Evaluating Access to Prehospital Care for Traumatic Brain Injury Patients in a Resource

Limited Setting: Focus on Prehospital Transport

by

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Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Science in the Duke Global Health Institute
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ABSTRACT

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Abstract

BACKGROUND: This study describes the prehospital transport of traumatic brain injury (TBI) patients and its impact on TBI outcome to inform quality improvement for the existing trauma system. Data was collected over 4 months at a major referral hospital in Moshi, Tanzania.

METHODS: Patient demographics, mechanism of injury, injury severity (Glasgow Coma Score), and vitals were recorded on presentation to the Casualty Department.

Prehospital factors recorded include time, distance and cost. Multivariable regression analyses evaluated the effect of prehospital factors on unfavourable patient TBI outcome, in-hospital factors and demographics were controlled for. Unfavourable outcome was defined as Glasgow Outcome Score<5 on discharge or death.

RESULTS: Road traffic injuries were the most common mechanism of injury (67.1%). The majority of patients were referred from other facilities in and around the region (62.3%), with 23% from the local public hospital. There was no evidence of prehospital care available in this region. Average prehospital duration was more than 1 hour, a third of this was spent in prehospital transit for a majority of the patients. A minority used Ambulances. Predictors of unfavourable outcome (GOS<5) were: prehospital time greater than 60 minutes, multiple physical transfers during the prehospital course and being referred from another hospital.

CONCLUSION: The lack of prehospital care calls for further research into prehospital interventions for this setting. Further analysis should be conducted with a larger sample size to increase accuracy of the findings.

Dedication

This thesis is dedicated to the individuals and families globally whose lives are forever changed by preventable injury. It is my hope that the findings of this study will go some way in preventing or alleviating the pain and heart break suffered by you and your families.

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List of Abbreviations

ALS	Advanced Life Support
AMO	Assistant Medical Officer
BLS	Basic Life Support
BTF	Brain Trauma Foundation
DALYs	Disability Adjusted Life Years
DBP	Diastolic Blood Pressure
ECSSA	Emergency Care Society of South Africa
ED	Emergency Department
EMS	Emergency Medical Services
GCS	Glasgow Coma Score
GOS	Glasgow Outcome Score
HIC	High Income Country
KCMC	Kilimanjaro Christian Medical Centre
LMIC	Low and Middle Income Countries
RTS	Revised Trauma Score
SBP	Systolic Blood Pressure
TBI	Traumatic Brain Injury

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1. Introduction

1.1 Burden of Injury

In 2010 injuries accounted for 11% of the global burden of disease causing 5 million deaths and 279,000 disability-adjusted life years (DALYs) (Murray et al., 2012). Through studies such as the global burden of diseases study the public health community has made concerted efforts to better understand this previously neglected cause of global mortality and morbidity. According to the World Health Organization, unintentional injuries were responsible for over 3.9 million deaths and over 138 million disability-adjusted life-years in 2004, over 90% of those occurring in LMICs . Over 91% of unintentional injury deaths and 94% of disability-adjusted life-years were lost in LMICs in 2004 (Chandran, Hyder, & Peek-Asa, 2010). These data on global injury epidemiology reveal a disproportionate burden in low-and middle-income countries (LMIC).

In sub-Saharan Africa the intentional injury burden in 2002 was 60.9 deaths per 100,000 people compared to rates of 32.0 and 27.7 in Europe and North America (Krug, Mercy, Dahlberg, & Zwi, 2002). The highest contributor to unintentional burden of injury was road traffic injury (RTI), 90% of RTIs occurred in LMICs with males in Africa having the second highest fatality rate out of all injuries, of 35.8 per 100,000 (Bowman, Seedat, Duncan, & Kobusingye, 2006).

While the focus has been on injury prevention, arguably the biggest challenges to survival after trauma are the disparities in the continuum of trauma care provision and quality worldwide (Dagal, Greer, & McCunn, 2014). Dagal et al found that patients with life-threatening injuries are six times more likely to die following a trauma in a low-income country than in a high-income country.

The disparities in trauma care are consistent with the economic disparities globally and concurrently where the burden of injury is highest. Subsequently poverty, insufficient health system resources and injury burden lead to a reinforcing loop with detrimental effects. In an effort to interrupt this vicious cycle there has been a call for trauma system interventions, including emergency medical systems (Hsia, Mbembati, Macfarlane, & Kruk, 2012). Higashi et al investigated the burden of injury in LMICs that could be averted through a basic surgical package. They found that potentially 21% of the injury burden in LMICs (52.3 million DALYs, comprising 23% of deaths and 20% non-fatal burden) could potentially be averted through basic surgical care. In their analysis, the researchers explicitly account for proportion of deaths that either occur on site or cases that did not reach a hospital noting that these would depend on broader infrastructural and policy issues such as first aid and referral systems to avert them. They conclude that while surgical care is important, prevention and improvements in

prehospital services are essential to prevent the substantial proportion of fatal cases occurring prior to hospital admission (Higashi et al., 2014).

1.2 Prehospital Trauma Care Systems

Prehospital trauma care systems are responsible for care delivery during the prehospital phase, or before arrival at a “fixed health-care setting” (e.g. hospital, clinic etc.) following a trauma event (Sasser, Varghese, Kellermann, & Lormand, 2006). These systems coordinate the prehospital (emergency) care and transport to a fixed health-care setting. The decision is usually made based on the severity of injury, facility capacity and distance to the treating facility. For the purposes of this study, prehospital care is defined as any intervention performed on the patient between time of injury and time to reach a fixed health-care facility. Prehospital factors identified in literature that may have an impact on disparities in trauma outcomes include: emergency medical services (EMS), scene times, access to trauma care and geography (Haider et al., 2013).

Trauma systems in general consume a substantial amount of public funds globally, for example in England the NHS spends £0.3-0.4 billion per year on hospital care for trauma. In the US in 2009, trauma systems cost the economy and health system \$693.5 billion in 2009 (Lin M, 2011). These costs do not include the lost economic output as a result of trauma which, in England was estimated to be as high as £3.7 billion annually (Morse A, 2010). Naturally, countries seek to reduce the cost of trauma and

evidence shows that despite the high costs the presence of a trauma system or trauma care can reduce long term morbidity of survivors and improve functional outcomes (Sasser, Varghese, Joshipura, & Kellermann, 2006). Mature trauma systems have been shown to be cost effective (MacKenzie et al., 2010), and there is evidence of a 5- to 15-fold return on investment for each patient returning to work (Durham et al., 2006). This emphasizes the importance of establishing the effect of trauma system care on quality of functional outcome (Lendrum & Lockey, 2013).

In high income countries (HICs), prehospital trauma management involves addressing and treating the life-threatening problems on a trauma patient ABC-Airway, Breathing and Circulation (Williamson, Ramesh, & Grabinsky, 2011). This can be extended to include addressing life threatening problems of DE-Disability and Exposure. There are two levels of prehospital care available, Basic Life Support (BLS) which involves non-invasive Cardiopulmonary Resuscitation (CPR) and Advanced Life Support (ALS) which has invasive procedures such as endotracheal intubation, intravenous line placement and needle-chest decompression as well as the administration of controlled medication (Stout, Pepe, & Mosesso, 2000), with ALS being the preferred choice in severe trauma where available.

A systematic review of prehospital management of TBI (traumatic brain injury) showed that above all, quality of prehospital care was the determining factor in patient

outcome. Initial goals of prehospital management of TBI include managing hypoxia and hypotension, while more advanced goals in mature trauma systems are to prevent elevated intracranial pressure and the subsequent cerebral herniation. The prevention of secondary injury is a major determinant of both short- and long-term outcome. (Stiver & Manley, 2008).

The majority of studies in HICs have shown that prehospital interventions for TBI patients to be life-saving (Alspaugh et al., 2000; Bernard et al., 2010; Lendrum, Kotze, Lockey, & Weaver, 2013; N. K. Mould-Millman, Sasser, & Wallis, 2013; Rudehill et al., 2002). Furthermore, more advanced forms of prehospital care such as aeromedical transfer have been shown to reduce mortality for blunt trauma patients by as much as 9% compared to land ALS systems (Baxt & Moody, 1987). It is important to note that there is data showing unfavorable outcomes with prehospital EMS intervention in HICs. For example, a study in Los Angeles, USA showed patients that used private transport arrived at hospital faster than those who used EMS and had better outcomes. In their study, Haut et. al investigate the effect of prehospital intravenous fluid therapy actually increased risk of mortality in trauma patients including traumatic brain injury (TBI) (Haut et al., 2011). However this study is consistent with the observation that the reduced mortality as a result of prehospital care is largely due to reduced prehospital

times, thereby reinforcing the importance of response and scene times as metrics in measuring trauma care system effectiveness (Lendrum & Lockey, 2013) .

Prehospital trauma systems are not homogenous internationally largely due to: resource limitations including physicians; medico-legal ramifications of adjunct providers; the history in their formation and background in military settings (Williamson et al., 2011). This variability and the unethical application of applying randomized trials, makes it difficult to compare and assess their true value. For example in comparing systems with physicians as part of the prehospital response team (as in the Franco-German “stay and stabilize” model) and those with paramedics or ALS (Advanced Life Support) care (as in the Anglo-American “scoop and run” model) (Al-Shaqsi, 2010; Roudsari et al., 2007).

Despite the challenges in measuring effectiveness of prehospital trauma systems the body of literature indicates that any prehospital trauma care system is better than none. Moreover, a prehospital care system integrated in a country’s health infrastructure has multiple use cases, responding to a variety of medical, obstetric and paediatric emergencies as well as natural disasters and terrorist threats (Sasser, Varghese, Joshipura, et al., 2006).

1.3 Prehospital Trauma Care Systems in Low and Middle Income Countries

Despite the fact that 24.3 million deaths and 1.02 million DALYs are addressable by prehospital and emergency care in LMICs (WHO, 2009), there is currently a dearth of research into emergency medical care in these settings, and particularly access to this care. Similarly within this context, there is very little known to date about the far-reaching socioeconomic impact of injury morbidity and mortality. While there are several barriers to accessing emergency care, the first barrier that a patient must always cross is arriving at the Casualty alive, without crossing this first hurdle all interventions available thereafter have limited impact on the overall burden. As such there has been a call to action for investments in emergency medical systems in LMICs (Kobusingye et al., 2005) and research, particularly in sub-Saharan African countries that face unique challenges (N. K. Mould-Millman et al., 2013)

According to a global survey on the status of road safety by the WHO 76% of 178 countries surveyed had a formal pre-hospital care system. However none of them was assessed for quality and 35% of 135 LMICs surveyed reported lacking a formal prehospital trauma care system (WHO, 2009). To bridge this gap there have been efforts to integrate innovative private sector solutions, the informal public transport sector with prehospital trauma care delivery (Mock, Tiska, Adu-Ampofo, & Boakye, 2002). For example, obstetric emergencies in have benefited from better outcomes by involving

innovative SMS-based alert systems in Rwanda and motorcycle ambulances in Malawi (Hofman, Dzimadzi, Lungu, Ratsma, & Hussein, 2008; Ngabo et al., 2012).

A number of studies have conducted a baseline survey of the prehospital trauma care system in sub-Saharan Africa and proposed starting points such as a centrally controlled communication system involving laypersons, commercial drivers, military, police and government ambulance services (Adeloye, 2012; T. Hardcastle, 2011; T. C. Hardcastle et al., 2013; Jayaraman et al., 2009a, 2009c; N. K. Mould-Millman et al., 2013). A few have gone a step further and investigated the effect of training lay first-responders to form the first part of the prehospital trauma care system as an intervention (Sangowawa & Owoaje, 2012).

South Africa is one of the few sub-Saharan countries with a formal prehospital trauma system, traced back to 1962 (even before the US) with the formation of the Accident Service trauma center and network (Cheddie et al., 2011). The prehospital care development can be traced back to 1979 when formal degree programs based at universities for paramedics were developed. The current structure of the system is formalized through a pre-hospital professional board at Medical Council level, the Professional Board for Emergency Care for the Health Professions Council and a separate board for pre-hospital providers, the Emergency Care Society of South Africa (ECSSA) (T. C. Hardcastle & Brysiewicz, 2013). There is even an established trauma

registry, the TraumaBank® managed by the Trauma Society of South Africa.

Unfortunately it is often criticized since only private hospitals subscribe to it due to a lack of government buy-in which skews the data. There are also many weaknesses in the system including lack of standardized trauma teams, low resources (both human and funding) and sub-standard training and care delivery in private fee for service facilities compared to government facilities. Despite the long history of trauma care in South Africa, Hardcastle et al argue that the biggest challenge is still the development of an appropriate trauma care system due to some of the issues mentioned which are observable throughout the sub-Saharan African region.

Ghana is another example of an African country with a prehospital care trauma system in its nascence. In some regions such as the Ashanti region there is a mix of private and public ambulance services available(C. N. R. Mould-Millman, S.D. Oteng, R., 2014). However the services are not ubiquitous therefore interventions involving lay person first aid training have been implemented. In one such intervention, an intervention involving the training of 335 commercial drivers using a 6 hour basic first aid course has been carried out. A pre-post self-reported interview process of 71 drivers showed that 61% had used their training to provide first aid since taking the course, and there was a 28% increase (2% vs. 35%) in crash scene management, 33% increase (2% vs. 35%) in airway management, 38% increase (4% vs. 42%) in external bleeding control and

15% increase in splinting of injured extremities (1% vs 16%) after the course compared to before (Mock et al., 2002) . This suggests that even in an absence of prehospital trauma care the existing informal prehospital transport mechanism could be built upon to improve prehospital care delivery. A study conducted in Iraq on road traffic injury patients it was determined that a prehospital trauma system does in fact reduce mortality in severe trauma which supports the case for more prehospital trauma care systems research and investment in LMICs (Murad, Issa, Mustafa, Hassan, & Husum, 2012).

In a study investigating mode of arrival (prehospital transport) by acuity of illness, injury and referral status in the Ashanti region of Ghana, Mould-Millman et al conducted a retrospective survey at an emergency center on all patients triaged (C. N. R. Mould-Millman, S.D. Oteng, R., 2014). They found that referred patients were almost two times as likely to arrive at the center by ambulance even though a minority of patients were transported via ambulance. They also found a strong correlation between acuity of illness or injury and use of ambulance transfer to arrive at the hospital. A great limitation in their study was the retrospective design, which made it difficult for them to link patient outcome with mode of transport.

1.4 Traumatic Brain Injury

According to the World Health Organization, TBI will surpass many diseases as a major cause of disease and disability by 2020. It is thought to affect as many as 10 million people annually; the burden of mortality and morbidity that this condition imposes on society, makes TBI a pressing public health and medical problem (Hyder, Wunderlich, Puvanachandra, Gururaj, & Kobusingye, 2007). Low and middle income countries also bear a disproportionate amount of the burden largely because they have a higher prevalence of risk factors of TBI which include road traffic accidents, drowning, falls and physical abuse, often alcohol use is also linked to these risk factors. The global incidence rate of TBI is estimated to be 200 per 100 000 people per year but this is likely to be underestimated (Harrison, 2010). TBI can be defined as:

“ ...a form of acquired brain injury, occurs when a sudden trauma causes damage to the brain. The damage can be focal - confined to one area of the brain - or diffuse - involving more than one area of the brain. TBI can result from a closed head injury or a penetrating head injury.”(Stroke, 2013)

1.5 Prehospital Management of Traumatic Brain Injury

TBI has been shown to be an exacerbating factor in trauma outcome worldwide. For example the mortality rate from blunt trauma and in the absence of TBI is 1%, when TBI is involved this goes up to 30%. Furthermore time is a critical risk factor for mortality as 50% of TBI fatalities occur within 2 hours or 120 minutes of injury (Badjatia et al., 2008; Baxt & Moody, 1987). As a result prehospital time from time of injury to arrival at a trauma care facility should be minimized as much as possible.

Guidelines for prehospital management of TBI best practises has been constructed between 1996 and 2005 from high quality evidence based research by the Brian Trauma Foundation (BTF) and the BTF Centre for Guidelines Management. Among their recommendations for adult TBI prehospital management are (Badjatia et al., 2008):

- Airway, breathing and circulation should be assessed with the priority being the establishment of a clear airway and necessary ventilator or circulatory resuscitation.
- Monitoring for hypoxemia (<90% arterial haemoglobin oxygen saturation) or hypotension (<90 mmHg systolic blood pressure (SBP)), including measuring Systolic blood pressure and diastolic blood pressure (DBP) using the most accurate available means as often as possible.

- Continuously measure blood oxygen saturation percentage levels prehospitally using a pulse oximeter
- Measurement of the Glasgow Coma Scale (GCS) by appropriately trained prehospital providers as a significant and reliable indicator of TBI severity. It should be repeatedly measured to identify improvement or deterioration and preferably prior to administering sedative or paralytic agents.
- Avoiding the use of paralytics to assist with endotracheal intubation for spontaneously breathing patients maintaining oxygen saturation [SpO₂] above 90% on supplemental oxygen in ground transported patients in urban settings. Treating hypotensive patients with isotonic fluids. With isotonic resuscitation an option for patients with GCS < 8. Caution should be heeded, as more studies are needed to support the benefit of this and solutions with mannitol and synthetic colloids, over the risk of secondary blood loss and worse cerebral hemodynamics.
- An organized trauma care system for all regions including protocols to direct EMS personnel to destination decisions for patients with severe TBI.
- Patients with severe TBI should be transported directly and immediately to a facility with available CT scanning, prompt neurosurgical care and ability to measure intracranial pressure (ICP) and treat intracranial hypertension.

- The mode of transport should be selected so as to minimize prehospital time for the TBI patient.

These guidelines were designed with a resource abundant setting in mind. As such, while they should be aspired to by developing trauma care systems the resource constraints call for a fiscally wise and disciplined approach to implementing the guidelines starting with those that have the strongest evidence base for improved outcomes in this setting.

1.6 Traumatic Brain Injury in Low and Middle Income Countries

Epidemiologic and etiologic information of accident and injuries in Tanzania is severely limited, as in most resource limited settings. However, a comprehensive study carried out in Moshi, Tanzania provides some important information that calls for more research into the epidemiologic profile of accidents and injury in resource limited settings and the socioeconomic impact on the community. The study carried out by Casey et al. found that the majority of injured patients presenting to the KCMC Casualty during the course of the 7 month study were from road traffic injuries (RTI). “Head injury was associated with increased mortality, OR 5.76 (95% CI 2.57, 12.92). No other injury location was clearly associated with mortality” (Casey et al., 2012). Around 5.4% of injured patients presenting died either on their way to the Casualty department or in the department before admission while the average length of hospital stay among all injured patients was 9.5 days. There was also a gender disproportionality with 73.4% of injured patients presenting being male. Additionally the majority (57.8%) of injured persons presenting fell into the working age population 15-44 years. This information suggests that there is likely to be a drastic socioeconomic impact of injury on the population in Moshi and the surrounding area that is covered by KCMC (Casey et al., 2012).

In researching prehospital trauma systems Mould-Millman et al. provide tenets for best practice, including delineating prehospital care research priorities well in the context of the full continuum of trauma care since it is just one link in the chain of survival (N. K. Mould-Millman et al., 2013). A study in Tanzania has shown that trauma resulting from RTIs is a leading cause of intensive care utilization and differences in survival is linked to poor pre-hospital care and lack of EMS (Chalya et al., 2011). This study has called for improved pre-hospital care of trauma victims to improve patient outcomes. As a result of the evidence base in literature and the tenets provided for prehospital trauma research in this region, this study was embedded within a larger study on quality improvement clinical practice for TBI patients which provides information on other weak links within the chain of survival that calls for further investigation.

1.7 Objectives

The objectives of this study were:

- i. To describe the prehospital epidemiology of TBI patients from point of injury to definitive care
- ii. To determine proportions of patients receiving formal prehospital care vs those not receiving any prior to presenting at the Casualty Department
- iii. To investigate the effect of pre-hospital transport, time to care and distance to care and their effect on TBI outcomes

We hypothesize that there will be little to no prehospital care given the results of other studies on prehospital trauma care systems in sub-Saharan Africa. As a result we also hypothesize that a minority of patients will have access to ambulance services and those that do will be associated with referral status and injury severity. We predict that a shorter prehospital transport time and mode will be associated with better patient outcomes.

2. Methods

2.1 Setting

This study was set at Kilimanjaro Christian Medical Center (KCMC) in Moshi Tanzania. The hospital has 450 beds and over 1000 staff. It serves a population of over 11 million people from Moshi Urban and the surrounding rural area in addition to the districts of Hai, Rombo, Mwanga, Same and Siha (see Appendix A2). KCMC is the largest private hospital in Moshi and also serves as the referral hospital for Northeastern Tanzania (as shown in Appendix A1). The main language spoken in this region is Swahili.

The continuum of trauma care at the hospital begins in the Casualty Department. In the annual hospital report for 2011, the hospital wrote about the Casualty Department outlining “The vision...to make the department a center of excellence in emergency medical care.”(Foundation, 2011) From the report it is clear that the department is possibly the busiest part of the hospital since it also serves as the entrance and receives an average of 80 to 100 patients a day. However challenges outlined do not cite infrastructure as a major problem “In spite of the very small space, it has been possible to attend all these patients.” A major problem cited in the report however is human resources; “Like other departments, Emergency Department (Casualty Department) has shortage of staff in all cadres i.e. doctors, nurses, medical attendants” (Foundation,

2011). Currently 4 doctors run the department, 4 registrars and one AMO (Assistant Medical Officer).

A significant proportion of admissions to Casualty due to accident or injury are expected to be due to road traffic injuries ranking 10th highest for cause of death 4rd highest among non-infectious disease causes globally (Chandran et al., 2010). This is also supported by the epidemiologic study of injury conducted at the hospital where researchers hypothesised a likely relation to “increased motorization in the setting of inadequate transportation infrastructure maintenance, lack of safety device use such as restraints and helmets, mixed road use by pedestrians or non-motorized vehicles, and the absence of pre-hospital and emergency care.”(Casey et al., 2012). In 2010 there were 3,582 road traffic fatalities reported in Tanzania; there is no vital registration system or Casualty Department based injury surveillance system incorporated in post-crash care. In addition less than 10% of seriously injured road traffic victims were transported by ambulance(WHO, 2013). The KCMC annual report for the department of general surgery named head injury as the number one condition in the department with a 40% of total admissions to surgery being for head injuries (358 out of 900) . In addition 40% of deaths in the surgical ward were due to head injury (22 out of 56) in the year 2011 as seen in table 1.

Table 1 Top 10 diseases admitted to surgery at KCMC and mortality outcomes (KCMC, 2011)

Clinical Disease	Admissions			Deaths		
	M	F	Total	M	F	Total
Head Injury	292	56	358	17	5	22
Intestinal Obstruction	120	66	99	12	2	14
Goitre	7	92	99	0	1	1
Diabetic foot	43	29	72	0	0	0
Appendicitis	19	22	41	0	0	0
Carcinoma oesophagus	43	20	63	3	1	4
Peritonitis	36	25	61	3	1	4
Burns	34	22	56	3	0	3
Carcinoma breast,	3	21	24	0	4	4
Carcinoma gastric	15	12	27	2	2	4

The Ministry of Health and Social Welfare of Tanzania states that the country's healthcare infrastructure (including private sector facilities and those run by NGOs) is designed such that as of 2005 70% of the population was within a 5 km radius of a hospital facility and 90% within 10km (Ministry of Health and Social welfare in collaboration with the World Health Organization, 2008). This study will be able to indicate how effective this organizational structure is and how it can potentially benefit from the integration of a prehospital trauma system in the continuum of trauma care.

2.2 Participants

Participants in this study were selected from the Traumatic Brain Injury registry at KCMC which created the sampling frame. Inclusion criteria include (see Fig. 2):

- i) Arriving at the KCMC Casualty Department alive and receive a diagnosis of TBI
- ii) Complete entry of demographics, prehospital and in hospital course in the TBI care and treatment log
- iii) Patient aged ≥ 18 and <65

The exclusion criteria of this study were as follows:

- i) Patient not diagnosed with TBI
- ii) Incomplete entry of demographics prehospital or in hospital course in the TBI treatment and care log
- iii) Patient dead on arrival (DOA)
- iv) Patient aged ≤ 17 and >65

2.3 Procedures

Institutional review for an amendment to the registry survey in order to capture prehospital data was obtained from KCMC. Approval for secondary use of data from the Trauma Care Log at KCMC was obtained from both Duke University and KCMC institutional review boards.

Data collection was carried out following institutional review approval from 1st July 2014 to 27th October 2014. The survey instrument (see Appendix A.3) was a paper questionnaire filled out by research nurses and the author, during the period. It was pretested for 1 month and the question on whether the patient received prehospital care was removed following this stage due to a saturation of responses in the negative. Data was entered into the secure, HIPAA compliant, online Research Electronic Data Capture (REDCap) platform by the data technician. The data was pre-coded for in REDCap, de-identified and only accessible by password.

2.4 Study Design

This was a prospective cohort study carried out over 4 months (July 2014-October 2014) using data from the KCMC Trauma Care Log registry. Only patients presenting with head trauma were included in the log.

Data were collected in 8 hour shifts covering 24 hours. At the beginning of each shift the research assistant nurses consulted the Casualty Department log book to ascertain how many patients had sought care.

Patients without complete prehospital data were excluded from the analyses. Similarly patients aged below 18 years or 65 years and above were excluded due to the different effects of TBI on these subsets of the population and their possibility of confounding the results.

2.5 Variables

2.5.1 Dependent Variable

i) Glasgow Outcome Score

The Glasgow Outcome Score is an indication of a patients' morbidity or mortality on discharge from the hospital. This was the primary outcome variable utilized in this study and was defined as follows on the registry:

Table 2 Glasgow Outcome Score (GOS) category definitions

Glasgow Outcome Score	Patient Outcome	Definition
5	Good Recovery	Resumption of normal life despite minor deficits
4	Moderate Disability	Disabled but independent. Can work in a sheltered setting
3	Severe Disability	Conscious but disabled, Dependent for daily support.
2	Persistent Vegetative	Minimal responsiveness
1	Death	Non Survival

For analysis purposes a $GOS \leq 4$ was considered and unfavorable outcome while a $GOS=5$ was considered a favorable outcome. Although there is an extended Glasgow Outcome Score (E-GOS) which makes a better distinction of the patient's disability post discharge, for the purposes of this research the GOS was chosen because only a binary outcome was necessary-favorable or unfavorable outcome and the GOS was sufficient to distinguish between these two possible outcomes.

2.5.2 Independent Variables

i) Total prehospital time

The total prehospital time taken from time of injury self-reported by the patient to time of arrival at the Casualty department was recorded. Prehospital time greater than 24 hours was excluded from the analysis due to survival for this length being an indicator for better outcome and potentially confounding the results. Patients or relatives were asked to provide the approximate time spent travelling on each stage of the patients' journey from injury to the Casualty department at KCMC. The individual times for each leg of the journey were recorded and summed to give a total transport time in minutes to avoid errors due to the three step delay in care (figure 1).

Figure 1 Factors contributing to delay in delivery of trauma care

ii) Transport Mode

Categorical variable describing the vehicle used to ferry the patient from the point of injury to the KCMC Casualty. Categories were Car, Taxi, Bicycle, Boda Boda (motorcycle taxi), Dala Dala (public mini bus), Police Vehicle, Ambulance, Bus , Other.

iii) Geography

Measured in terms of districts by self-report from victims or good Samaritans and family accompanying them to Casualty. Hospital and clinic names visited prior to arrival at Casualty were also recorded. Districts were Moshi Urban, Moshi Rural, Hai, Rombo, Mwanga, Same and the newly created Siha district. Patients outside of Kilimanjaro region were designated “other” for this variable. This variable was a proxy for distance to care.

iv) Interruptions to journey

This is an ordinal value obtained from the number of times a patient changed modalities on their prehospital transit to the KCMC Casualty department. The values were 0 for 1 modality used or one leg of the journey, 1 for 2 modalities or legs of the journey, 2 for 3 modalities or legs of the journey and 3 for 4 modalities or legs of the journey

2.5.3 Confounding Variables

i) Glasgow Coma Scale

This is a mentation scoring measure used to indicate the extent of a TBI within 48 hours of injury. The scale can be summarized as follows:

Table 3 Breakdown of the Glasgow Coma Scale

BEHAVIOR	RESPONSE	SCORE
Eye opening response	Spontaneously	4
	To speech	3
	To pain	2
	None	1
Verbal response	Oriented	5
	Confused	4
	Inappropriate	3
	Incomprehensible	2
	None	1
Motor response	Obeys commands	6
	Localizes to pain	5
	Withdraws from pain	4
	Flexion to pain	3
	Extension to pain	2
	No motor response	1

The GCS score is calculated by summing a score for each of the 3 behavioral components therefore the minimum GCS is 3 and highest is 15 with 15 representing the best possible score. Head injury classification by the GCS is as shown in table 4.

Table 4 Head Injury Classification by GCS Score

Head Injury Classification	GCS Score
Severe Head Injury	≤8
Moderate Head Injury	9-12
Mild Head Injury	13-15

There are other trauma scores such as the injury severity score (ISS), apache score and Kampala trauma score. However the GCS was chosen due to the fact that an earlier study has shown low GCS to be a good predictor for both mortality and morbidity in this specific population using the same sampling frame (Lynch, 2013).

ii) Revised trauma score (RTS)

In the hospital setting this is considered a more accurate predictor for patient outcome than GCS as it includes hypoxia as a predictor for mortality which was shown in an earlier study of this population (Lynch, 2013). Severity of injury on arrival was easier to measure than GCS as RTS is not easily calculated at the bedside much less in an emergency setting. RTS ranges from 0 (0.027 survival probability) to 7.84 (0.988 survival probability) and is calculated as follows:

Table 5 RTS classification for GCS, SBP and RR

Glasgow Coma Scale (GCS)	Systolic Blood Pressure (SBP)	Respiratory Rate (RR)	Coded Value
13-15	>89	10-29	4
9-12	76-89	>29	3
6-8	50-75	6-9	2
4-5	1-49	1-5	1
3	0	0	0

$$RTS = (GCS * 0.9368) + (SBP * 0.7326) + (RR * 0.2908).$$

Where: GCS= Glasgow Coma Score, SBP= Systolic Blood Pressure, RR= Respiratory Rate

iii) Age

Age in years as a continuous variable.

iv) Gender

Gender as a categorical variable reported as male or female.

v) Mechanism of Injury (MOI)

Categorical variable created according to the International Classification of Diseases, Ninth E codes (ICD-9). Options included were Road traffic injury, assault, drowning, fall or other.

vi) Alcohol Involvement

Categorical variable to log whether alcohol was involved in the injury. Assessed by research nurses either by self admission, clinical judgment or using a breathalyzer to measure blood alcohol concentration of the TBI patient. Any concentration above 0% was counted as having alcohol involvement

vii) Casualty Disposition

Categorical variable to capture information on where the patient went next in the continuum of trauma care after assessment in the Casualty department. The

locations were Intensive Care Unit (ICU), Surgery ward, Operating Theatre, Home or Death/Morgue.

2.6 Analysis

Data were entered into REDCap by the data technician and checked by the author for missing data and other anomalies. Statistical software Microsoft Excel 2013 (Microsoft Corp, Washington) was used to clean the data. Patients with missing variables were eliminated from all analyses on prehospital factors. The data was then entered and analyzed using Stata 13.0 (Statacorp, Texas). We reported baseline characteristics of all patients. Continuous variables were summarized using means, standard deviations, medians, and inter-quartile ranges (IQRs) as appropriate. Frequencies and proportions were used to describe categorical data with confidence intervals of the proportions.

Each variable was identified through literature and in the field and included in a conceptual model (see Appendix A.3). Each variable was then tested using the chi2 test and Fishers exact test where appropriate. Due to the presence of known risk factors for mortality multiple logistic regression was performed adjusting for potential confounders. Prehospital care was not adjusted for due to the evident lack of prehospital care in pretesting the survey instrument. Variables included in the

generalized linear model (GLM) for multivariable regression analysis were identified by the univariate analysis.

Disjoint indicator variables were created for the nominal categorical variables and dummy variables were created for all others.

A binomial logistic model was used in order to calculate odds ratios directly because the outcome, GOS favorable or unfavorable was binary. Interaction terms were introduced for each iteration. Results of the logistic regressions were deemed to be statistically significant at p values < 0.05 . The minimally sufficient adjustment set was then used to report the adjusted risk ratios.

Results

During the study From July 1st 2014 to October 27th 2015 there were 261 patients enrolled in the TBI registry and screened for this study. Inclusion/Exclusion was as follows:

Figure 2 PRISMA flow diagram of enrollment process

3.1 Sample characteristics

Table 6 describes the 146 patients enrolled in the study meeting our inclusion criteria.

Table 6 Summary of study population included in study

		<i>Frequency</i>	<i>Percent (%)</i>
Sex	Male	128	87.8
	Female	18	12.2
	Total	146	100
Mechanism of injury	Road Traffic Injury	98	67.1
	Assault	24	16.4
	Fall	7	4.8
	Other	17	11.6
	Total	146	100
Alcohol Involvement	Yes	64	43.8
	No	67	45.9
	Total	146	100
Glasgow Coma Score	≤8	13	8.9
	9-12	10	6.8
	13-15	123	84.2
	Total	146	100
Casualty Department Disposition	ICU	2	1.4
	Surgery ward	135	92.5
	Operating theatre	2	1.4
	Death	1	0.7
	Home	6	4.1
	Total	146	100
Referred patient	Yes	91	62.3
	No	55	37.7
	Total	146	100
Glasgow Outcome Score	Favorable (5)	134	91.8
	Unfavorable (1-4)	12	8.2
	Total	146	100

Figure 3 Distribution of mechanism of injury in study sample

Figure 4 Distribution of GCS scores upon arrival at the Casualty Department

Table 7 Population distribution for GCS, SBP, RR and RTS

Variable	Mean	STD. Deviation	Range (min- max)	Interquartile range
Glasgow Coma Score (GCS)	13	2.701	3-15	14,15
Systolic Blood Pressure (SBP)	123.39	19.890	59-201	110,144
Respiratory Rate (RR)	20.97	3.648	16-49	20,22
Revised Trauma Score (RTS)	7.52	0.721	4.09-7.84	7.55,7.84

3.2 Objective 1

“To describe the prehospital epidemiology of TBI patients from point of injury to definitive care”

A majority of patients were injured in Moshi Urban (35.6%, n=52) followed by in Moshi Rural (28.1%), with 28 injured outside of the Kilimanjaro region (19.2%), see table 8.

Table 8 District in which patients began their journey to KCMC Casualty post injury

District in which patients began their prehospital journey after injury	Frequency (%)
Moshi Urban	52 (35.62)
Moshi Rural	41 (28.08)
Hai	10 (6.85)
Rombo	3 (2.05)
Mwanga	4 (2.74)
Same	5 (3.42)
Siha	3 (2.05)
Other	28 (19.18)

Of 146 participants aged 18-64 years and with complete pre-hospital transit time data, the mean prehospital transit time was 90.03 minutes (range 2-990 minutes, 123.39 SD) and the median 60 minutes. For these patients the mean cost of prehospital transport was 11179.86 TZS (range 0-220000, SD 27288.45, n=139) and median was 0 TZS (See table 8 for summary).

Table 9 Prehospital transit time descriptive statistics

Variable	Median	IQR.	Min	Max
Total prehospital time (minutes)	185.50	(60-1115)	0.00	24690
Prehospital transport time (minutes)	60.00	(35-100)	2.00	990
Prehospital transport cost (TZS)	0.00	(0-10000)	0.00	220000

To track each patient's journey from point of injury to the location it was necessary to break the journey up into "legs". The majority of patients had 2 legs to their journey. As shown in table 9. The most "legs" travelled were 4, which was the case for 2 (1.4%) patients and the most common was 2 legs which accounted for 57.5% (n=84), as shown in table 8. For each leg of the journey the beginning and end locations in terms of district

were recorded and name of hospital travelled from if applicable, the cost of each leg, the mode of transport used as shown in table 9, and 10.

For 36.9% (n=54) of patients this was the only transport they used to reach the KCMC Casualty Department from the point of injury. The majority, 57.5% (n=84) of patients had 2 legs of their journey to get from point of injury to KCMC Casualty department. A minority, 4.1 % (n=6) patients used 3 modalities to reach the hospital and 1.4% (n=2) used 4 modalities. Only 2.05% (n=3) of patients used an ambulance from point of injury to the KCMC Casualty Department compared to 67.4% (n=62) who used it on the second leg of their journey. Police vehicles were used by 12.9% (n=20) of patients on their first leg of the journey compared to 4.4% (n=4) on the second leg.

Table 10 Costs of prehospital transport for each leg of the journey

Transport mode		Cost (TZS)				
		n	Mean	Median	Range	SD
1 st leg	Car	97	3896.91	0	0-15000	16755.28
	Taxi	7	7571.43	5000	3000-18000	5503.25
	Boda Boda	14	2250	0	0-12000	3501.37
	Dala Dala	1	0	0	-	-
	Police Vehicle	20	0	0	-	-
	Ambulance	3	11000	0	0-33000	19052.56
	Other	4	0	0	-	-
2 nd leg	Car	11	15454.55	0	0-65000	22411.44
	Taxi	7	6714.29	5000	3000-15000	4270.61
	Boda Boda	1	0	0	-	-
	Dala Dala	1	50000	50000	-	-
	Police Vehicle	4	0	0	-	-
	Ambulance	62	11193.55	0	0-120000	26328.22
	Bus	4	8000	2500	0-27000	12780.19
3 rd leg	Other	2	0	0	-	0
	Car	11	15454.55	0	0-65000	22411.44
	Ambulance	5	19590	0	0-67950	29993.17
4 th leg	Bus	2	8750	8750	2500-15000	8838.84
	Taxi	1	5000	0	-	-
	Ambulance	1	0	0	-	-

The most popular mode of transport for the different legs of the journey were as shown in table 11:

Table 11 Summary of the most popular modes of prehospital transport for different stages of a patients journey from point of injury to KCMC Casualty

Leg of journey	Mode	Percent
First	Car	66.44%
Second	Ambulance	67.39%
Third	Ambulance	62.50%
Fourth	Taxi	50.00%
	Ambulance	50.00%

3.3 Objective 2

“To determine proportions of patients receiving formal prehospital care vs those not receiving any prior to presenting at the Casualty Department”

Of the 146 patients included in the study a total 91 (62.3%) patients were referred from other facilities to KCMC. 21(23.1%) were referred from the local public hospital, Mawenzi. A further 70 (76.9%) were referred from other facilities in the region. Of those patients not referred, only 1 (1.82%) used an ambulance for transport. The most popular method of transport to Casualty for 32 (58.18%) of these patients was private car. Followed by police vehicle for 16 (29.09%). Of the patients that were referred from another facility 65 (71.43%) used a private car to get to the referring facility from point of injury, 12 used a boda boda (13.19%) and 2 used an ambulance (2.20%). Only 3 patients

(2.05%) who were not referrals had more than 1 leg in their journey to the Casualty department at KCMC. Of the referral patients, 62 (69.66%) used an ambulance from the referring facility to the Casualty at KCMC only 9 (10.11%) used a private car and 4 (4.49%) used a police vehicle.

In investigating the association between severity of injury and transport mode chosen from point of injury 11 (84.62%) of severely injured patients were transported from the scene using a private car, 1 (7.69%) used a boda boda and 1 (7.69%) used a police vehicle. Those with moderate injury predominantly used cars too (70%, n=7) with 2 (20%) using police vehicles. Of those with mild injury again the majority, 79 (64.23%) used private cars and 17 (13.82%) used police vehicles with 3 (2.44%) using ambulances.

A summary of these results are in table 12.

Table 12 First mode of transport from scene of injury stratified by injury severity (GCS score) and Unfavorable GOS score

Transport mode	Injury Severity (GCS) (%)			Unfavorable GOS (<5) (%)
	Mild (13-15)	Moderate (9-12)	Severe (≤ 8)	
Car	79 (64.23)	7 (70.00)	11 (84.62)	10 (83.33)
Taxi	6 (4.88)	1 (10.00)	-	0 (0.00)
Boda Boda	13 (10.57)	-	1 (7.69)	0 (0.00)
Dala Dala	1 (0.81)	-	-	0 (0.00)
Police vehicle	17 (13.82)	2 (20.00)	1 (7.69)	2 (16.67)
Ambulance	3 (2.44)	-	-	0 (0.00)
Other	4 (3.25)	-	-	0 (0.00)
Total	123 (100)	10 (100)	13 (100)	12 (100)

There is correlation between prehospital transport by car and unfavorable GOS outcome, possibly explained by the fact that the majority (84.62%) of severely injured patients use a car as their means of transport from site of injury.

Table 13 Transport mode from scene of injury stratified by injury mechanism of injury

Transport mode	Mechanism of Injury (%)			
	Road traffic injury	Assault	Fall	Other
Car	70 (71.43)	13 (54.17)	3 (84.62)	11 (64.71)
Taxi	2 (2.04)	1 (4.17)	3	1 (5.88)
Boda Boda	6 (6.12)	4 (16.67)	-	4 (23.53)
Dala Dala	1 (1.02)	-	-	-
Police vehicle	16 (16.33)	3 (12.50)	-	1 (5.88)
Ambulance	1 (1.02)	1 (4.17)	1 (14.29)	-
Other	2 (2.04)	2 (8.33)	-	-
Total	98 (100)	24 (100)	7 (100)	17 (100)

While transport by private car was the most common mode of transport from scene of injury by both injury severity and mechanism of injury there appears to be an association between road traffic injury and police vehicle transport from scene of injury (16.33%, n=16) and similarly for assault (12.50%, n=3). Interestingly no severely or moderately injured patients used an ambulance on the first leg of their journey from the scene of injury. All 3 (2.44%) who used an ambulance on the first leg of the journey had mild head injury. Whereas for the second leg of the referred patients' journey 69.66% (n=62) used ambulances. Our pre-test survey included data on prehospital care

received, initial results showed that no single patient received prehospital care at the site of injury or in prehospital transit, we removed this question in subsequent surveys.

3.4 Objective 3

“To investigate the effect of pre-hospital transport mode, time to care, referral status and distance to care and their effect on health outcomes”

Mechanism of injury, interruptions to journey and prehospital transport time to total prehospital time ratio were not found to be significant in their effect on outcome if any.

All the variables bivariate analyses on GOS are summarized in table 15. Variables considered to be significant predictors for TBI patient outcome ($p < 0.05$)

The adjusted values for variables included in the minimally sufficient adjustment set i.e. the best model with this data are also indicated in table 14.

Final Model-Minimally sufficient adjustment set:

$$E(\text{GOS Unfavorable}) = \beta_0 + \beta_1 \text{Prehospital Time} + \beta_2 \text{Interruptions} + \beta_3 \text{GCS} + \beta_4 \text{Gender} + \beta_5 \text{Referral}$$

Table 14 Predictors for unfavorable TBI outcome

Variable	Level	Unadjusted RR (95% CI)	Adjusted RR* (95% CI)
Prehospital Time	≤ 60 minutes (ref)	1.00	1.00
	> 60 minutes	2.60 (0.4-19.4)	1.13 (0.12-10.33)
Transport Mode 1	Car (ref)	1.00	1.00
	Police Vehicle	0.97 (0.23-4.09)	-
Transport Mode 2	Car (ref)	1.00	1.00
	Police Vehicle	2.75 (0.22-34.33)	-
	Ambulance	1.42 (0.20-10.25)	-
Geography	Moshi Urban (ref)	1.00	1.00
	Moshi Rural	0.63 (0.06-6.75)	-
	Hai	7.80 (1.49-40.87)	-
	Siha	8.67 (1.06-70.74)	-
	Outside Kilimanjaro	4.64 (0.96-22.41)	-
Interruptions	0 (ref)	1.00	1.00
	2	3.00 (0.68-13.18)	1.21 (0.01-182.83)
GCS	≤ 8	1.00	1.00
	9-12	0.13 (0.02-0.86)	0.10 (0.01-0.77)
	14-15	0.03 (0.01-0.13)	0.04 (0.01-0.15)

Variable	Level	Unadjusted RR (95% CI)	Adjusted RR* (95% CI)
Age	18 (ref)	1.00	1.00
		0.97 (0.91-1.02)	-
Gender	Female (ref)	1.00	1.00
	Male	1.55 (0.21-11.28)	0.48 (0.05-4.27)
Alcohol	No (ref)	1.0	1.0
	Yes	1.31 (0.37-4.66)	-
	Unknown	3.35 (0.84-13.43)	-
Referral	No(ref)	1.00	1.00
	Yes	3.02 (0.69-13.29)	1.57 (0.04-11.33)

Casualty disposition while highly correlated with outcome (Pearson Chi2 34.648, $p < 0.001$) was not significant in influencing patient outcome in the multivariable regression models.

Table15 Characteristics of Casualty dispositions by GOS and GCS

Casualty Disposition	Unfavorable GOS (<5) (%)	GCS (%)		
		Mild	Moderate	Severe
ICU	2 (100)	1 (50.00)	0 (0.00)	1 (50.00)
Surgery ward	9 (6.67)	115 (85.18)	10 (7.41)	10 (7.41)
Operating Theatre	0 (0.00)	1 (50.00)	0 (0.00)	1 (50.00)
Death	1 (100)	0 (0.00)	0 (0.00)	1 (100)
Home	0 (0.00)	6 (100)	0 (0.00)	0 (0.00)

The size of the dataset and the large number of covariates limited our ability to obtain many statistically significant observations from our logistic regression models.

4. Discussion

This study brings much needed knowledge into both the prehospital trauma care infrastructure and the prehospital journey epidemiology for traumatic brain injury patients in this setting. We have established that there is little to no prehospital infrastructure in this region. We have also established that predictors for risk of unfavorable TBI outcome include: prehospital time, referral status, and interruptions to a patient's journey. However, caution must be taken when interpreting these results since the relationships are not causal.

Our study concurs with the current body of prehospital literature on sub-Saharan Africa (C. N. R. Mould-Millman, S.D. Oteng, R., 2014). Our study also shows very low ambulance utilization (2%) in the prehospital stage, and the majority of ambulance service use was in inter-hospital transfers (67.39%). The study revealed no presence of prehospital care services in the piloting stages precluding further data collection. These findings are as the literature delineated a dearth of functioning trauma care systems in the SSA region. Our data suggests that cost could be a major prohibitive factor in ambulance service use which shows that at each stage of a patient's prehospital journey the ambulance transport is the most expensive (see table 12).

Similarly there was correlation between severe injury ($GCS \leq 8$) and private car as the mode of transport from the point of injury. This could be due to the observation that cars are ubiquitous in the region and a quick transport option, additionally it is

logistically easier to transport a severely injured patient who may be unconscious in a private vehicle where they can be laid down though a further qualitative study is needed to tease out the socio-cultural reasons behind the high use of cars. As a result there was an observed higher proportion of unfavorable outcomes for patients who used cars as transport from site for injury. Conversely the variable transport mode was not significantly associated with overall outcome in the multivariable analysis. Again purely association and not causation was studied. There needs to be further study on this relationship with a larger dataset given the small sample size of 146, to investigate the reasons behind choice of transport and whether there is a higher risk of worse outcome with this mode or if it is simply a correlation skewed by the numbers. Our sample size calculation indicates a sample size of 1100 is needed to estimate incidence of unfavorable GOS of 10.5% with a power of 80% at the 5% alpha significance level. This is based on the assumption of outcome incidence of 10.5% (Lynch, 2013) and expected incidence in our current sample of 8%.

It is of interest to know which trauma scoring method was a more accurate predictor for this population for triaging purposes given inconclusive data globally (Gabbe, Cameron, & Finch, 2003; Roorda, van Beeck, Stapert, & ten Wolde, 1996; Savitsky & Rodenberg, 1995). Our bivariate analyses show that the RTS is not a better predictor compared to GCS for this population however the results of the multivariable analyses give slightly better results with RTS as a predictor compared to GCS. Our

results do not support the validity of one over the other for this population and further studies are necessary. Similarly it did not seem to have a bearing on Casualty disposition as of the patients admitted to the ICU wards 50% had a mild GCS on presentation yet all had unfavorable outcomes

As the first known prospective cohort study on prehospital transport capturing time in this region our data is difficult and inappropriate to compare to existing studies which have occurred in countries with prehospital trauma infrastructure and systems. Our data show the mean total prehospital time was 185.50 minutes (see table 10). In Scotland this has been reported to be 73 minutes and in Germany the mean is 247 minutes with no significant differences in injury severity on arrival at the facility to treat or mortality rates. However in these countries follow two different approaches to prehospital management, the German “Stay and Play” model means that patients are receiving care in the field whereas the Scottish “Scoop and Run” model means patients are rushed to the nearest appropriate facility to treat. In our setting no definitive care was delivered for the duration of the prehospital time. More research should be done on the possible reasons behind the delay to care in this region. Further analysis should be conducted with a larger sample to investigate the influence of transport mode and time on patient outcome since our data was inconclusive and not statistically significant for these variables.

As expected a majority of the patients enrolled in this study were male (87.8%) and the most common mechanism of injury was RTI (67.8%) this supports earlier epidemiological studies in this region (Casey et al., 2012; Lynch, 2013). There was also strong concordance with Lynch's study indicating high prevalence of alcohol involvement in the injuries in this region (Lynch, 2013), our data shows 43.8% prevalence.

4.1 Implications for policy and practice

In HICs the role of the prehospital team or EMS is to determine injury severity, initiate patient injury management and decide the most appropriate destination hospital for the patient. In resource limited settings such as this one, there is no EMS service and an apparent lack of all prehospital care. Therefore a gap in the public knowledge on how to deal with severely injured patients could be a factor behind the high number of referrals observed (62.3%) and multiple legs and therefore delays in the prehospital course of TBI patients in this region. This calls for an investment into public education on handling all trauma patients including traumatic brain injury patients. In the short term this is very feasible and can make a real difference in favorable patient outcomes. Such education could be included in road licensing tests and made mandatory in basic education. By making this information easily accessible for all road users, motorists and pedestrians alike, there could be significant reductions in referral rates of trauma patients as they travel straight to the appropriate health care facility. While it could be

suggested that mobile applications (given their ubiquitous use in the region) be used for triaging patients it could create another unnecessary time delay since the general public is not qualified to use the GCS trauma scoring system for example (Badjatia et al., 2008), other alternatives could be researched. In terms of clinical practice at the moment resource limit the monitoring of hypoxia or facilitate GCS triaging in the field which might prove beneficial in deciding where to seek care. Innovative, low cost solutions preferably usable by lay people should be developed to aide in prehospital monitoring and triaging.

A long term aim is to establish a formal fully integrated prehospital trauma system. The model should be context and resource specific, in a comparison of international EMS models a major factor is whether to follow the “scoop and run” or “stay and stabilize” model which focuses on bringing the hospital to the patient(Al-Shaqsi, 2010). It may be the necessary to construct a regionalized trauma system in rural populations such as this as evidence shows they are not best serviced by a centralized trauma location(Lendrum & Lockey, 2013).

In order to sustain such a system emergency medicine training is key throughout the continuum of trauma system care in order to realize the full benefits of any prehospital intervention (Martel et al., 2014; N. K. Mould-Millman et al., 2013). Several international bodies including the World Bank and WHO as well as national governments globally have recognized the need for concerted and sustained efforts across a range of sections

in order to improve road safety through preventative measures (Peden & Sminkey, 2004; Peden & Toroyan, 2004).

4.2 Implications for further research

There could be a sociocultural and socioeconomic reason behind choices of prehospital transport. For example a study investigating the prehospital transport choices of high acuity patients reporting to a hospital emergency center in Ghana showed the majority of patients regardless of injury severity or acuity of illness would use their own means using private or public transport (76.6%). (C. N. R. Mould-Millman, S.D. Oteng, R., 2014). Factors such as this should be further investigated in this population to design and implement the most context appropriate prehospital interventions. Finally, funding for injury research globally is significantly lower than for infectious diseases and chronic non-communicable diseases. The burden of injury and its preventative nature however call for more dedicated resources to research in this field (Vu et al., 2013).

4.3 Study strengths and limitations

Limitations:

- i. Inference was limited to association and could not be extended to causation because it was not an experimental study such as a randomized control trial.
- ii. Small sample size limited our ability to adequately generalize for the entire population. It also limited the statistical significance of some of the covariates.
- iii. Bias: Residual confounders, recall bias in prehospital information, and survivors bias since we were unable to collect prehospital mortality data or DOA data.
- iv. Contextual nuances that could be obtained from a qualitative study are missing
- v. Co-morbidities and complications during in hospital time, quality of care not controlled for.
- vi. Total prehospital time: Only those with a total prehospital time of less than 24 hours were included in the study.

5. Conclusion

The study found the absence of a prehospital care system, formal or informal in this region. This adds vital information to the inventory of prehospital and out-of-hospital care systems in sub-Saharan Africa. This baseline study prior to an implementation of a prehospital system provides information on the local prehospital practices and evaluates how they relate to outcomes in order to prioritize an outcomes based approach to measuring the efficacy of any future prehospital interventions. All these are vital tenets for recommended research of prehospital trauma care systems in sub-Saharan Africa and the next steps are to direct research and development of context appropriate and innovative prehospital interventions in this area.

A relationship between prehospital time and outcome was shown, factors contributing to making prehospital transport a barrier to access are hinted at e.g. cost and injury severity. Additionally the results show a relationship between more patient transfers (interruptions to the journey) and worse outcome. Possible gaps in care delivery along the trauma continuum highlighted by this study are surgical capacity and TBI triaging efficacy. As a pilot this is an effective methodology that African researchers and collaborating international researchers might use given existing trauma registries. This will add to prehospital research in the region and build emergency medicine research capacity.

Appendix A

Appendix A.1 Map of Tanzania with Kilimanjaro region highlighted in red

Appendix A.2 Map of Districts within the Kilimanjaro Region (excluding the new district of Siha)

A.3 Conceptual Model

Appendix B

K.G.M.C. Traumatic Brain Injury Treatment and Care Log SID: _____

MRN: _____

Date of Injury: (dd/mm/yy) ____/____/____

Time of Injury: (24hr) _____

Date of Arrival: (dd/mm/yy) ____/____/____

Patient arrival time: (24 hr) _____

Treatment team arrival: (24 hr) _____

Casualty MD: _____

Anesthesia MD: _____

Surgery MD: _____

Patient age: _____

Patient sex: Male Female

Mechanism of Injury: (Circle One)

☐ Road Traffic: (Pedestrian, Motorcycle, Car)

☐ Drowning

☐ Assault: (Fist/Foot, Gun, Knife, Domestic)

☐ Fall: (from height _____, from ground)

☐ Other: _____

Was the injury: (☐ unknown)

☐ Unintentional ☐ Self-Inflicted ☐ Inflicted by other

Alcohol involved?: ☐ No ☐ Yes ☐ Unknown

VS: T _____ RR _____ Pulse _____

BP _____ / _____ Pulse Oxygen _____

☐ NP due to lack of BP cuff

☐ Done by researcher ☐ Done by nurse

Repeat VS: T _____ RR _____ Pulse _____

BP _____ / _____ Pulse Oxygen _____

☐ Glucose _____

AVPU: Alert

(circle one) Responds to Verbal stimuli only

Responds to Painful Stimuli only

Unresponsive

Pupils on arrival: Right: _____ mm ☐ R ☐ NR

Left: _____ mm ☐ R ☐ NR

☐ EQUAL

AIRWAY:

☐ Intact (no gurgling, snoring, drooling)

☐ NOT intact

☐ oral/nasal airway

☐ intubation

time _____ ☐ NP ☐ PTA

time _____ ☐ not performed

BREATHING:

☐ Chest auscultated

☐ NOT auscultated

☐ oxygen applied

☐ chest radiograph

☐ chest tube placed

time _____ ☐ NP ☐ PTA

time _____ ☐ NP ☐ PTA

time _____ ☐ NP ☐ PTA

CIRCULATION:

☐ Pulses evaluated

☐ Pulses NOT evaluated

☐ Fluids started

☐ Labs Sent

☐ Hgb

☐ Blood grouping

time _____ ☐ NP ☐ PTA

time _____ ☐ not performed

☐ not performed

☐ not performed

DEFICIT:

☐ GCS calculated ☐ GCS not calculated

☐ Moved all extremities ☐ not able ☐ NP

☐ Seizure? ☐ No ☐ sz

☐ skull radiograph

☐ CT brain

☐ Mannitol started

☐ cervical collar placed

☐ anti-sz med started

Med: _____

time _____ ☐ NP ☐ PTA

time _____ ☐ NP ☐ PTA

time _____ ☐ NP ☐ PTA

time _____ ☐ NP ☐ PTA

time _____ ☐ NP ☐ PTA

EXPEDITE:

☐ transported to ICU

☐ to surgery

☐ to OT

☐ death, mortuary

☐ to home

time _____ ☐ NP

time _____ ☐ NP

time _____ ☐ NP

time _____ ☐ NP

time _____ ☐ NP

Eye Opening (choose one)	Spontaneously	4
	To Speech	3
	To Pain	2
	None	1
Verbal Response (choose one)	Oriented	5
	Confused	4
	Inappropriate	3
	Incomprehensible	2
Motor Response (choose one)	None	1
	Obeys Commands	6
	Localizes to pain	5
	Withdraws from pain	4
	Flexion to pain	3
	Extension to pain	2
GCS Total Score:		/15

History:

Pre-hospital Course:

Modes of transport: CAR, TAXI, BICYCLE, BODA BODA, DALA DALA, POLICE VEHICLE, AMBULANCE, BUS or OTHER

Stage of Journey from Site of Injury	Mode of Transport	Cost (TZS)	FROM (site of injury/ dispensary/hospital name & district)	TO (dispensary/hospital name & district)	TRAVEL TIME (HH:MM)
1					
2					
3					

Hospital Course:

☐ had surgery for TBI injury Date _____ Time _____
☐ No TBI surgery
☐ had surgery for other injury Date _____ Time _____
☐ No surgery
☐ went from surgery 1 to ICU Date _____ Time _____
☐ No ICU

☐ received some pre-hospital care from trained nurse/MD
☐ received some pre-hospital care from trained lay responder
☐ No pre-hospital care

Referral: ☐ referral from Mawenzi
☐ Yes ☐ No
☐ referral from other: _____

Outcome:

☐ Death ☐ Alive at discharge
☐ Date of Death ☐ Discharged from ICU
☐ Time of Death ☐ Date discharged from ICU _____
 Location of Death ☐ Not in ICU
☐ ICU ☐ Discharged from hospital
☐ Surgery 1 Date: _____
☐ OT

Glasgow Outcome Score: _____

5	Good Recovery	Resumption of normal life despite minor deficits
4	Moderate Disability	Disabled but independent. Can work in a sheltered setting
3	Severe Disability	Conscious but disabled. Dependent for daily support
2	Persistent vegetative	Minimal responsiveness
1	Death	Non Survival

Presumed cause of death, Reasons for or against surgery:

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