

RESEARCH ARTICLE

Implementation of a multi-center digital trauma registry: Experience in district and central hospitals in Malawi

Kevin Croke¹  | Linda Chokotho² | Sveta Milusheva³ |
Jonna Bertfelt³ | Saahil Karpe³ | Meyhar Mohammed³ |
Wakisa Mulwafu³

¹Department of Global Health and Population, Harvard T.H. Chan School of Public Health, Boston, Massachusetts

²Department of Surgery, College of Medicine, University of Malawi, Zomba, Malawi

³Development Impact Evaluation Unit, World Bank Group, DC, Washington

Correspondence

Kevin Croke, Department of Global Health and Population, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA.
Email: kcroke@hsph.harvard.edu

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Abstract

Background: Trauma is a rapidly growing component of the burden of disease in developing countries; yet systematic data collection about trauma in such contexts is relatively rare.

Methods: This paper describes the implementation of a trauma registry in 10 government-run hospitals in Malawi, with a focus on implementation logistics, stakeholder engagement strategies, and data quality procedures.

Results: 51 337 trauma cases were recorded over the first 14 months of registry operations. The number of cases per month, data accuracy, and the geographic coverage of the registry improved over time as data quality measures were implemented.

Conclusions: Multi-center digital trauma registries are feasible in low-resource settings. Stakeholder engagement, periodic in-person and frequent digital follow up with data teams, and regular channeling of findings back to data collection teams help to improve data quality and completeness over a 14 month period. Financial and staffing constraints remain challenges for sustainability over time, but this experience demonstrates the feasibility of large-scale registry operations.

ABBREVIATIONS: AVPU, alert, voice, pain, unresponsive scale; DHO, District Health Officer; DRTSS, Directorate of Road Traffic and Safety Services; KCH, Kamuzu Central Hospital; HMIS, Health Management Information System; LMIC, low or middle income country; 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; RTA, road traffic accident; TR, Trauma Registry.

KEYWORDS

trauma care, data systems, road traffic accidents

1 | BACKGROUND

Injuries are among the top 10 leading causes of mortality in the world, and this is projected to increase over the coming decades.¹ Low and Middle Income Countries (LMICs) are disproportionately affected and account for almost 90% of injury-related deaths globally.² Despite the growing need to understand and tackle this urgent issue, trauma care systems are weak in many LMICs.

One part of the trauma care gap in LMICs is incomplete data. The formulation of new and effective policies with regard to trauma, prevention, and care depends on a solid body of evidence on which to make decisions.³ In high-resource health settings, systematic collection of data about trauma cases, including cause, treatment provided, and outcome, is often captured through trauma registries, and is considered an essential element of a well-functioning trauma care system.⁴ These registries can facilitate quality improvement processes,⁵ injury prevention initiatives, injury-focused research, and policy development, by improving understanding of the epidemiology of trauma and the correlates of patient outcomes.^{6,7} Many LMICs lack systems for collecting data on trauma, such as trauma registries, as well as emergency response systems for adequate trauma care.^{4,8,9} It has been shown that just 1% of publications using trauma registry data come from the lowest income countries.¹⁰ In particular, there are relatively few trauma registries in Africa, despite the rapidly growing incidence of trauma, including from road traffic accidents (RTAs), which are a growing source of trauma in most developing countries.¹¹ This makes it challenging to understand the burden of injury, resource needs, and the impact of initiatives to improve access to quality trauma care.¹²

There have been efforts to reduce the gaps in data collection in several low-income countries. Yet where registries do exist, they are often limited in the amount and quality of data they collect,^{9,13} and there is no standardized way to determine data quality and assess its improvement in trauma registries. High quality and complete data is necessary to support better care and improved trauma outcomes in LMICs.

Injuries are an important contributor to the burden of disease in Malawi, contributing to 6% of all deaths.³ In addition, road accidents are a rapidly growing subcategory of trauma, with the number of accidents increasing from 7390 in 2013-14 to 8194 in 2015-16.¹⁴ Yet despite this burden, there is currently no nation-wide trauma data collection or registry in the country. The Government of Malawi's Health Management Information System (HMIS) is designed to register every patient who comes to the hospital, but details about the cause of trauma, medical care received, and outcome of trauma cases are poorly captured in these registries. For example, in a review of medical records, data on injury type was missing in 44.9% of cases and the cause of trauma was absent in 82.7% of cases.¹³

In Malawi, the Ministry of Health's (MOH) efforts to curb trauma are outlined in the National Non-communicable Diseases Action Plan (2012-2016). This strategy includes a goal of reducing the incidence and impact of trauma and related disabilities in Malawi through effective policy action, targeted primary prevention interventions, effective emergency and rehabilitative services, strengthened research capacity, and effective advocacy. The MOH also seeks to improve the quality of collected data on trauma in order to better inform policy. Additionally, the Ministry of Transport and Public Works (MOTPW) aims to reduce road traffic related fatalities by 20% between 2015 and 2020.¹⁵ In line with these policy priorities, there have been several recent research initiatives to strengthen trauma data collection in Malawi, including a trauma registry implemented in Kamuzu Central Hospital for more than 10 years.⁷ However, there remains insufficient attention to trauma, and inadequate data for evidence-based policy action.^{3,13} Additionally, there is no national initiative to scale up the use of trauma registries in Malawi. For example, an assessment of trauma care in Malawi in July 2013 to 2014 found that in addition to gaps in equipment, supplies and training for trauma care, only two out of 12 hospitals were capturing systematic trauma data through a registry.¹⁶

The objective of this paper is to describe the implementation of a trauma registry in 10 hospitals in Malawi and to highlight challenges and lessons learned with respect to stakeholder engagement, implementation of digital data collection, and other measures that contributed to the continuous improvement of data quality over the first year of the initiative.

2 | METHODS

2.1 | Overview of registry

In collaboration with the MOH, the research team set up a trauma registry in 10 of the largest health facilities in Malawi. Registry planning began in February 2018, piloting started in June 2018, and full-scale data collection began September 2018 and is ongoing as of July 2020. In this study, we use data for all trauma patients recorded in the trauma registry from 1 September 2018 until 31 October 2019. In the registry, trauma patients were defined as those who had sustained one or multiple injuries to any body region or regions, irrespective of severity. Data is 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 come to the hospital for the first time since the injury happened are entered into the registry; follow up visits are excluded.

The trauma registry data is collected using a digital trauma registry tool, which is a Computer Assisted Personal Interview (CAPI) survey programmed by the research team using SurveyCTO and implemented with Samsung Galaxy Tab E tablets. This tool is used to collect 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, Kampala Trauma Score, and details on up to three injuries (The full set of variables is listed in Appendix S1). Responses are based on self-report of patient to the data clerk except vital signs and other medical data, which are entered after a clinical staff member's assessment.¹ Data collection is initiated by the data clerk when patients are waiting to be seen by the clinical staff. Demographic information, time, location and type of trauma is entered at this point; vital signs, AVPU and GCS scores can also be entered if they are taken by the data clerk or the nurse registering the patient's arrival at the hospital. The medical information that is filled in after the patient has been attended to by clinical staff includes information about the injury, treatment and outcome on day one, and vital signs, AVPU and GCS scores if they have not yet been entered. If the patient is admitted overnight, the clerk will visit the patient the next day to collect information about vital signs, AVPU, GCS scores, further treatment received, and the patient outcome as of day two. Data clerks can open and close the data collection tool at any point without losing data, and over time it has been possible for the data collection teams to adapt the process of filling in the trauma registry to avoid any disruption to patient care.

Trained data clerks in each health facility collect the data. There are two tablets at each facility that are used for the data collection. The data is encrypted and transmitted using the SurveyCTO server to a secure server. The data collected from all facilities is aggregated into a single database that is updated weekly with all new trauma cases recorded in each facility. The data collected is considered administrative health data owned by Malawi Ministry of Health, similar to Health Management Information System (HMIS) data, and can be used for purposes of planning, research, or developing policies. Like other trauma registries,⁸ since the data is considered part of administrative data collection, consent is not sought from patients for data capture.

In addition to data from the trauma registry, administrative records relating to implementation, and a contemporaneous implementation journal maintained by the research coordinator were reviewed, with key themes extracted for this paper.¹⁷ We also use District Health Information Software (DHIS2) data provided by the Health Management Information System (HMIS) of Malawi for data validation of trauma registry records.

After describing the setting of this trauma registry, the three phases of planning, implementation, and ongoing data quality control are outlined below. Table 1 summarizes the key principles that were followed to set up this multi-site trauma registry.

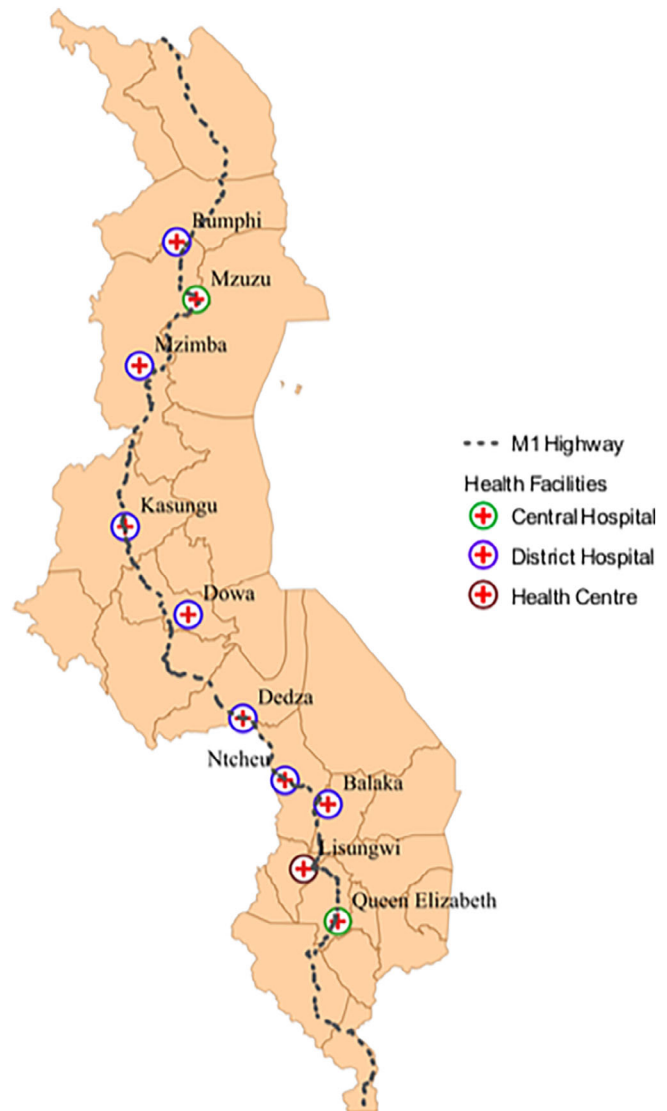
TABLE 1 Principles followed for setting up the trauma registry (TR)

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 Trauma Registry (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 give feedback on the draft tool and proposed processes; after implementation begins they receive data weekly and give feedback continuously
Trauma registry implementation	Pre-testing TR	Drafted TR tool was pre-tested in 1 central and 1 district hospital, with trained HMIS data clerks
	Piloting TR	Pilot testing of TR tool, data management process and data feedback loops, in 1 central and 1 district hospital
	Data collection team	1 TR coordinator (clinician), 1 ER clinician and 3 data clerks from each hospital, selected by the DHO
	Training	2 days; 1 day classroom training (including role play) & 1 day "on the job training"/ shadowing
	Refresher training	After 11 months; informed by the data collection and data quality to date. Two main objectives: 1) to improve data quality for key variables like vital signs, cause and intent of trauma and 2) to train new data clerks
Data quality assurance activities	Ongoing support and communication	Each TR Coordinator has a main point of contact within the Trauma Registry Monitoring team, who aim to respond to any request within 24 hours by phone or WhatsApp
	Field visits	2 supervisory visit to all hospitals in the first 6 months, and then as needed
	Dashboard on Dropbox paper	Weekly sharing of descriptive statistics
	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
	2 data validation exercises	Comparison of TR data with regular HMIS data

2.2 | Setting

In Malawi, primary care for trauma is provided in health centers, secondary care is available in district hospitals, and serious trauma cases are meant to be referred to referral hospitals. However since there are relatively few referral facilities in the country and they are primarily located in urban centers, a significant amount of trauma care, including for serious cases, is provided in district hospitals.¹³ The trauma registry for this project is currently in operation in two referral hospitals, seven district hospitals and one community hospital. The hospitals are located along the main north-south highway in Malawi, the M1. Five of the hospitals are located on the southern segment of the M1, between Lilongwe (the capital city), and Blantyre (the commercial hub). Another five hospitals are located along the M1 to the north of Lilongwe. The distance between the northernmost and southernmost hospital included in the study is approximately 800 km. The five health facilities between Lilongwe and Blantyre were chosen because they are participating in a World Bank-supported project which seeks to improve trauma care in Malawi, especially for RTAs.² The additional five facilities were chosen because they share certain features with the five facilities that were selected for the World Bank project (including location within 20 km distance from the M1, and high volume of trauma patients from RTAs on the M1) and will act as a control group for a study that will analyze the impact of the

FIGURE 1 Map of Health Facilities
Health facilities implementing Trauma
Registry along M1 [Colour figure can be
viewed at wileyonlinelibrary.com]



project. The hospitals included in the trauma registry are (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 District Hospital, Balaka District Hospital, and Queen Elizabeth Central Hospital. [Figure 1] The registry covers a significant portion of Malawi's trauma care facilities, including two out of the country's four central referral hospitals and seven out of 22 district hospitals.

2.3 | Trauma registry planning and stakeholder involvement

We developed and launched the registry in collaboration with MOH with the goal that elements of it could eventually be incorporated into routine HMIS data collection. With this goal in mind, stakeholder engagement was a key element in the registry planning phase, with several stakeholder engagement events and consistent communication and feedback throughout the process between the research team and MOH counterparts.³

With the goal of establishing MOH involvement from the start, a one day workshop was held in Lilongwe, Malawi in January 2018, with stakeholders including MOH staff, District Health Officers (DHOs) and District Medical Officers (DMOs), other district and central hospital representatives, and external researchers, as well as the Malawi Roads Authority (MRA), the Directorate of Road Traffic and Safety Services (DRTSS), and the Malawi Police. The main objectives of the workshop were to establish a shared understanding among stakeholders about data availability on road traffic crash trauma and other types of trauma in Malawi, and to explore feasible ways of collecting improved data (such as by setting up trauma registries and strengthening administrative data collection) based on international best practices and stakeholder views about how these methods could be adapted to the Malawian context.

This workshop and subsequent field visits generated feedback from stakeholders on feasible implementation modalities and led to an agreement on the value of a prospective registry. Following the workshop, planning and preparation for the trauma registry started in February 2018. In the 6 months leading up to the start of the trauma registry, the research coordinator developed the work plans, drafted and programmed the trauma registry tool, and developed a training plan and manual to train trauma clerks who would be the entering the trauma data.

A second meeting was held in June 2018, with representatives from MOH as well as DHOs and DMOs in the 10 participating districts. The participants gave additional extensive feedback on the draft trauma registry data collection tool including proposals for re-phrasing and re-ordering questions. They also discussed logistics and protocols on sharing data most efficiently with participating hospitals, and on critical implementation details. In parallel with these stakeholder consultations, research team members who had participated in previous and ongoing trauma registries at Queen Elizabeth Central Hospital (QECH) and Kamuzu Central Hospital (KCH) were consulted, and the design and implementation modalities of these registries was reviewed. Pre-pilot testing took place at Queen Elizabeth Central Hospital and Dedza District Hospital in June and July 2018, with a team of three experienced HMIS clerks serving as data collectors. In July 2018 a larger team at Dedza District Hospital was trained and a longer pilot data collection phase was launched. The experience and data from these two phases of piloting was used to further refine the trauma registry questionnaire and protocols.

2.4 | Trauma registry implementation

The trauma registry teams were initially composed of two clinicians and three data clerks from each hospital, selected and invited to work on the trauma registry by the DHO in each of the districts. (These clerks were already working in facilities as HMIS data clerks and were invited to join the trauma registry project). Based on the stakeholder meetings held in January and July 2018, 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 trauma registry teams.⁴ They were responsible for making sure that all trauma cases that arrived at the hospital were registered (including on 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 for communication with the research coordinator; reporting any issues with the trauma registry; and serving as a local resource person on the trauma registry (which also required that they personally enter at least five cases per week). The trauma coordinator was also responsible for training new data entry clerks who joined the trauma registry team after the initial training. 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.⁵

We trained trauma registry teams in August 2018, holding one training for the five hospitals in the north and one for the five hospitals in the south. The training consisted of a one-day classroom training (including role-play) and a second day where trainees returned to their home hospitals and were visited and shadowed by the trainers. As data entry is done by clerks rather than clinical staff (to avoid overburdening clinicians and interrupting care), training

included specialized topics such as teaching clerks how to take vital signs and assess Glasgow Coma Scores. It also dealt with issues such as when to delay data capture because a patient required immediate care, or was unconscious or otherwise incapacitated. By late August 2018, all 10 hospitals had started piloting the trauma registry. September 2018 was the first full month of data collection.

After 11 months of using the trauma registry, a refresher training was held, in which members of the research team visited each of the hospitals for one day to conduct training on-site. The refresher training had two main objectives:

- To improve data quality, with specific focus on key variables like vital signs (heart rate, respiratory rate, blood pressure, and temperature), cause and intent of trauma, and the definition of serious injury; and
- To train new data clerks who had been added to the team over the first 11 months.

2.5 | Data quality assurance

Data quality has been a persistent challenge in trauma registries in low resource settings.⁹ In light of this experience from other settings, the research team put in place an extensive set of data quality protocols to support collection of comprehensive and accurate data.

Oversight of the implementation of the trauma registry is done by the research coordinator (based in Lilongwe) and three part-time research assistants, located in three different regions to better support data collection and manage technical and logistical data collection issues as they arise in the field. Based on the team's experience piloting the registry as well as managing data collection in other settings, five pillars of data quality were identified: (a) clear and consistent communication between the research team and health facility coordinators; (b) transparency and sharing of data; (c) high frequency data checks; (d) data validation; and (e) logging of process.

The most important factor in ensuring good data quality has been consistent communication. From the start of the implementation of the trauma registry, a Whatsapp group with all trauma registry coordinators and the trauma registry monitoring team was set up. This group was used frequently to share information, challenges, or feedback on the work with the trauma registry, about anything from data entry challenges to specific logistics and operational questions. Over the first 6 months, all hospitals were visited by the research coordinator and at least one of the data collection assistants from the research team at least twice, and several hospitals received additional visits. Group calls between the monitoring team and trauma coordinators were piloted in September 2018, but were replaced with individual calls on a weekly basis. The feedback provided on these calls includes information about the quantity, quality and trends in the data received from the trauma coordinator's hospital in the past week. Each trauma coordinator has a dedicated contact person on the research team to consult when challenges arise, and this contact person aims to respond to any request within 24 hours, usually by phone or WhatsApp.

The second pillar is transparency and sharing of data. The research team created a data dashboard on "Dropbox Paper" (a feature of the Dropbox file hosting service) in early November 2018. The goals of the dashboard are to give data collection teams frequent feedback, to give them a tangible sense of what their data collection is being used for, and to provide them with aggregate up-to-date trauma data that they can utilize to inform care and planning. They receive summary statistics on weekly number of entries since inception; weekly number of entries in the past 3 weeks; number of entries per entry point; ranges of vital signs entered; average number of cases each weekday; and averages during the day and at night. For sharing insights on trauma care at hospital level, the variables they receive are: causes of trauma; outcomes of trauma; means of transport to hospital; and trauma by gender and age group. Data from all hospitals is visualized, so that trends in the data can be followed over time and compared between hospitals. The dashboard also has sections which are specific to each facility, aimed at helping the coordinators (and hospital management) follow up on issues in the hospitals where they work.

The research team also conducts high frequency checks on the incoming data to flag potential issues, including outliers and errors in the data entry. These issues are then reported back to the trauma coordinators and the data

clerk who has made the mistake. They include checks on missing data in important variables, such as vital signs, or notable outliers and logically inconsistent answers, such as when the diagnosis indicates that a patient is very badly injured but the recorded outcome is "treated and sent home." These checks started in November 2018, after 2.5 months of data collection. There are 15 checks and the research team conducts all of them once a week.

In addition to high frequency checks for outliers and inconsistent responses, the research team also conducted a data validation exercise. In government health facilities in Malawi, paper registers are used to register patients; these capture basic demographic and medical information. This data is 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"). On two occasions during the first year of data collection (November 2018 and June 2019), the number of entries in the new trauma registry was validated by comparing to the number of entries in these paper registers in all participating facilities. While there are challenges with comprehensiveness of this HMIS data, the comparison provides a first indication of the comprehensive coverage of the trauma registries.

Finally, in order to keep track of challenges, changes in the teams, and feedback reported from the trauma coordinators, a log is kept by the research coordinator to record issues over time at each of the hospitals. This log helped the trauma registry monitoring team respond to the reported challenges and follow up on suggested and implemented solutions.

3 | RESULTS

51 337 trauma cases were recorded over the 14 month period from September 2018 to October 2019. There were steady increases in number of trauma cases recorded from September 2018 to October 2019, with 2523 cases recorded in September 2018, and 4853 recorded in October 2019 (Figure 2).

Figure 3 shows data quality over time, as measured by the capture of complete basic vital signs by month. Data quality improved over time in central hospitals. At the start of the registry in September 2018, just over 70% of cases in central hospitals had complete entries for heart rate, blood pressure, respiratory rate, and temperature, and the average completeness rate for vital signs over the first 6 months was 76%. Over the second 6 month period, the completeness rate was 87%. For district hospitals, the average completeness rate for vital signs remained relatively consistent; over the first 6 months the completeness rate was 90%, compared to 88% over the second six-month period.

Similarly, the rate of outliers in vital signs (blood pressure, respiratory rate, heart rate, and temperature) declined from 12% in the first 3 months of data collection (September–November 2018) to 3% in September/October 2019. An outlier here is defined as a value falling beyond the ranges stated below, and was flagged to the data collection team for further inspection and discussion, with particular focus on cases where the levels were implausible given otherwise modest or moderate injuries (ie, the GCS score was not low). This was done to distinguish between possible equipment error or data entry mistake [Figure 4]. Outliers for all the vital signs are defined as follows:

- For Systolic Blood Pressure, defined as values ≤ 75 or ≥ 190 ;
- For Respiratory Rate, defined as values ≤ 13 or ≥ 30 ;
- For Body Temperature, defined as values ≤ 34 or ≥ 40 ; and
- For Heart Rate, defined as values ≤ 50 or ≥ 130 .

A third measure of data quality is completeness of data measured by trauma registry data capture relative to HMIS registers. All patients presenting at public facilities are supposed to be registered in the HMIS, so if many more patients were captured in HMIS with trauma-related conditions than in the registry, it would indicate flaws in the trauma registry's data capture processes. The registry tool captures much more in-depth information about trauma

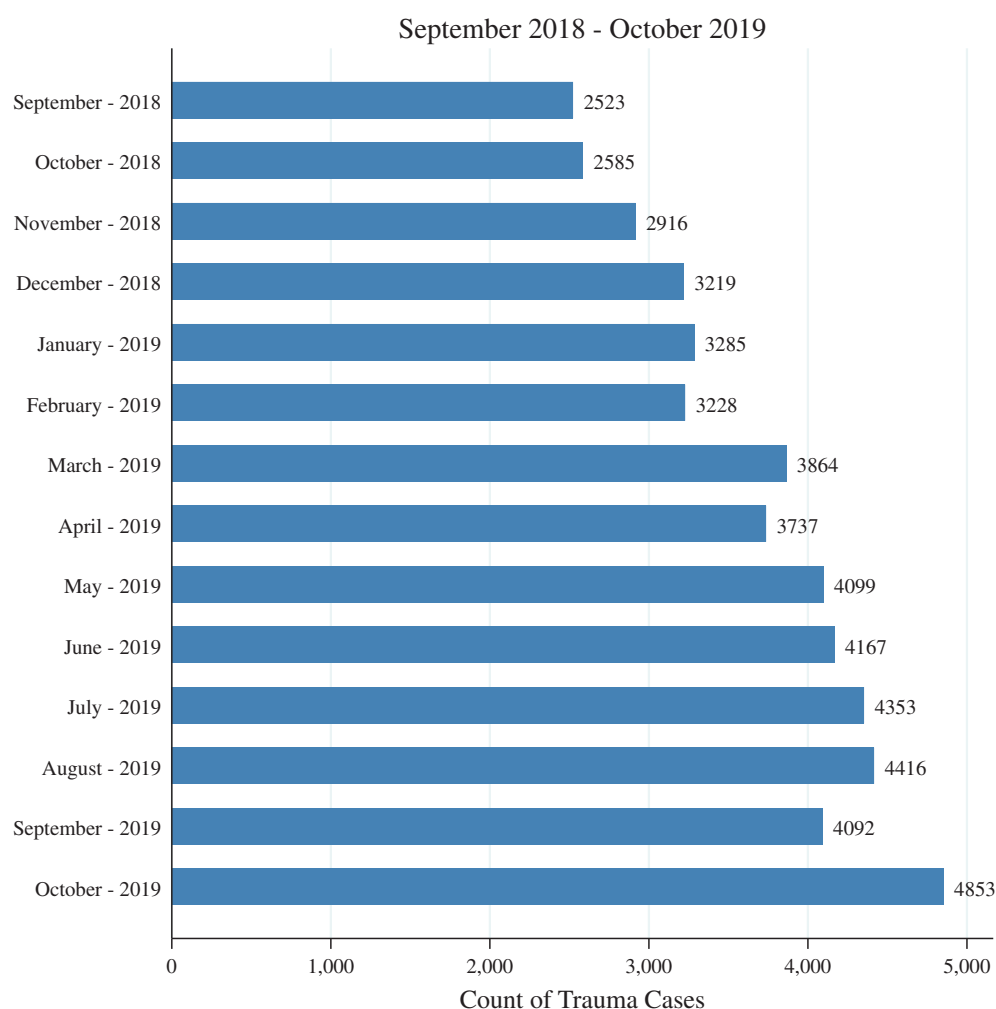


FIGURE 2 Total number of trauma cases by month, September 2018–October 2019 [Colour figure can be viewed at wileyonlinelibrary.com]

patients than the HMIS registries (by design), and the validation exercises show that it has also begun to equal or exceed the breadth of coverage of HMIS registers. The first data validation exercise was conducted in November 2018 and the second in June 2019. The first data validation (Table 2) indicated that the trauma registries were capturing 76% of total cases captured by the HMIS system, while by the second, registries were capturing more cases than the HMIS (104%). (Table 3).

An additional measure of trauma registry coverage relates to geography. The trauma registries have sought to capture accurate measurements of the location of trauma incidents, in order to inform policy decisions as well as to provide a data source for evaluation of Malawi's efforts to strengthen emergency medical services, including centrally dispatched and equipped ambulances, to improve trauma care. In the first month of implementation (September 2018), the sub-district location variable (known as the "Traditional Authority" level in Malawi) was missing for 2.1% of observations, while by October 2019 this variable was missing for 0.7% of observations. This is reflected in Figure 5, which shows how the Traditional Authorities from which trauma location data was captured from has progressively expanded from September–October 2018 to September–October 2019.

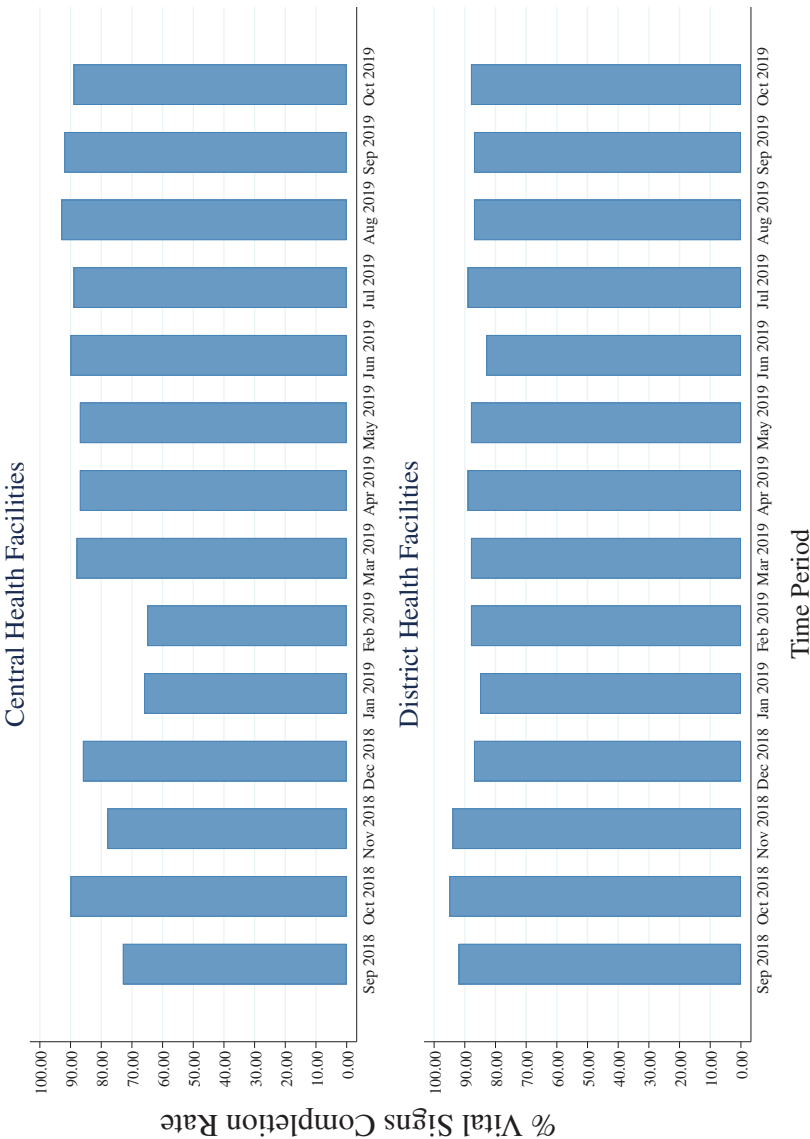


FIGURE 3 Average completion of vital signs data entry between central and district facilities at monthly level [Colour figure can be viewed at wileyonlinelibrary.com]

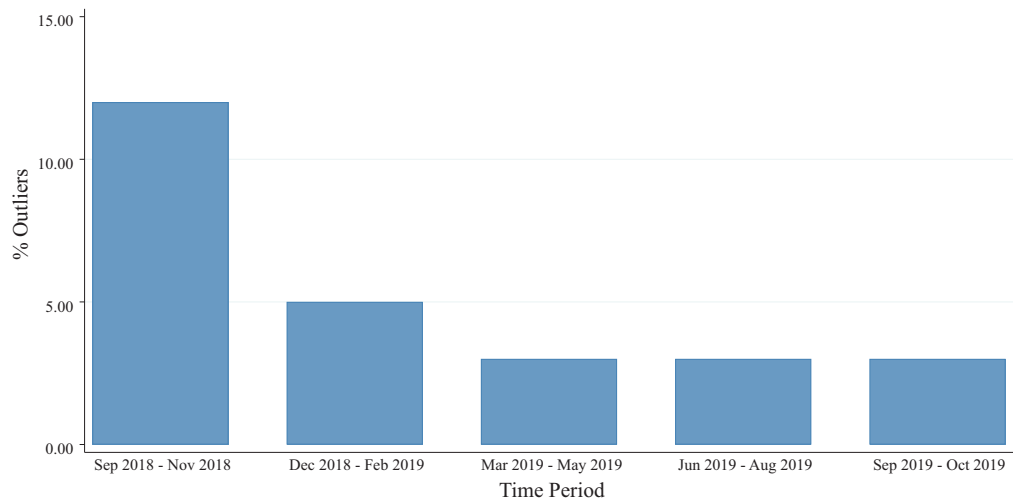


FIGURE 4 Rate of outliers in data entry of vital signs across 3 month time periods [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 2 Data Validation 1, November - 2018

Hospital	Date collected	Dates of data ^a	Total trauma cases, HMIS	Total trauma cases, registry	registry coverage (%)
QECH	14.01.19	19-25 Nov	155	119	77
Balaka	25.12.18	19-25 Nov	114	118	104
Ntcheu	21.12.18	19-25 Nov	94	56	60
Dedza	18.12.18	5-11 Nov	106	38	36
Lisungwi	07.01.19	19-25 Nov	24	16	67
Dowa	-	-	0	18	
Kasungu	22.12.18	19-25 Nov	59	71	120
Mzuzu	21.12.18	19-25 Nov	148	55	37
Mzimba	22.12.18	19-25 Nov	154	121	79
Rumphi	23.12.18	19-25 Nov	36	58	161
Total			890	670	75

^aThis represents the range of dates within which the number of trauma cases from the Trauma Registry and HMIS was collected for comparison.

4 | DISCUSSION

This paper seeks to share the experience of setting up and maintaining a digital trauma registry in a low resource setting where data on trauma is scarce and digital data collection methods in health facilities are not standard practice.

In this paper we find that it is feasible to collect comprehensive trauma data across multiple geographically dispersed hospitals using digital data collection tools in the Malawian context. There are several differences between this trauma registry and others previously implemented in Malawi. First, to our knowledge this is the first multi-site trauma registry in Malawi and the first to date to combine data collection from central (referral) hospitals, district hospitals, and a community hospital. In addition, this trauma registry collects more detailed information than previous

TABLE 3 Data Validation 2, June - 2019

Hospital	Date collected	Dates of data ^a	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%

^aThis represents the range of dates within which the number of trauma cases from the Trauma Registry and HMIS was collected for comparison.

registries on specific mechanisms of injury (especially road traffic crashes) and location of injury. Previous registries in Malawi have highlighted the heavy toll of RTAs,¹⁸ suggesting the need for more detailed data to inform policy, especially along the heavily traveled M1 transport corridor. Finally, this trauma registry was collected digitally, using "point and click" data collection interfaces to limit typing of free text answers (potentially saving time and reducing errors), and dramatically decreasing the time lapse between data collection and presentation of data to facility managers and data staff. Large numbers of cases were collected, with increasing data consistency, completeness, and quality over the course of the registry.

Like other trauma registries in similar contexts, two key challenges were institutional support^{19,20} and data quality.^{8,21} From the start, an emphasis was placed on developing the registry with the active cooperation and extensive input from Ministry of Health stakeholders. The initial steps of consultation through workshops, field visits, and several rounds of receiving feedback and incorporating it into both the registry tool itself and into registry processes were important for establishing this support and engagement. Similarly, frequent contact and follow up between the research team and facility-based trauma registry teams and facility managers helped maintain strong working relationships. Follow up occurred through in person visits but also through weekly WhatsApp chats when data and results from ongoing data collection were shared with facility-level staff and issues discussed. These forms of ongoing engagement were especially important when there was need to iteratively test and adapt different approaches to solve data collection challenges. 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.

The research team addressed data quality in several ways over the course of the project. The first was by investing in digital data collection tools and skills. Shifting trauma data collection from paper to tablets has been successful in other LMIC settings,²² but paper-based registries remain common. Despite some initial skepticism from counterparts, the project's experience shows that tablets are a feasible data collection tool in this setting. While initial implementation can be more costly in terms of training time and upfront cost of tablets, in the long run there are several key advantages to collecting data digitally. First, it reduces data entry errors that can occur when entering data collected on paper into a digital database. Second, it enables researchers to include hard-coded controls in what input is allowed, which also limits data entry mistakes. Third, it helps to ensure completeness of data as fields can be made mandatory in order to ensure data clerks or clinicians enter data for all of them. Fourth, it helps the data collector with skip patterns, making sure that only the questions valid for the situation are being answered, so that there are fewer contradictions in the data. Fifth, it allows for rapid basic analysis of data, demonstrated by the weekly

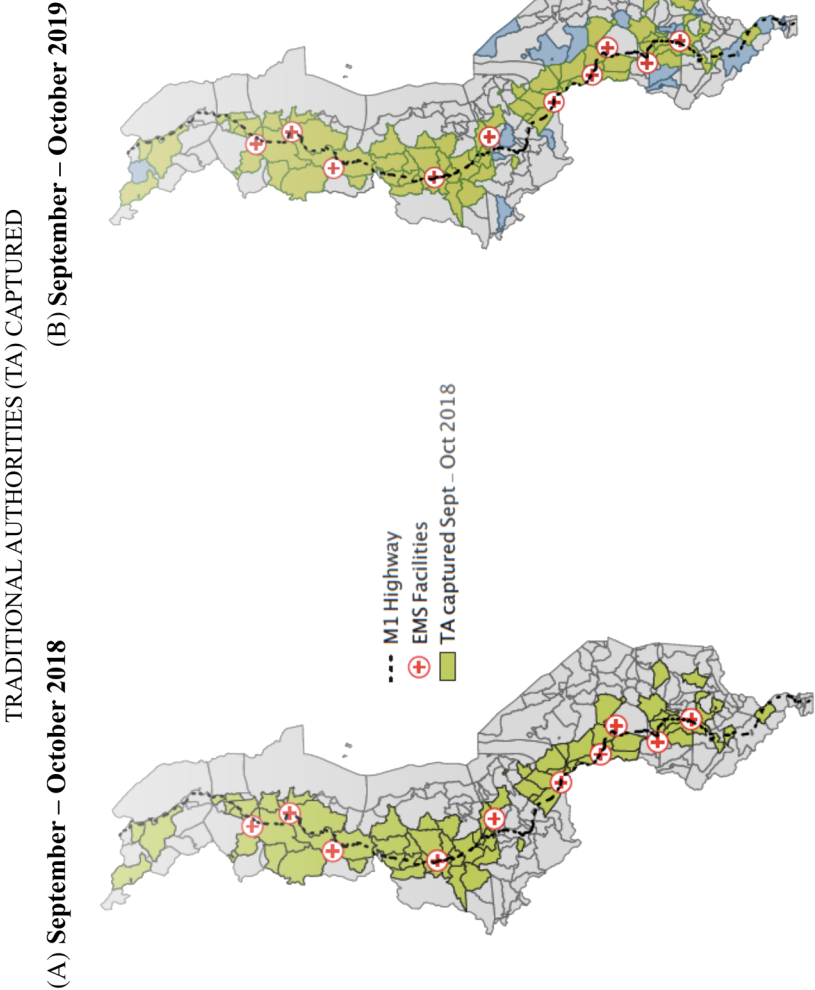


FIGURE 5 Traditional authorities (TA) captured in September–October 2018 and September–October 2019 [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

Dropbox Paper summaries (described above) which are shared with facilities. This can facilitate learning by data collectors and thereby continuously improve the trauma registry, while also giving front line health workers clear visual evidence of trends in their hospital and how they compare to other facilities in the study.

Beyond this, data quality was ensured through the same methods of ongoing in-person and digital communication with trauma data collection teams that were mentioned above, such as WhatsApp groups and sharing of Dropbox paper results from data analysis, and through the activities of the team which conducted ongoing visits and refresher trainings. The first year of trauma registry data collection shows several patterns which reflect increasing data completeness and quality over time, and as data quality protocols were put in place, including increasing completeness of clinical data (such as vital signs) and location data (such as the place where the trauma occurred), increased accuracy (ie, reduced outliers), and more comprehensive capture of cases when compared to HMIS registers.

The registry and the process by which it was implemented also have several limitations. Even though data quality has improved over time, ongoing supervision is key. Malawi has a shortage of front line health workers, and these staff have multiple demands on their time. It is possible that without ongoing data quality monitoring, attention to the registry might diminish and data quality could decrease over time. A second limitation relates to the availability of funding. Some forms of data quality controls, like high frequency data quality checks, can be streamlined, and much of the data quality-related communication can take place over digital platforms, but ongoing commitment to a registry does require significant time commitments from a research team, including both field staff and researchers in academic and policy institutions. Finally, there are also limitations to the range of variables collected. 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, or to capture detailed information on quality of care for hospitalized patients.

An important consideration going forward is sustainability, which relates closely to the limitations mentioned above. This challenge is shared with many other registries established in low income settings.²⁰ The basic cost for running the registries, including minimal field-based supervision, is around 5800 USD per month (4 263 000 MWK) for the 10 facilities, or on average 580 USD (426 300 MWK) per facility per month. This does not include the additional supervision, quality checks, and researcher travel and time that was invested so that the data meet the rigor and reliability standards demanded for academic publication - many of which have been highlighted in this paper. Even the basic cost of 580 USD per facility/month (426 300 MWK) is substantial, given all the competing needs in a low-resource setting such as Malawi's health sector. Nevertheless, this cost could be further decreased if certain steps are taken. The trauma registry works with data clerks who are already employed by facilities to record and digitize incoming data. If data clerks and clinicians are trained and supported to collect more detailed information on incoming patients, and this data collection is incorporated into their daily responsibility, it would significantly decrease costs and increase the precision of data being collected. Incorporating this type of data collection into everyday work will require paring down the indicators to those that are most useful. Some oversight and data checks would still be necessary to maintain quality, but these could be performed at a lower cost if they were part of a broader emphasis on strengthened administrative data quality systems. Policymakers will have to balance the benefits of such registries with the costs that they entail.

More generally, there are efforts underway to digitize medical records in Malawi, such as through the efforts of the Baobab Health Trust. Integrating trauma registries into such an electronic EMR system is a long-term goal for sustainability. As the research team continues data collection, the next phase of the project will explore how the transition can be done to integrate this into the existing system. This will involve significant capacity building, and will also require additional investments into digitizing data collection at facilities. Through these efforts, it can be possible for trauma registry data collection to continue beyond the length of this research project.

This paper has shown that it is possible to establish a multi-center electronic hospital-based trauma registry which can collect good quality data in a low income setting. Proper planning prior to implementation, on-going monitoring and regular feedback to the hospital teams during data collection are vital to ensure successful operation of the registry.

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ETHICS STATEMENT

Ethical approval for this study was granted by the Malawi National Health Sciences Research Committee (NHSRC), protocol May 18, 2030.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

CONSENT FOR PUBLICATION

Anonymous information was used in this manuscript to ensure confidentiality.

AUTHOR'S CONTRIBUTIONS

Kevin Croke, Linda Chokotho, Sveta Milusheva, Wakisa Mulwafu, Saahil Karpe, Meyhar Mohammed, and Jonna Bertfelt contributed to the design of the study. Meyhar Mohammed contributed data analysis, including creation of Figures. Linda Chokotho, Wakisa Mulwafu, and Jonna Bertfelt led data collection activities. Kevin Croke, Linda Chokotho, Sveta Milusheva, Wakisa Mulwafu, Saahil Karpe, Meyhar Mohammed, and Jonna Bertfelt contributed to drafting and revising the article. All authors had access to the data and can take responsibility for the integrity of the data and the accuracy of the data analysis. All authors read and approved the final manuscript.

DATA AVAILABILITY STATEMENT

Microdata is not yet publicly available since it is considered Malawi Ministry of Health patient data.

ORCID

Kevin Croke  <https://orcid.org/0000-0002-4750-9280>

ENDNOTES

- ¹ One registry question about alcohol is based on the self-reporting from the patient, although the response option "suspected" can be used when the patient denies having drunk alcohol but a nurse, doctor or data clerk suspects that this is untrue.
- ² The project, implemented by the MOH, includes training first-responders, paramedics and ambulance dispatchers; setting up an ambulance system with a toll-free emergency number, central dispatch system, and dedicated ambulances; and improving trauma treatment capability in hospitals along the M1 corridor.
- ³ The trauma registries were initiated as an activity in a project financed by the World Bank, focused on improvement of emergency medical services for road traffic accidents. A steering committee of Ministry of Health and medical officials meet on a quarterly basis to review and guide all project activities, including the trauma registries. The trauma registry team has periodically briefed this steering committee and received their approval for registry activities.
- ⁴ In the Malawian health system, clinical officers undergo 3 years of post secondary school education in clinical medicine and are awarded a diploma in clinical medicine at the end of their training. They provide care in primary and secondary care health facilities independently, but work under the supervision of doctors in tertiary care facilities.
- ⁵ Hospital attendants are a lower level cadre of workers who were not initially included in registry teams. It was decided to involve them in facilities where there was shortage of data clerks, such that the data clerks who were recruited initially were not enough to ensure uninterrupted data capturing in the registry.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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