff who were trained to work in the EMS pilot already held positions in the government run health care system. In addition, the role of an EMS Operations Manager in practice begins at a very early stage, during the preparatory work leading up to the system launch, yet this position was among one of the last ones to be filled. Instead, the preparatory work of the EMS pilot weighed heavily on the MOH staff assigned to oversee the EMS project, among his many other duties and responsibilities.

Starting out with defining the role of this critical position of Operations Manager and filling this position at the early stages of designing the system could then ensure that the duties and position details of all other personnel can be designed early on as a main responsibility of that Manager.

Finally, as the EMS pilot offered a completely new framework (in Malawi) for ambulance use, an Operations Manual was developed, taking into consideration all practical and HR related aspects, and remains an essential guiding document. Such a manual needs to cover all aspects of everyday work in sufficient detail, including logistics, operations, equipment and HR, as well as medical treatment guidelines, and it is ideally designed for ease of reference in EMS staff operations. However, a document like this can only be of help if the full EMS team feels ownership over the manual and everyone working within the system has access to a copy, so that they can consult accordingly on all procedures and record-keeping. The Malawi EMS pilot could have benefited from the development of such a manual at an earlier stage to help guide the system, and dissemination of the Manual across the wider EMS team is still not complete.

Anytime that a new system is being implemented, irrespective of the specific type of system, having 1) a guiding document to outline the system in detail; 2) dedicated management early on that can help define the roles of all actors in the system based on the guiding document; and 3) building clear understanding of and buy-in for how the new system differs from and improves on business as usual across all stakeholders are critical to ensuring its successful implementation.

Call Center/Centralized Dispatch Challenges

One of the key features that makes the Malawi EMS pilot different from the district management approach to ambulance services (i.e. business as usual) is the centralized *118 call center and dispatch system. During early stages of the pilot, the set-up of this crucial component of the EMS system was not prioritized with the attention that was required. This likely arises from a lack of 1) knowledge or expertise within MOH on the technology solutions considered in communication platforms, 2) coordination with the telecommunications industry, and 3) establishing the right level of resources to make a call center available (24–7, year-round).

The EMS pilot would have benefitted from having a dedicated ICT specialist to assist MOH from the beginning of its implementation, to work through setting up all the technical requirements for a functional, complex system. This includes, among other things, liaising with MACRA (The Malawi Communications Regulatory Authority) and telecom providers in setting up a toll-free emergency number, and later assuring that there is reliable and back-up internet connection for the Call Center. It would also have included a more thorough market scanning to identify available technologies, system software configuration and testing to manage incoming emergency calls and ambulance dispatch, in order to validate that the system can receive emergency calls, capture emergency incident information, and communicate the same with the EMS responders. Though the call center and dispatch platform are capably equipped for this purpose, the major constraint of the computer-aided dispatch system was the compatibility and cost to access cloud-based systems and Voice-Over-Internet Protocol within Malawi.

For any EMS model or systems, an active and engaged ICT specialist support is required from the initial stages of an EMS project to help with scoping of all possible models for delivering effective EMS services, evaluating the technical requirements and feasibility for each model within the specific country context, providing guidance during the process of choosing a model based on the evaluation conducted, and supporting the process of implementation.

Collection and Use of Performance Data

Given the fact that the EMS is a pilot project, where an assessment and decision shall be made on its continuation, expansion, or closure, capturing and monitoring relevant metrics on both operations and costs is crucial. The Malawi EMS pilot collects a wealth of data and has improved the monthly monitoring of call center and ambulance operations, as well as financial resources necessary to maintain services, through systematic monthly reporting that summarizes key performance statistics.

Nevertheless, the data-informed feedback-loops for adjusting service delivery are still weak, and the day-to-day use of data to track EMS response could support optimizing operations. Further, there is an abundance of data that is available but as yet not fully analyzed or used (e.g. ambulance GPS data, details on the types of emergency calls received at the call center, EMS response and patient delivery timelines, and the effectiveness of information and awareness campaigns on the EMS in reaching the public), which will be further analyzed in a forthcoming EMS pilot assessment.

When piloting a new system, generating comprehensive data on operations and costs and analyzing it in a timely manner is important for the development of an effective and optimized system.

EMS Pilot Launch

The development and roll-out of a new system like the EMS pilot, where friction-free operations are essential, would have benefitted from more detailed schematics for data management fully in place rather than pressure to meet a set launch date. The roll-out plan leading up to and following the launch should clarify and guide as many operational details as possible, such as whether all activities shall be launched on the same day or one at a time, or whether roll-out should be staggered geographically. Further, the launch plans could have benefitted from testing the different component functions individually and as a system. This type of testing might help narrow down and troubleshoot parts of the system that require fine tuning for effective operation. The following functions would be useful to test before an EMS service following a similar model to the pilot system in Malawi goes live.

- **Call Center.** Is the call center functioning?
  - Are calls to the emergency number forwarded from all telecom providers to the dispatch center where they are answered by a trained dispatcher that knows when and how to dispatch an ambulance?
- **Communication platform/channels.**
  - Can the dispatchers reach the community first responders, an ambulance, paramedics and the receiving hospital where the patient shall be taken?
  - Can EMS staff receive and send all necessary information to attend, respond and report on an incident, from dispatch to drop off?
- **Human Resources.** Are all call center and paramedic positions filled with staff suitably trained for respective positions?
- **Resources and Equipment.** Does the EMS staff have access to all the equipment and resources needed to respond to an incident in their catchment area, using the EMS system?
  - Are ambulances available on the ground?
  - Do ambulances have fuel?
  - Do ambulances have medical equipment and consumables and is there a plan for restocking when supplies run low?

Effective testing of each component of a new EMS system, as well as testing of the entire system prior to a broad launch can help to quickly identify and resolve challenges and could lead to significant improvements in the efficiency of the launch and the system at large.

Communications Strategy and Campaign

To date the communication campaigns to the public regarding the intention and proper use of the new EMS system have been limited, with a large-scale awareness campaign yet to be undertaken. It is therefore likely that the general public is not yet well informed of the *118 emergency number or when and how it should be used. An EMS communication campaign strategy, which includes a range of different activities, was developed in 2019. However, different unforeseen events, including the onset of the COVID-19 pandemic, have delayed the roll-out of the campaign. The lack of communication to the public has likely hampered the success of the EMS pilot, seen from the low number of emergencies reported and attended to as well as the high numbers of prank calls, both of which have become threats to the sustainability and further roll-out of the EMS.

For the communication campaign to be successful and cost-effective it is recommended that an evaluation is done in conjunction with its implementation, to identify the most effective communication channels. The DIME team worked together with the EMS team to set up data collection in the Call Center to collect data from some callers on how they learned about the emergency number. These data have only been collected from persons calling the *118 emergency number for one of following reasons: 1) to learn about EMS/ medical advice or 2) called from outside EMS coverage area, since for these calls an ambulance is not sent, while for any emergency calls within the coverage area, the dispatcher must focus on getting an ambulance dispatched and it is therefore not possible to collect additional information.[10] While these data are somewhat limited since they only ask a subset of callers how they heard about the EMS, they are still useful to give a sense of how information about the EMS seems to spread quickest. Initial analysis shows that most callers have learned about the emergency number from other community members, demonstrating the potential effectiveness of this channel (**Figure 17**). Continued collection and analysis of these data as the communications campaign is rolled out can provide guidance in real-time in terms of how well the campaign is working, and could potentially help the EMS pilot team quickly pivot to allocate resources towards those channels that prove to be more effective.

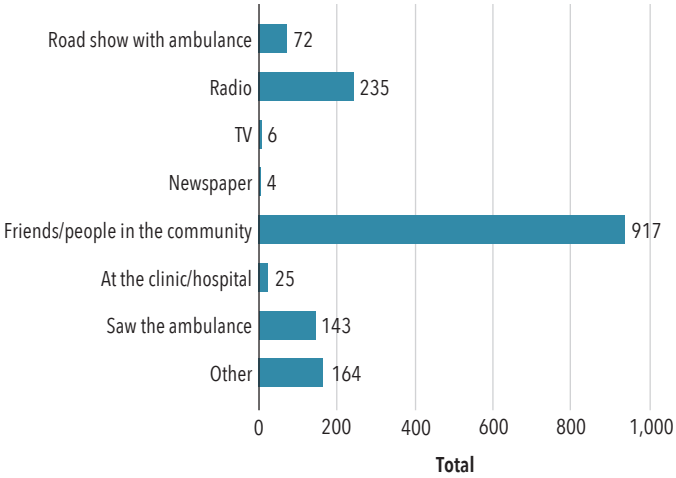


Figure 17. EMS Awareness Source

Note: These data have only been collected from persons calling the *118 emergency number for one of following reasons: 1) to learn about EMS/ medical advice or 2) called from outside EMS coverage area

Given the important role of the public in any EMS system to contact the system in case of an emergency and thus start the chain of steps for the provision of EMS services, effective communication to the public regarding the system, how it works and when it should be used is critical. Data collection to understand how the public is interacting with the system can also be invaluable for improving the communication process and thus the functionality of the system.

[10] For prank, dropped or weak signal calls it is not possible to obtain information from the caller.

SECTION VII

Discussion, Policy Relevance, and Recommmendations

Through the three-part analysis presented in the report, consisting of 1) the process of setting up and running the trauma registry; 2) epidemiology of trauma in Malawi; and 3) insights from the implementation process of the EMS pilot, we aim to give a comprehensive picture of both current and remaining challenges as well as opportunities, for decreasing trauma incidence and improving trauma care and trauma outcomes in Malawi.

The Trauma Registry

Despite some initial skepticism from counterparts, the work of setting up and running a digital TR showed that tablets are a feasible data collection tool in this setting. While initial implementation can be more costly when using digital tools, in terms of training time and upfront cost of tablets, in the long run there are several key advantages to collecting data digitally. For example, the data

can be immediately available for analysis, to inform operations, policy development and decision making. Digital data also increases completion rates and improves data quality. Further, the programmed TR has instant automated checks on the data, to help prevent data entry errors. The checks include constraints on input values and automatic skip patterns. As efforts to digitize medical records in Malawi are already under way, it is suggested to integrate the TR into such an electronic EMR system, for long term sustainability. The analysis of the TR implementation also shows that it is possible to collect good quality data on trauma in Malawi, if there is effort put into the planning and maintenance of the same.

Insights from the data that were collected through the TR were shared with facilities on a weekly basis and many of the TR coordinators and hospital management teams found this information important and useful for reporting and planning purposes. This type of data-informed operations can be highlighted as a good example within the MOH. The analysis demonstrates the potential of trauma registries to inform both preventive policies (e.g. when and where road traffic trauma occurs) and clinical care (e.g. training needed based on the types of injuries requiring care). A continuation and a refinement of the TR, including greater detail on care delivered and patient outcomes, could contribute to the evidence base regarding trauma care in Malawi.

While the data can give a picture of the volume and causes of trauma, the demographics of patients, and the modalities through which trauma victims access care, the registry is limited in its ability to capture population level data. This is because the TR was only implemented in ten facilities in the country that were not chosen to be representative of the population (instead they are chosen based on the EMS pilot project). Additionally, it does not capture detailed information on quality of care for hospitalized patients due to the complexity of capturing such information systematically. Future TR efforts might address these points for more comprehensive data on trauma in Malawi.

Trauma in Malawi

It is widely understood that trauma is a growing problem in many sub-Saharan African countries, including Malawi. The TR sought to fill the knowledge gap about trauma in Malawi with a large-scale data collection effort from both central and district hospitals. The analysis of the data shows both similarities with data from trauma registries in other African settings as well as key areas of divergence.

Like data from other TRs in the region, the Malawi TR shows marked gender and age patterns in the incidence of trauma, with overrepresentation of males and younger adults. (Chichom-Mefire et al. 2017; Botchey et al. 2017; Samuel et al. 2009; Banza et al. 2016). However, the share of injuries stemming from RTCs (19.6%) is lower than several other comparable countries. For example, the corresponding RTC rates in other settings were 55% in Cameroon (Chichom-Mefire et al. 2017); 36% in Kenya (Botchey et al. 2017); and 50% in Uganda (Kobusingye et al. 2002). A much smaller study of only one facility in Malawi for only 5 months in 2008 found 43% of cases were RTCs, but the scope was quite limited, and the data collection exercise was more than a decade ago (Samuel et al. 2009). These trauma registries were largely implemented in tertiary or other urban referral facilities. By contrast, in this registry, which includes more district hospitals located outside of urban areas, the most common mechanism of injury is falls. However, **RTCs make up almost half of admitted trauma cases (48%).** Furthermore, the nature of the RTCs in this setting is distinctive. In several other settings, major causes of RTCs were motorcycle-related crashes (Sawe et al. 2021a), while in the Malawi TR, **roughly half (49%) of RTC victims are non-motorized road users such as pedestrians and cyclists.** These findings are consistent with those of Banza et al (2016), who also found a heavy burden of injury from RTCs on pedestrians and cyclists in a trauma registry at Kamuzu Central Hospital in Malawi. **This suggests the need for targeted policies and infrastructure that aim to improve the built environment to recognize safety features that protect vulnerable road users.**

Further, the analysis of the data also shows limited adherence to safety practices for motorized RTCs. Malawi law requires drivers and front seat passengers to wear seatbelts (WHO, 2018), yet the TR data shows that **84% of patients who were passengers of motor vehicles such as cars, buses, and trucks report not having worn a seat belt**. Similarly, helmets are required for both drivers and passengers of motorbikes, yet **52% of patients who were drivers or passengers of motorbikes report not wearing a helmet.** These findings are similar to those of Sundet et al. (2021) who find limited seat belt use among RTC patients in Lilongwe. **This highlights the scope for increased seat belt and helmet use to reduce RTC-related trauma in Malawi.**

Another concerning finding, which related directly to the work with the EMS pilot, is the **major delays observed in time to reach hospitals and treatment**, which can be analyzed using the "three delays" framework (delays in the decision to seek care, delay from injury to hospital, and delay from arrival to being seen) (Calvello et al. 2015). **Patients in this registry report long delays between the time of their injury and the**

time they reach the hospital. In terms of seeking care, around one quarter of cases seek care more than 24 hours after the trauma, including some severe cases.[11] This signals the need for additional research to understand barriers to choosing to seek care sooner. Focusing on those cases that arrive within 24 hours of the trauma, for RTCs, median time to arrival at the hospital is 1.4 hours. Several other registries in the region have recorded much shorter pre-hospital delays (Chichom-Mefire et al; Kobusginye et al). These long delays however are consistent with findings from the Kamuzu Central Hospital registry in Malawi (Samuels et al. 2009). Notably, being close to the road is more closely linked to timely care than injury severity. RTCs (both serious and non-serious), which happen on the road where transport options are present, have a median time to arrival of 1.4 hours, but all serious non-RTC cases have a median time to arrival of 4 hours. This comparison highlights major barriers to transport for non-RTC serious trauma cases. Furthermore, **only 6% of admitted trauma cases use ambulances to reach hospitals, with half of patients coming using a private or commercial vehicle**. In Malawi ambulance transport is used more often for referral across facilities than for emergency transport from trauma sites to hospitals.

[11] Unfortunately, it is not possible to distinguish directly between the time taken to decide to seek care and the transport time to hospital.

EMS Pilot

Firstly, **there needs to be a greater emphasis and understanding on how an EMS system is unique and different from previous ambulance use in Malawi**. Information on the EMS System, its overall goals, and the related timelines and sub-objectives should be communicated to all staff working on the EMS pilot or in close collaboration with the EMS pilot. Further, new ways of operating and delivering services need to be coupled with clear communication. This should include not only how the EMS system will operate, but also what positive outcomes are expected in implementing the EMS. It is also important to directly link these outcomes to the specific components of the EMS Pilot and how they improve the existing system. This is important both for the EMS staff and non-EMS staff in the pilot hospitals, to build confidence and buy-in in the new system and generate more awareness for the public that is the direct user.

Deciding on a launch date should be determined by deployment readiness. The EMS pilot launch date was changed multiple times, which led to challenges in planning and allocating necessary resources for the EMS pilot. Relatedly, as the emphasis of an emergency care system lies in its rapid response, testing of different functions separately and in relation to each o ther, as well as a live test of the entire system, is crucial. Prior testing and confirmation of system conformance would have been advisable in connection with the launch.

There are large amounts of data generated and collected as part of the EMS operations, specifically, the computer-aided call center and dispatch software platforms used in this pilot. It must be emphasized that a fundamental premise of digital technology in this instance is its automatic collection and storage of data available for analysis. As the data collected through the above-mentioned systems will be useful in deciding how EMS operation and financial resources needs can be optimized when moving forward, it is suggested that additional effort is put into synthesizing the data that are already available.

With regards to the EMS Communication Campaign, a timely and successful communication campaign about the MOH's intentions of the EMS, proper use of *118 and ambulance dispatch availability is important. There is still a need to educate the public on how and when an emergency number should be contacted.

Recommendations

Based on our findings we would like to make the following recommendations:

1. The data demonstrate the burden of road traffic crashes for health facilities and the need to implement additional policies that can decrease RTCs, which will help to alleviate resource needs within health facilities.
2. There is a need to target policies and infrastructure to improve road safety for the most vulnerable users — pedestrians and cyclists.
3. The data collected shows the scope for targeting greater seat belt and helmet use to reduce RTC-related trauma in Malawi, through both increased enforcement of related road laws and public safety advocacy.
4. Investment in a comprehensive communications campaign and use of existing data to help guide and evaluate the effectiveness of the campaign will be important.
5. There should be increased use of all the different data that are collected by the EMS systems and within health facilities in order to help guide operations and lead to higher effectiveness.
6. A continuation and a refinement of the TR, including greater detail on care delivered and patient outcomes, could contribute to the evidence base regarding trauma care in Malawi. Streamlining of the variables collected (by identifying the most important ones) and integration into existing data collection practices in health facilities can help support sustainability.
7. Increased investment in digital data collection in health facilities could help to improve the quantity and quality of data collected and increase the usefulness of the data for policy planning and health facility operations.

While the EMS pilot has seen some implementation challenges, it has come a long way and certainly improved its operations over time. It has helped to facilitate the collection of rich data, both within facilities as well as through the dispatch center, and as these data are further leveraged, they can help to inform more effective policymaking and decisions intended to reduce trauma and improve health outcomes.

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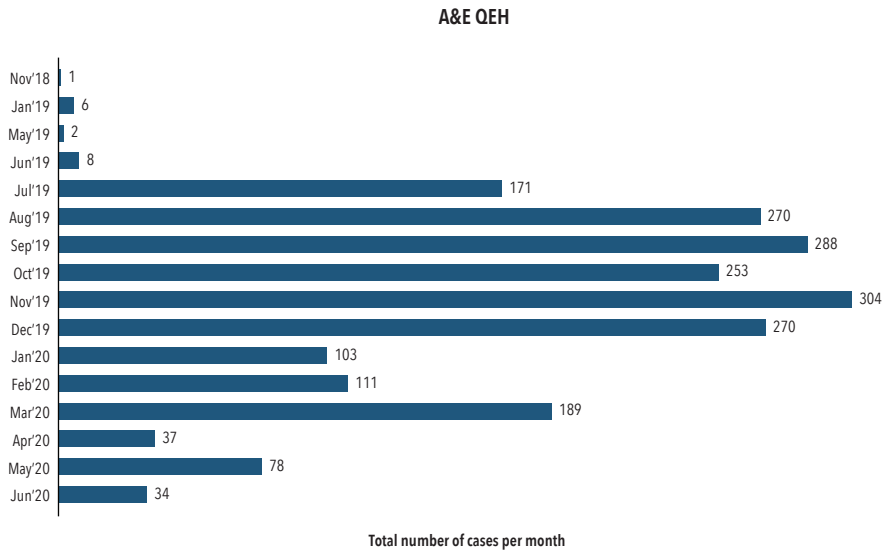
APPENDIX 1

Additional Figures and Tables



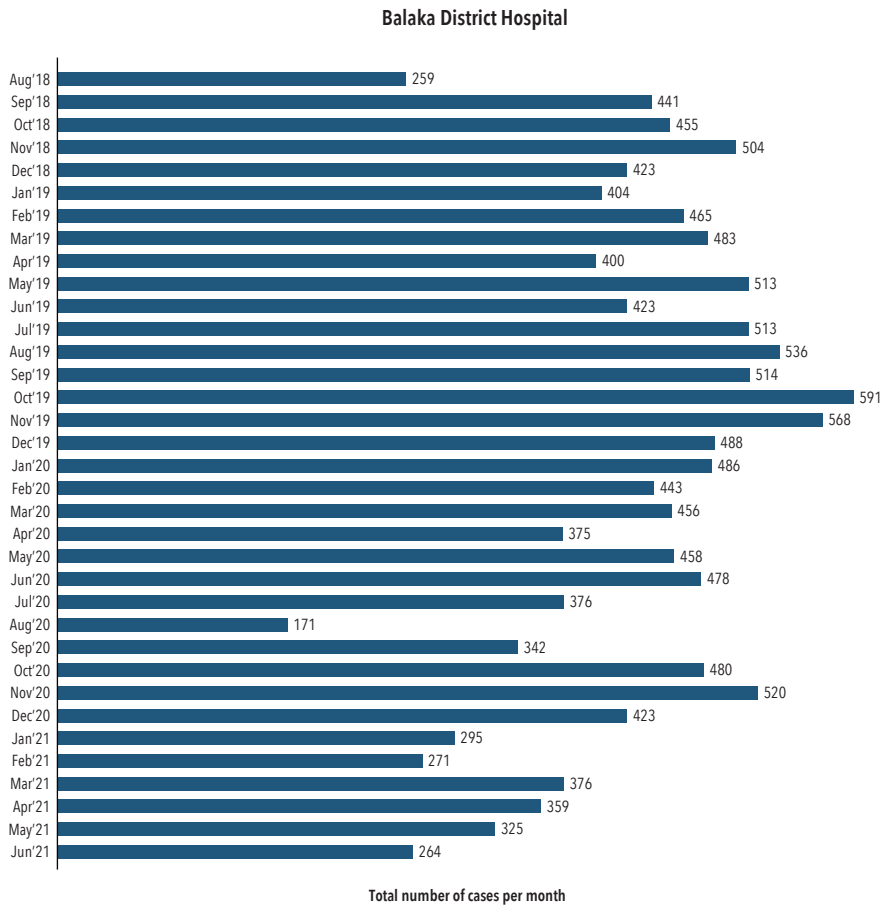
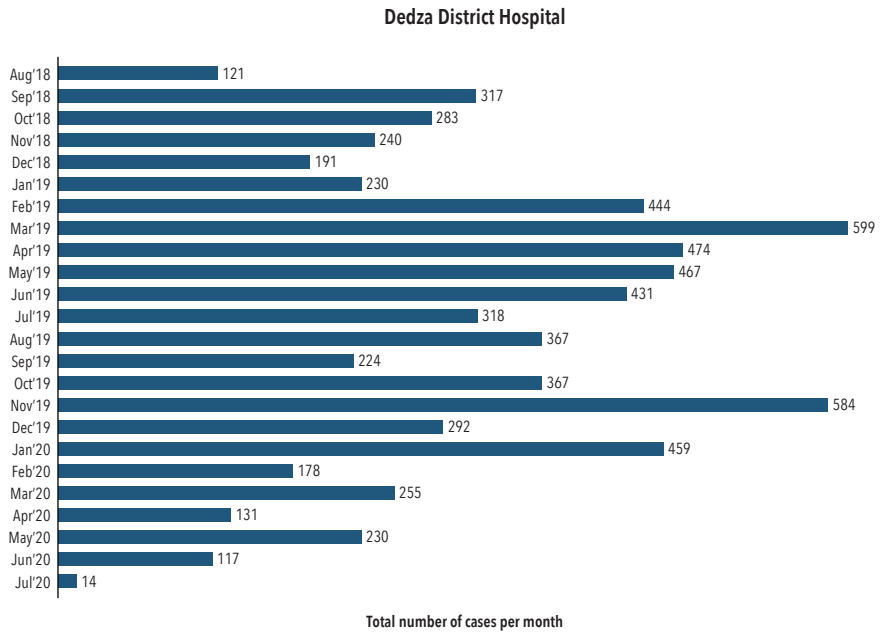


Figure A1. Monthly Trauma Cases by Facility



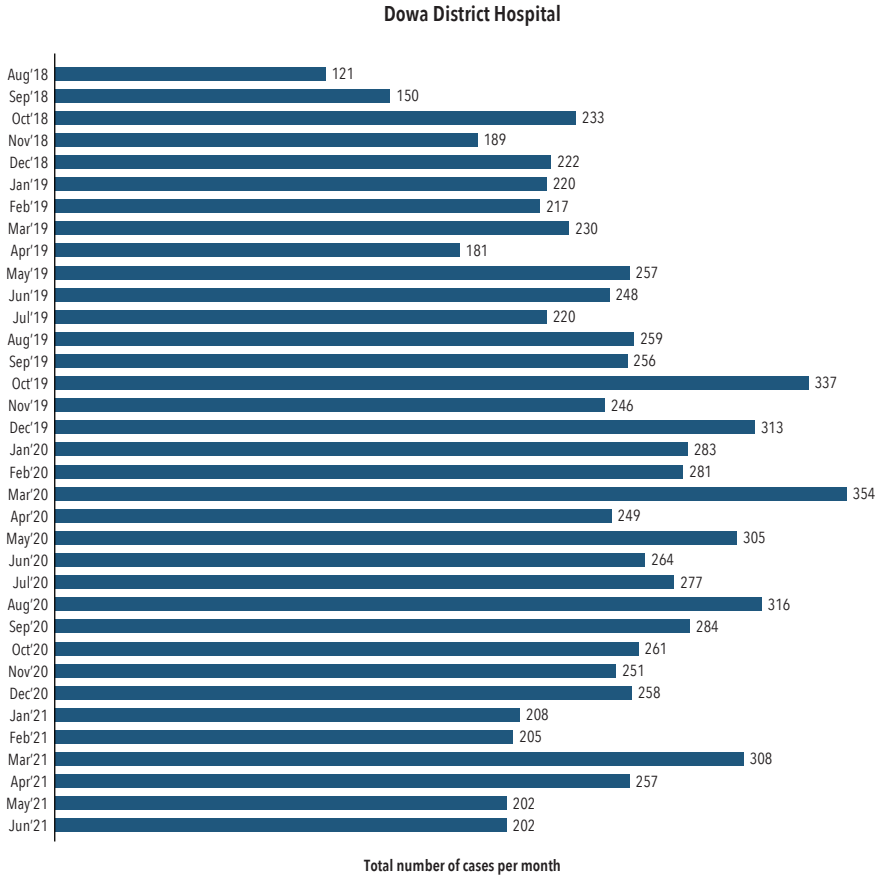
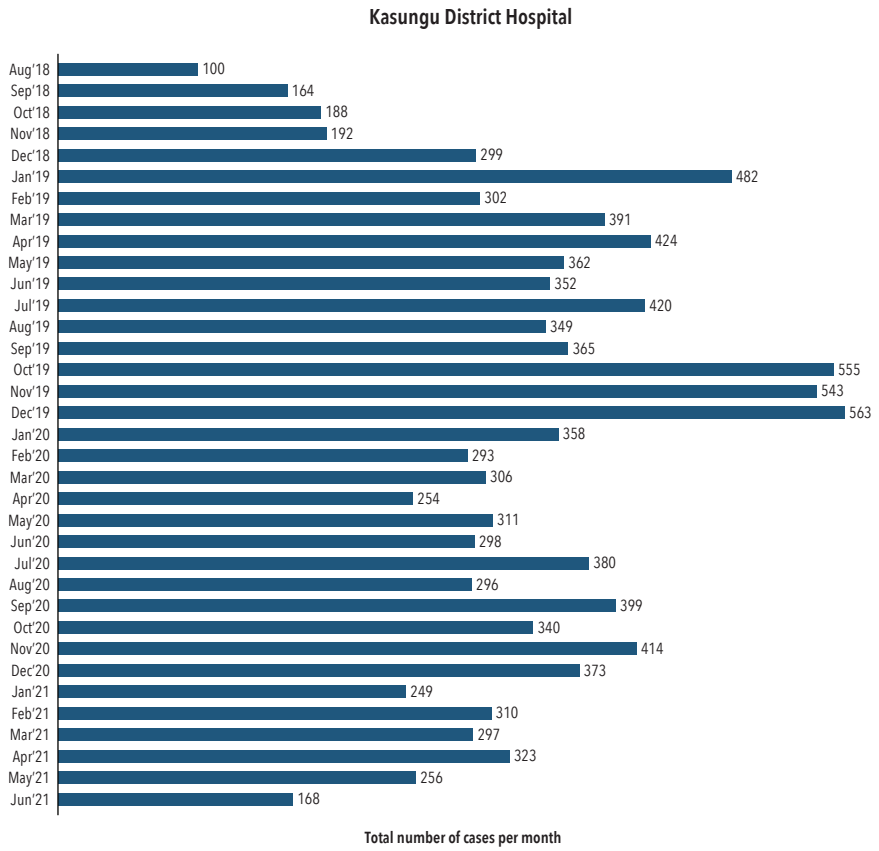


Figure A1. Monthly Trauma Cases by Facility (*continued*)



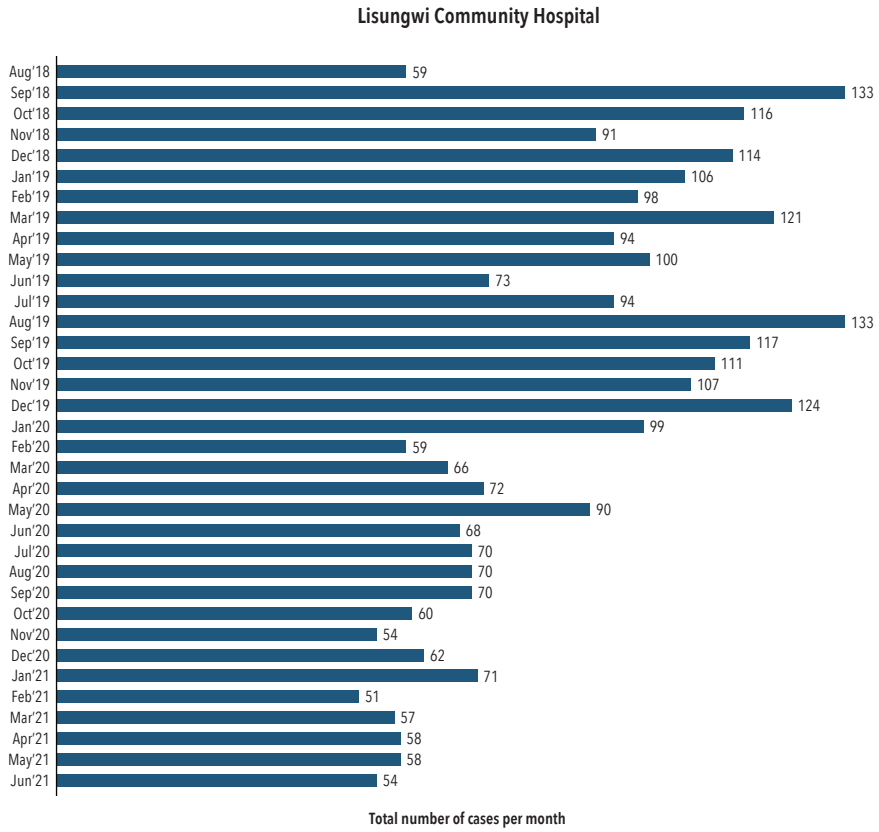
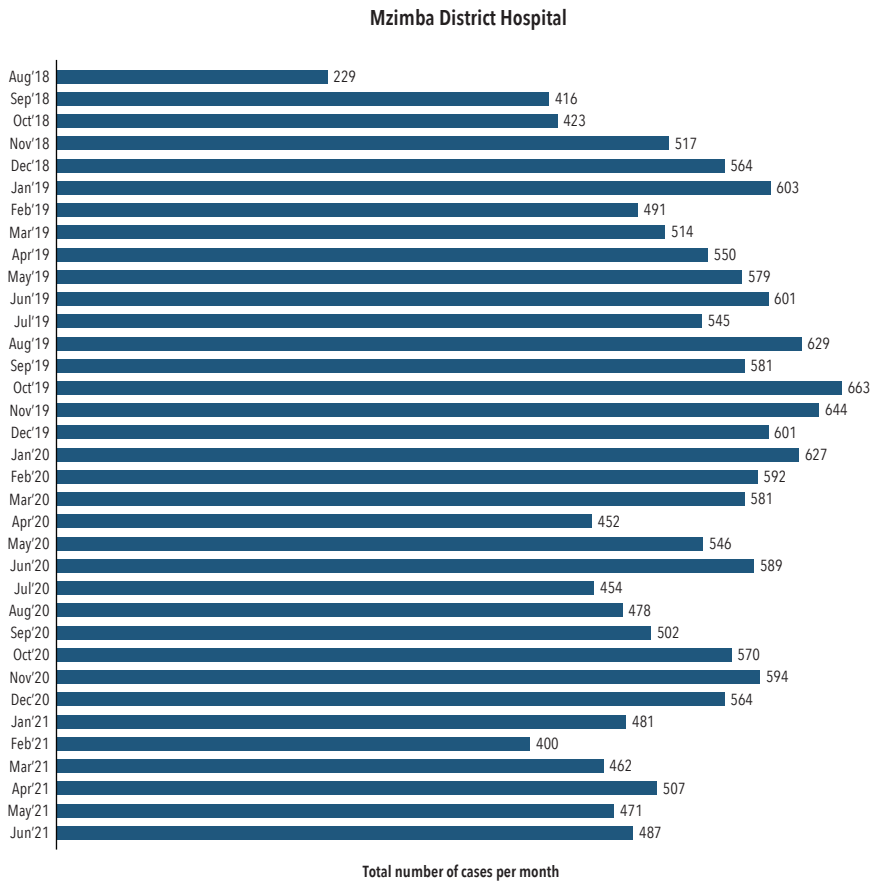


Figure A1. Monthly Trauma Cases by Facility (*continued*)



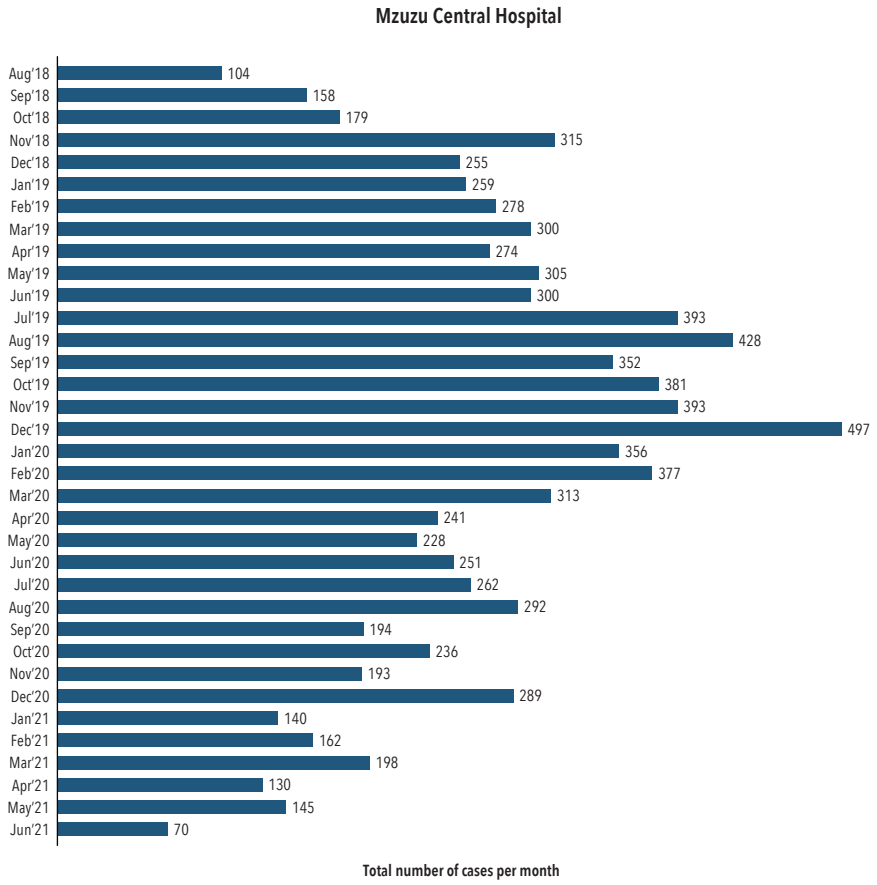
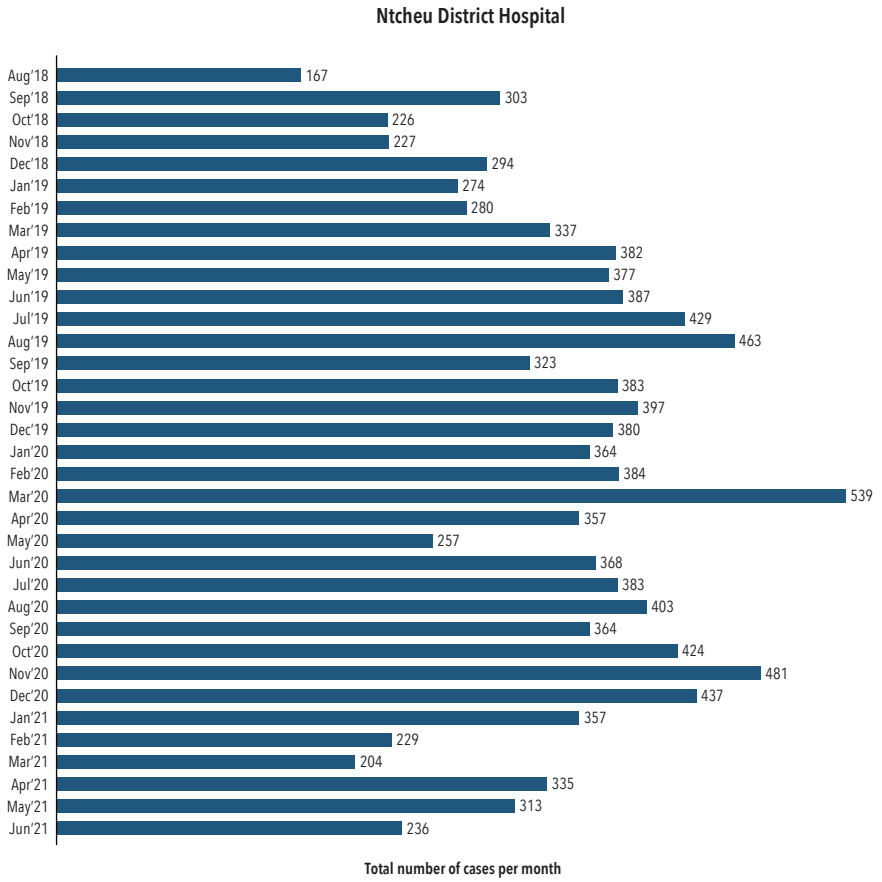


Figure A1. Monthly Trauma Cases by Facility (*continued*)



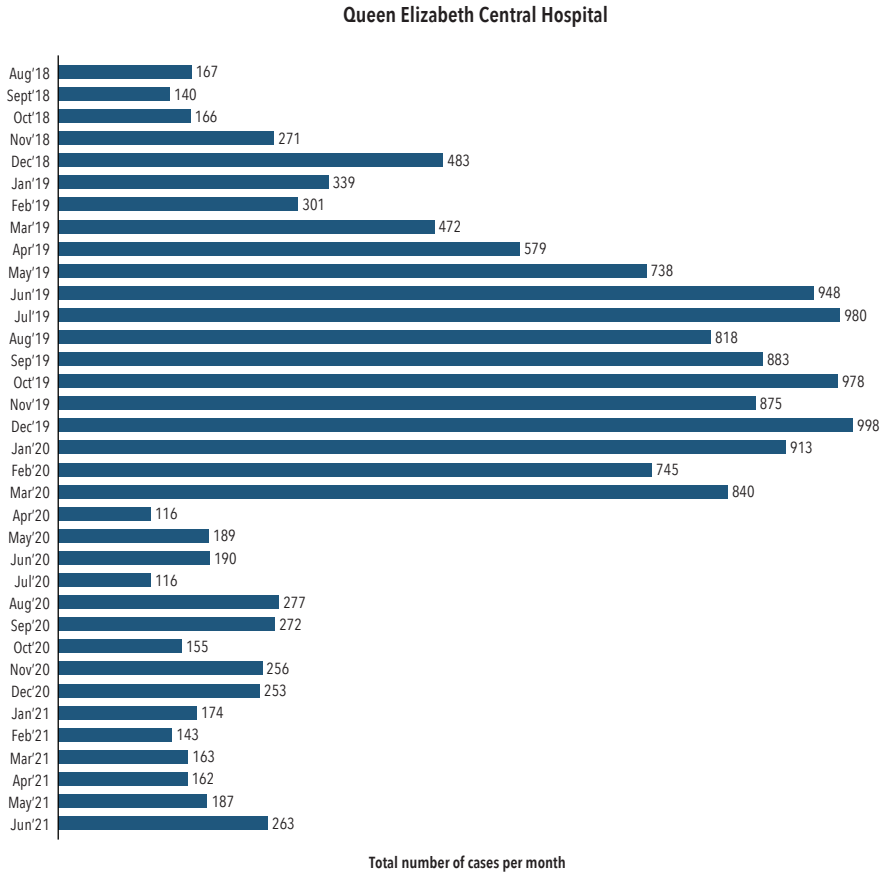


Figure A1. Monthly Trauma Cases by Facility (*continued*)

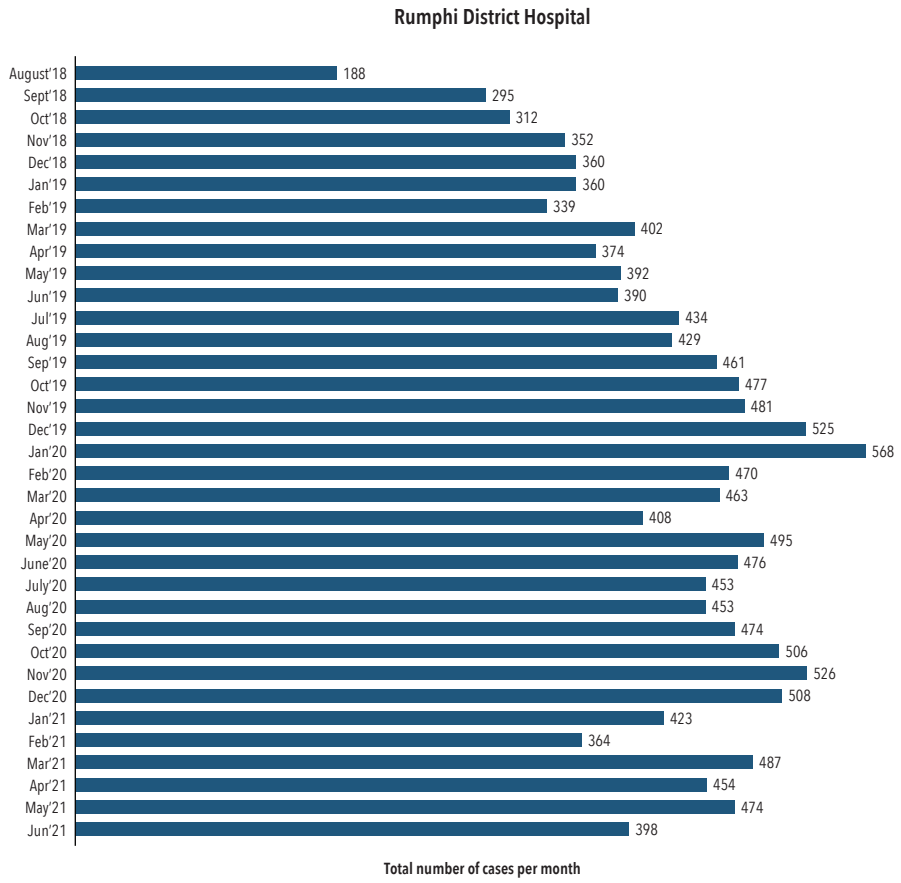


Figure A1. Monthly Trauma Cases by Facility (*continued*)

Table A1. Trauma Cases by Facility

Hospital name	Total incoming trauma cases	Total incoming RTC	Total hospital admission
Balaka District Hospital	5335	1077	437
Dedza District Hospital	5178	554	139
Dowa District Hospital	2754	550	311
Kasungu District Hospital	4659	1302	227
Lisungwi Community Hospital	1344	351	196
Mzimba District Hospital	6332	1221	982
EVIzuz u Central Hospital	4001	1129	489
Ntcheu District Hospital	4375	702	219
Queen Elizabeth Central Hospital	10308	1916	336
Rumphi District Hospital	4955	793	273
Total	**49241**	**9595**	**3609**

APPENDIX 2

Trauma Registry Questions

The trauma ID assigned to this person is SMYCP665
Please record this trauma ID in the patient's health passport.
Who is filling in this trauma registry?
Which hospital is this?
Was the patient transferred here from other facility?
From which facility was the patient referred?
What was the patient's mode of transport to hospital?
What date and time did the patient arrive at the hospital?
What is the first name of the patient?
What is the last name of the patient?
How old is the patient?
This patient is less than 1 year. Please enter the patient's age in months. 0-12 months
What is the patients gender?
What is the highest level of education for this patient?
What is the patients occupation?
In what region does the patient reside?
In what district does the patient reside?
In what TA does the patient reside?
In what village does the patient reside?
Do you have a mobile phone?
Please enter a phone number to the patient.
Who is the owner of this phone number?
What is the name of the person who owns the phone?
Can you provide a phone number to someone who is close to you, to for example a family member or friend?
Please enter the secondary phone number.
Who is the owner of this phone number?
What is the name of the person who owns the phone?
What date and time did the trauma happen?
In what setting did the accident happen?
In what district did the trauma happen?
In which TA did the trauma happen?
In which village/location did the trauma happen?
Was the patient under influence of alcohol or other drugs?
What was the patient's mode of transport from crash site to first health care facility?
How can the area where the accident happened best be described?
What was the patients role on the road?
What type of vehicle was the patient in at the time of the accident?
What did the patient collide with, at the time of the accident?
What was the pedestrian hit by?
What was the cyclist hit by/hit?
What was the motorcyclist hit by/hit?

(*continues on next page*)

What was the oxcart driver or passenger hit by/hit?
Was the patient wearing a helmet at the time of the accident?
Was the patient wearing a seatbelt at the time of the accident?
Heart rate (beats/ minute)
Body temperature C
Blood Pressure (systolic)
Respiratory Rate (breathes/minute)
What is the patient's neurological status?
Best eye response
Best moto response
What is the total GCS Score
Date and time patient was attended to by doctor or other medical professional, for care?
Please record the most serious injury that patient has.
What type of injury is this?
Is this an open or closed fracture?
Where is the injury located?
Is this a serious injury?
Please record the second most serious injury that patient has. What type of injury is this?
Is this an open or closed fracture?
Where is the injury located?
Is this a serious injury?
Please record the third most serious injury that patient has. What type of injury is this?
Is this an open or closed fracture?
Where is the injury located?
Is this a serious injury?
On a scale from no pain to severe pain, how much pain are you in right now? Is it none, mild, moderate or severe?
What was the patients outcome at casualty department? On the day of arrival.
Which hospital was the patient referred to?

(*continues on next page*)

DAY 2 FOLLOW UP
Is the patient still in the hospital?
Where is the patient?
What is the patient's (trauma) id?
Heart rate (beats/minute)
Body temperature C
Blood Pressure (systolic)
Respiratory Rate (breathes/minute)
What is the patient's neurological status?
Best eye response
Best verbal response
Best moto response
What is the total GCS Score
On a scale from no pain to severe pain, how much pain are you in right now? Is it none, mild, moderate or severe?
What treatment has the patient received, since arriving at the hospital?
What is the patients outcome, today?
Which hospital was the patient referred to?
Which body part was treated?

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