Epidemiology and Predictors of Mortality of Traumatic Brain Injury at Kigali University

Teaching Hospital Accident and Emergency Department

by

Elizabeth Ann Krebs

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Duke University

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Charles Gerardo

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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2015
ABSTRACT

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Background:

Traumatic Brain Injury (TBI) is a leading cause of death and disability. TBI patients in low and middle-income countries (LMIC) have twice the odds of death than in high-income countries. There is limited data describing the epidemiology and mortality predictors for TBI in LMIC.

Objective:

Determine epidemiology and predictors of mortality in TBI patients at Kigali University Teaching Hospital Accident and Emergency Department (KUTH A&E).

Methods:

Consecutive, injured KUTH A&E patients were prospectively screened for inclusion by reported head trauma, alteration in consciousness, headache, or visible head trauma. Exclusion criteria were <10 years old, presenting >48 hours after injury, or repeat visits. Proportions of survivors and deaths for each independent variable assessed were calculated and differences identified with Chi squared testing. Data were assessed for association with death using logistic regression. Significant variables were included in an adjusted multivariable
logistic regression model then refined via backwards elimination until all
variables were significant at P <0.05.

**Results:**

Between October 7, 2013 and April 6, 2014 we enrolled 684 patients. 12 (2%) were
excluded due to incomplete data. 81% were male with mean age of 31.5 years
(range 10 – 89, SD 11.8 years). Most patients (75%) had mild TBI (Glasgow Coma
Score (GCS) 14-15), while 15% had moderate (GCS 9-13), and 10% had severe TBI
(GCS 3-8). Multivariable logistic regression and refinement by backwards
elimination determined that GCS <14, hypoxia, bradycardia, tachycardia and age
>50 years predicted mortality with a Bayesian Information Criteria of 215.96.

**Conclusion:**

GCS <14, hypoxia, bradycardia, tachycardia and age >50 years were associated
with mortality among TBI patients at KUTH A&E. These findings can guide
clinicians in prioritizing care for patients at highest risk of mortality.
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This study would not have been possible with Dr. Jean Claude Byringiro and Dr. Stephen Rulisa who helped conceive and execute the entire project. All of my mentors above named as authors were also invaluable in the design and analysis performed in this study as well as Dr. Larry Park.
1. Introduction

Unintentional Injury was responsible for the largest number of Disability Adjusted Life Years lost (DALYs) worldwide in 1990.\(^1\) The World Health Organization (WHO) reports that in 2002 injury was responsible for 1 in 10 adult deaths.\(^2\) Low and Middle Income Countries (LMIC) disproportionately carry this burden, reporting 90% of injury related DALYs.\(^3\) This represents a tremendous, potentially preventable loss of life and productivity.

1.1 Traumatic Brain Injury

Traumatic Brain Injury (TBI) will impact as many as 10 million people worldwide each year and it is estimated by the WHO that by 2020 TBI will have surpassed many other diseases as a major cause of death and disability.\(^4\) Among types of injuries, Traumatic Brain Injury (TBI) is the most likely to result in death or permanent disability.\(^5\) Worldwide, TBI is the leading cause of disability in people under the age of 40 causing severe disability in 150-200 people per million each year and resulting in loss of the most productive years of life.\(^6\)

1.2 Traumatic Brain Injury in LMIC

Just as in general injuries, LMIC tend to suffer a much greater burden of disease related to TBI, with higher mortality rates and worse outcomes than their higher income counterparts do.\(^7\) Of 3.9 million deaths and 138 million Disability Adjusted Life Years lost (DALYs) attributable to unintentional injury over 90% of these impacted LMIC.\(^8\) As countries develop and motorization increases rates of Road Traffic Injuries (RTI) stand to increase. RTI are the leading cause of TBI and the WHO predicts that by 2020 RTI will be the 3\(^{rd}\) leading cause of death worldwide and 90% of these impact people in LMIC.\(^9\)\(^10\) Analysis of more than 8,000 TBI patients showed that severe TBI patients in LMIC have more than twice the adjusted odds of death then their high income counterparts.\(^11\) LMIC have a high prevalence of risk factors for TBI which are further complicated by healthcare systems that are poorly equipped to provide the highest quality of medical care. This lethal combination predisposes LMICs to higher incidence and case-fatality ratios of TBI.\(^12\)

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\(^7\) Georgoff P, Meghan S, Mirza K, Stein SC. Geographic Variation in Outcomes from Severe Traumatic Brain Injury. World Neurosurgery. 2010
1.3 Medical Care in Rwanda

Rwanda is a small, landlocked, densely populated country in East Africa. The total population is approximately 11 million; the capital city of Kigali is home to about 1.15 million people. The decentralized public healthcare system includes nurse staffed health centers, district level hospitals, and referral hospitals/tertiary care centers. The 1994 Genocide of the Tutsi’s devastated Rwandan infrastructure and the health system. Progress has been achieved since then, and leaders within the Ministry of Health and National University of Rwanda are working diligently to improve human resources and health care infrastructure. However, serious challenges in providing high quality care to injured patients remain. In 2012 a national survey of surgical and trauma capacity found only 5.5 doctors per 100,000 individuals, 1.2 operating theatres per 100,000, 0.15 general surgeons per 100,000, and 0.09 orthopedic surgeons per 100,000 people. While these findings are not substantially different from other Sub-Saharan African settings, The American College of Surgeons recommends a minimum of six general surgeons per 100,000 individuals. In further contrast a global study found that high-income countries have 14-25 operating theatres per 100,000 individuals. Kigali University Teaching Hospital (KUTH) is the only public hospital with the ability to provide the highest levels of TBI care with services like Computed Tomography (CT) scanning.

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critical care, and neurosurgical services. KUTH receives transfers of injured patients from district hospitals nationwide and a Kigali city based Emergency Medical Services system directly transports injured patient to KUTH. The hospital serves as the primary teaching facility in the country and the only location where surgical subspecialty care is available.

1.4 Traumatic Brain Injury in Rwanda

Just as in other LMIC Rwandan TBI patients suffer high mortality rates. Unpublished data from a registry of trauma patients at one referral level hospital noted the mortality rate of patients with severe TBI was 58%. An analysis of road traffic injury patients from 2005 reported an 89% mortality rate among patients with severe TBI (defined as a Glasgow Coma Score < 9). Unfortunately few data describe which factors most significantly contributed to these TBI related deaths in Rwanda and other LMIC, and what can be done to improve the situation.

1.5 Traumatic Brain Injury and Secondary Brain Injury

Several reports, mostly from high-income settings, have shown TBI mortality rates increased by 20-35% in patients who suffer hypoxia (low blood oxygen, definitions range per study from PO2<60, spO2<90-94%). Even worse outcomes are

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17 Petroze R, personal communication, 8/10/2012
19 McHugh et al. Prognostic Value of Secondary Insults in Traumatic Brain Injury: Results from the IMPACT Study. JOURNAL OF NEUROTRAUMA Volume 24, Number 2, 2007
reported in hypotensive (low blood pressure) patients.\textsuperscript{23,24} In other African settings where TBI mortality rates are high, these important causes of secondary brain injury are often under-recognized and under-treated.\textsuperscript{25} Currently there are no data from KUTH about treatment of hypoxia and hypotension in TBI patients.

### 1.6 Objectives

We hypothesized that the strongest predictor of mortality among factors potentially amenable to intervention was hypoxia. Therefore our objectives included collection of prospective data from a representative sample of acute TBI patients cared for at KUTH A&E and analysis of this data to determine important predictors of mortality. Understanding these predictors of mortality could guide clinicians in providing appropriate care to these most critically ill patients.

\begin{thebibliography}{9}
\bibitem{22} Petroze, R. Personal Communication. October 2012.
\end{thebibliography}
2. Methods

Between October 7, 2013 and April 6, 2014, we conducted an observational prospective cohort study of all acute TBI patients that presented to KUTH A&E for care.

2.1 Setting

KUTH, with approximately 500 patient beds, is the largest public referral center in Rwanda serving the entire population of 11 million residents. It is centrally located in Kigali very near the city center. This study took place in the dedicated Accident and Emergency department (A&E) that includes as many as 30 beds and has rooms for resuscitations and procedures. KUTH has a neurosurgery service, a five bed Intensive Care Unit with ventilators available, a 64 slice CT scanner, and is staffed primarily by General Practitioner physicians with the ability to call on specialist care. Rwanda is engaged in a large Human Resources in Health (HRH) program to improve healthcare provider skills and capacity.\(^1\) During the period of this study a post-graduate diploma program in emergency medicine for physicians was just beginning. Emergency nursing education was being provided in a less formal setting.

2.2 Study Personnel

Data was collected by four Research Assistants (RAs) and one Study Coordinator (SC). All study staff were educated as nurses and had prior clinical experience. Rigorous training of staff was performed including Good Clinical Practice certification,

\(^1\) http://hrhconsortium.moh.gov.rw, accessed on March 23, 2015
viewing of videos of specific patient findings that may be observed, and practice scenarios. After initial training a pilot period began during which the ability to correctly screen for inclusion and exclusion criteria, judge performance of patient care interventions, as well as Glasgow Coma Scale (GCS) determination was verified.

2.3 Participants

RAs evaluated every injured patient that arrived at KUTH A&E for care. TBI was defined in our population as at least one of the following:

- **Inclusion Criteria**
  - headache
  - report of trauma to the head
  - visible trauma to the head
  - any alteration in consciousness in the context of an injury.

If a patient had a TBI the RAs would screen for additional criteria:

- **Inclusion Criteria**
  - 10 years of age or older
  - injury less than 48 hours prior to presentation at KUTH
  - seeking care at KUTH for this injury for the first time
  - not dead on arrival

- **Exclusion Criteria**
  - less than 10 years of age
  - injury greater than 48 hours prior to presentation at KUTH
  - this injury has already been evaluated at KUTH
  - dead on arrival

All assessed but excluded patients were recorded in a study register.
2.4 Data Collection Procedures

The study protocol was approved by Rwandan and American IRBs including Duke University Hospital, KUTH ethics committee and the Rwandan National Health Research Council. An exemption of full review was granted by Duke as this was deemed a quality improvement project and other approving IRBs granted a waiver of consent as this was a purely observational study and all identifying information was transformed to anonymize participants. A case report form (Appendix A) and data dictionary were used to collect data on individual patients. RAs closely observed the care of TBI patients for their first four hours in A&E. RAs did not interact with patients or family, all data was collected through direct observation, discussions with A&E staff, and inquiry of the patient chart when needed. No patient received compensation for participation in this study.

RA observation of patients ended after four hours or until the patient’s death or admission for definitive care in a hospital ward or the operating theatre. The next day the SC would locate all enrolled patients in the hospital and determine if they had surgery for TBI or other reasons, the patients’ Glasgow Outcome Scale (GOS), and if the patient had other severe injuries (defined as one that necessitated hospital admission or surgery). A follow up data form (Appendix B) was completed for each patient by the SC. These assessments continued daily until the patients’ death or discharge from
KUTH. If a patient was transferred to another facility or escaped from the hospital this was considered the day of their discharge. All data collected by the SC was done via observation and discussions with staff caring for the patient.

2.4.1 Quality Control of Data Collection and Data Management

Paper data forms were completed by RAs and the SC. Every form was hand checked for errors on a weekly basis so that no more than seven days elapsed between data collection and correction of errors. When missing data or errors were found corrections were made through staff recall and consulting the patient’s chart when necessary. While complete records of this are not available we estimate that this protocol was necessary in an average of ~1:27 patients. Additional study staff entered the data from the paper forms into a Redcap database. An investigator (EK) checked every Redcap database entry against the original paper form for errors and made corrections when needed.

A further quality control method of patient register comparisons were instituted one month into this six month study. Every day study staff compared our study register to KUTH patient registers in A&E, the neurosurgery units, the ICU, the operating theatre, and the inpatient surgical ward in order to identify any missed patients. Five times a patient was identified that should have been enrolled in the study but was missed by the RA. Data was collected retrospectively on these patients when possible though they were not included in the final analysis. Data from these patients were used
to show that the population of missed patients is not substantially different from those included in our cohort. At the end of the data collection period the triage registers utilized in the preceding six months were analyzed for the type of chief complaint of patients seen in KUTH A&E. These registers are intended to capture every patient that is treated in A&E. Injury chief complaints included any notation of fracture, contusion, traffic crash, fall, assault, polytrauma, burns, cuts to skin, dislocations, or other things that the RA thought indicated an injury. Head injuries were indicated by notation of “céphalie after trauma”, “trauma cranie”, “head injury”, wounds to the head, or confusion after trauma. Numbers of patients enrolled and missed by our study were descriptively compared with data from the triage registers.

Periodically over the duration of this study an investigator would collect data in parallel to RAs and SC to verify that judgments were still being made accurately. An investigator would observe a patient with an RA and ask them what was the GCS score for eye opening, verbal and motor responses as well as how the RA made this determination.

2.5 Measures

All measures recorded by the RA or SC during data collection and utilized in this analysis are defined here in the order they were completed on data collection forms, see Appendices A & B for more details.
2.5.1 Airway

RAs observed patients for any snoring, gurgling, or blood/secretions in the mouth that constituted an abnormal airway for that patient. If none of the above were present the airway was declared normal.

2.5.2 Suctioned

RAs observed and recorded the time when a patient received suctioning of secretions/blood from the mouth by a nurse or doctor.

2.5.3 Oral/Nasal Airway

RAs observed and recorded the time when a nurse or doctor placed a nasal or oral airway into the enrolled patient, or indicated that the patient arrived with such an airway device in place.

2.5.4 Intubated

RAs observed and recorded the time when a doctor placed an endotracheal tube into the enrolled patient, or indicated that the patient arrived with such an airway device in place.

2.5.5 Mode of Arrival/EMS

RAs observed and recorded the mode of patient arrival. Ambulance arrival indicated transfer from another hospital or health center, EMS transport was performed by the local emergency medical service that brings acutely injured patients to KUTH.
A&E, other vehicle indicates any non-medical form of transportation, and on foot indicates that the patient walked in for care.

2.5.6 Auscultation

RAs observed and recorded the time when a doctor auscultated the breath sounds of the patient using their stethoscope.

2.5.7 Oxygen Administration

RAs observed and recorded the first time when a nurse or doctor placed the patient on any form of oxygen. They could also indicate that the patient arrived with oxygen on.

2.5.8 Evaluate Pulses

RAs observed and recorded the time when a doctor first evaluated at least one of the carotid, radial, or femoral pulses of a patient.

2.5.9 Intravenous (IV) Access Initiated

RAs observed and recorded the time when a nurse or doctor placed an IV line in the patient. They could also record if the patient arrived with an IV access in place.

2.5.10 IV Fluids Given

RAs observed and recorded the time when a nurse or doctor began infusing intravenous fluids into a patient, or if the patient arrived with IV fluids infusing.
2.5.11 Glasgow Coma Score GCS

RAs observed and recorded their own interpretation of the patients Glasgow Coma Score (GCS) at the earliest possible point after patient arrival. This assessment was performed from afar by noting stimuli that caused the patient to open their eyes, noting the quality of verbal responses of the patient, and noting any motor response. RAs were permitted to ask the nurses to interact with patients in a way that they could adequately observe a patient for their reaction. RAs also recorded the physicians’ assessment of GCS by asking directly what GCS was calculated for a patient or observing what was written in the patient’s medical record. Physicians did not always calculate a GCS so the GCS that was entered as the first GCS is used in the analysis. RAs received extensive training to ensure they were able to accurately determine a GCS through observation.

2.5.12 Cervical Collar Placed

RAs observed and recorded the time when a nurse or doctor placed a cervical collar on the patient or if the patient arrived with a collar in place. Additionally, when a collar was placed, RAs assessed the quality of placement by observation of significant head movement or misalignment of the collar.

2.5.13 Vital Signs

RAs observed and recorded the time and values of the first vital signs that were assessed upon the patient’s arrival at KUTH A&E. This included temperature, heart
rate, respiratory rate, blood pressure, blood oxygen saturation, and blood glucose.

When particular information was not obtained in normal practice by staff this was recorded, and no vital signs were ever taken by RAs.

2.5.13.1 – Heart Rate

Tachycardia is most commonly defined as a heart rate faster than 100 beats per minute in adults though this definition of tachycardia is somewhat controversial. Bradycardia is a heart rate slower than 60 beats per minute. We categorized by heart rate to determine the earliest possible point when recognition and intervention for an elevated heart rate could potentially impact patient outcomes; heart rate of less than 60, 60-89, 90-99 or >100 beats per minute.

2.5.13.2 – Tachypnea

Tachypnea, a respiratory rate faster than 20 breaths per minute, has been associated with worse outcomes in trauma patients. We dichotomized the recorded respiratory rate to tachypnea (>20 breaths per minute) or a rate <=20 breaths per minute). While hypopnea, or a too slow respiratory rate, could be a predictor of mortality, there were too few hypopneic patients in this study to allow analysis of this factor.

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2.5.13.3 – Hypotension

We stratified systolic hypotension to include < 90 mmHg, 90-100 mmHg and >100 mmHg with a goal of early notification of the need for intervention.\(^5\) \(^6\) \(^7\)

2.5.13.4 – Hypoxia

Hypoxia was determined noninvasively through fingertip pulse oximetry measurement of blood oxygen levels. We trichotomized hypoxia at < 90%, 90-94% and >94%.\(^8\) \(^9\) \(^10\) \(^11\)

2.5.14 Cause of Injury

RAs selected the cause of the injury from a list of options and answered associated follow up questions related to helmet use in the appropriate setting. This information came from A&E staff who asked the patient or witnesses and sometimes from pre-hospital personnel.

2.5.15 Alcohol use

RAs observed and recorded any indication that alcohol was involved in the injury. This included the RA smelling alcohol, A&E or pre-hospital staff reporting a


suspicion that alcohol use was involved, or the patient’s own admission that they used alcohol.

2.5.16 Insurance Status

RAs determined the patient’s insurance status by asking the billing staff at KUTH A&E. This was measured because many Rwandans anecdotally reported they believe that patients lacking insurance do not get the same medical care as those with insurance and may have worse outcomes.

2.5.17 Orders

RAs recorded the time that orders for various radiological and laboratory evaluations were ordered by the treating doctor. The time reflects only the time of order placement, not actual completion of the study or drawing of the sample.

2.5.18 Neurosurgical Consult

RAs determined and recorded the involvement of the neurosurgery team in the case during the patient’s first four hours in A&E. This included noting a time that the team was contacted, when it was written as an order in the patient’s chart, and when the team actually arrived if at all. This information was obtained through direct observation and/or asking clinical staff.

2.5.19 Other Severe Injuries

In the event that a patient died in A&E before follow up could be completed the RAs assessed for other severe injuries through observation and inquiry of doctors and
nurses. Other severe injuries are defined as any injury outside of TBI that required hospital admission or any kind of surgery performed in the operating theatre. This definition was amended from the definition used in the Kampala Trauma Score ("An injury serious enough to warrant admission on its own")\textsuperscript{12} to be relevant in the KUTH setting.

\textbf{2.5.20 Follow Up – Hospital Events}

The SC recorded the dates of any surgical procedures the patient had during their admission as well as the dates of discharge or death.

\textbf{2.5.21 Follow Up – Other Severe Injuries}

This is the same assessment noted earlier that would be performed by RAs if the patient died in A&E. The SC noted at the time of death or discharge any other severe injuries defined as anything outside of TBI requiring hospital admission or surgery.

\textbf{2.5.22 Severity of TBI}

GCS is commonly used to describe the severity of TBI.\textsuperscript{13} For this study we defined severe TBI is defined by a GCS of 3-8, moderate TBI by a GCS of 9-13 and mild TBI including only GCS of 14-15. This was determined by consensus of study, KUTH A&E and neurosurgery leadership. This approach was supported by comparison of the

\textsuperscript{12} MacLeod, Jana BA, et al. "A comparison of the Kampala Trauma score (KTS) with the revised Trauma score (RTS), Injury Severity Score (ISS) and the TRISS method in a Ugandan Trauma registry." \textit{European Journal of Trauma} 29.6 (2003): 392-398.
crude outcomes of GCS 13, 14 and 15 patients and finding that a GCS of 13 had a substantially higher mortality rate than the higher levels of GCS.

### 2.6 Analysis

While broadly focusing on identifying factors that could improve outcomes among TBI patients at KUTH A&E we narrowed in on causes of secondary brain injury that could be simply intervened upon. We hypothesized that in this population hypoxia is associated with an increased rate of death among TBI patients. The primary outcome was in hospital mortality, no secondary outcomes were analyzed.

#### 2.6.1 Sample Size Calculation

Based on prior data from KUTH and the literature we estimated a baseline mortality rate of 35% in the non-hypoxic moderate/severe TBI population and 60% in the hypoxic population.\textsuperscript{14,15,16} To detect such a difference of 25%, with an alpha of 0.05% a power of 80%, a sample of 70 hypoxic and 70 non-hypoxic patients with moderate/severe TBI was required (calculated in Stata 12.2 software). The same sources indicate that approximately 40% of the study population is likely to be hypoxic, thus requiring outcome data from 200 total moderate/severe TBI patients.

\textsuperscript{16} Petroze, R. Personal Communication. October 2012.
2.6.2 Primary Analysis- Descriptive Statistics

Summary statistics were used to describe the cohort of patients and look for differences between enrolled patients and missed patients as well as survivors and deaths among enrolled patients. Chi squared tests were performed to identify significant differences between the groups. Any variable with a P value of <0.1 was considered a potential predictor of mortality and included in further analyses. Next, Chi squared testing was again performed to identify associations between each of these potential predictors of mortality.

2.6.3 Primary Analysis – Predictors of Mortality

Logistic regression was performed to examine the crude associations between potential predictors and mortality. Variables with P=<0.10 were included in a multiple logistic regression model. Independent variables were sequentially removed from the model starting with the largest P values, checking for a decrease in the Bayesian Information Criteria (BIC) with each refinement of the model. We continued refining in this fashion via backwards elimination until a final model was determined when all variables were significant at P <0.05 and the BIC indicated the best fit.

2.6.4 Secondary Analysis – Hypoxia and Mortality

Descriptive statistics were used to calculate mortality differences among hypoxic and non-hypoxic patient groups and statistically significant differences were identified using Chi square testing. The odds ratio of hypoxia and mortality after adjusting for
other independent predictors of mortality was calculated through multiple logistic regressions.

All Statistical analyses were performed using Stata 12.2 (StataCorp, College Station, TX).
3. Results

Between October 7, 2013 and April 6, 2014 KUTH A&E triage registers recorded 5405 patients who visited A&E during this time. A chief complaint that included some kind of injury was recorded in 2303 patients (42.6%). Of the 2303 injured patients, 710 (13.1% of all patients, 30.1% of all injured patients) had a chief complaint indicating a head injury. Independent of the triage registers 867 TBI patients presented to the KUTH A&E and were screened for inclusion criteria by RAs. Of these, 684 patients were enrolled, and 183 patients did not meet inclusion criteria and were thus excluded from enrollment. Of note, the triage registers failed to identify at least 157 head injured patients that were captured by this study.

Patient miscategorization, illegible records and loss of the patient to follow up led to 12 missed patients (1.8%) who otherwise would have been enrolled. These patients were not included in the analysis to determine mortality predictors. There were only minor differences between enrolled versus missed patients. The Glasgow Comas Score (GCS) was not assessed by physicians on every patient so for consistency the RA assessed GCS was used in this analysis. We confirmed excellent agreement between physician and RA determined GCS using Kappa coefficients.
Figure 1 – Breakdown of patients presenting to KUTH A&E during study period.
Ovals represent data from triage registers; squares show data from this study. All TBI patients in this study had head injuries but not all head injuries identified on triage registers met our definition of TBI.

The mean age was 31 years (SD 11.8 years). Age was categorized into five groups of <18 years, 18-30, 31-40, 41-50, and >50. Mortality in each group was compared and substantially increased in the >50 group so the variable of age was dichotomized to <=50 or >50 (Table 1).
<table>
<thead>
<tr>
<th>Age in years</th>
<th>Survivors (610)</th>
<th>Deaths (62)</th>
<th>Mortality %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18</td>
<td>49</td>
<td>3</td>
<td>5.8</td>
</tr>
<tr>
<td>18-30</td>
<td>292</td>
<td>23</td>
<td>7.3</td>
</tr>
<tr>
<td>31-40</td>
<td>177</td>
<td>17</td>
<td>8.8</td>
</tr>
<tr>
<td>41-50</td>
<td>54</td>
<td>5</td>
<td>8.5</td>
</tr>
<tr>
<td>&gt;50</td>
<td>37</td>
<td>11</td>
<td>22.9</td>
</tr>
</tbody>
</table>

Chi squared testing examined associations between each independent variable and death. Any variable with a P value of <0.1 was considered a potential predictor of mortality and included in further analyses. Demographic factors that differed between deaths and survivors include age, sex, alcohol use and whether or not the patient was transferred for care. Table 2 describes these findings. Each of the independent variables examined included some missing values. The percentages next to each value refer to the proportion of total survivors and deaths in each category of the variable.
Clinical characteristics were examined in the same way as demographics and were more dramatically different among survivors and deceased (Table 3). Statistically significant factors include GCS, airway status, oxygen levels, heart rate, blood pressure, and number of other severe injuries.
Table 3 – Clinical Characteristics – Survival versus Death

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Totals</th>
<th>Survivors (610)</th>
<th>Deaths (62)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCS 14-15</td>
<td>502 (74.7%)</td>
<td>493 (80.8%)</td>
<td>9 (14.5%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>GCS 9-13</td>
<td>103 (15.3%)</td>
<td>88 (14.4%)</td>
<td>15 (24.2%)</td>
<td></td>
</tr>
<tr>
<td>GCS 3-8</td>
<td>67 (10%)</td>
<td>29 (4.8%)</td>
<td>38 (61.3%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Normal Airway</td>
<td>574 (86.4%)</td>
<td>537 (88.5%)</td>
<td>37 (64.9%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Abnormal Airway</td>
<td>90 (13.6%)</td>
<td>70 (11.5%)</td>
<td>20 (35.1%)</td>
<td></td>
</tr>
<tr>
<td>No Hypoxia (&gt;94%)</td>
<td>472 (82.7%)</td>
<td>446 (85.9%)</td>
<td>26 (50.0%)</td>
<td></td>
</tr>
<tr>
<td>Mild Hypoxia (90-94%)</td>
<td>76 (13.3%)</td>
<td>63 (12.1%)</td>
<td>13 (25.0%)</td>
<td></td>
</tr>
<tr>
<td>Hypoxic (&lt;90%)</td>
<td>23 (4%)</td>
<td>10 (1.9%)</td>
<td>13 (25.0%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>No Tachypnea (&lt;20)</td>
<td>329 (55.9%)</td>
<td>294 (55.7%)</td>
<td>25 (49.0%)</td>
<td></td>
</tr>
<tr>
<td>Tachypneic (&gt;=20)</td>
<td>260 (44.1%)</td>
<td>234 (44.3%)</td>
<td>26 (51.0%)</td>
<td>0.36</td>
</tr>
<tr>
<td>Bradycardic (&lt;60)</td>
<td>23 (4.7%)</td>
<td>15 (2.8%)</td>
<td>8 (15.1%)</td>
<td></td>
</tr>
<tr>
<td>Normal (&gt;=60 - &lt;90)</td>
<td>241 (49.4%)</td>
<td>228 (61.3%)</td>
<td>13 (24.5%)</td>
<td></td>
</tr>
<tr>
<td>Mild Tachycardia (90-100)</td>
<td>105 (21.5%)</td>
<td>101 (18.9%)</td>
<td>4 (7.6%)</td>
<td></td>
</tr>
<tr>
<td>Tachycardic (&gt;=100)</td>
<td>119 (24.4%)</td>
<td>91 (17.0%)</td>
<td>28 (52.8%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>No Hypotension (&gt;=100)</td>
<td>546 (93.3%)</td>
<td>503 (94.2%)</td>
<td>43 (84.3%)</td>
<td></td>
</tr>
<tr>
<td>Mild Hypotension (90-99)</td>
<td>20 (3.4%)</td>
<td>17 (3.2%)</td>
<td>3 (5.9%)</td>
<td></td>
</tr>
<tr>
<td>Hypotension (&lt;90)</td>
<td>19 (3.3%)</td>
<td>14 (2.6%)</td>
<td>5 (9.8%)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>0 Other Injuries</td>
<td>574 (85.4%)</td>
<td>532 (87.2%)</td>
<td>42 (66.7%)</td>
<td></td>
</tr>
<tr>
<td>1 Other Injury</td>
<td>65 (9.7%)</td>
<td>54 (8.9%)</td>
<td>11 (17.7%)</td>
<td></td>
</tr>
<tr>
<td>2+ Other Injuries</td>
<td>33 (4.9%)</td>
<td>24 (3.9%)</td>
<td>9 (14.5%)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

3.1 Results – Predictors of TBI Mortality

Univariate and multiple logistic regressions were used to identify independent variables predictive of mortality. The crude odds ratio of death for all independent variables found to be statistically significant at a threshold of $P = <0.1$ were examined (Table 4). This adjusted model including all statistically significant crude independent variables utilized 506 observations, 15 degrees of freedom and has a BIC of 228.79.
Table 4 – Crude and Adjusted Mortality Predictors

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Crude Mortality - OR (95% CI)</th>
<th>P Value</th>
<th>Adjusted Mortality - OR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &lt; 50</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Age &gt; 50</td>
<td>3.54 (1.70-7.39)</td>
<td>&lt;0.01</td>
<td>3.84 (1.13-13.11)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Female</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2.32 (0.98-5.52)</td>
<td>0.06</td>
<td>4.79 (0.89-25.86)</td>
<td>0.07</td>
</tr>
<tr>
<td>No Alcohol</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Alcohol</td>
<td>0.42 (0.19-0.95)</td>
<td>&lt;0.05</td>
<td>0.63 (0.18-2.18)</td>
<td>0.46</td>
</tr>
<tr>
<td>Not Transferred</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Transferred</td>
<td>4.89 (2.83-8.45)</td>
<td>&lt;0.001</td>
<td>1.34 (0.50-3.60)</td>
<td>0.56</td>
</tr>
<tr>
<td>GCS 14-15</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GCS 9-13</td>
<td>9.34 (3.96-22.00)</td>
<td>&lt;0.001</td>
<td>5.40 (1.56-18.72)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>GCS 3-8</td>
<td>71.78 (31.69-162.55)</td>
<td>&lt;0.001</td>
<td>59.11 (16.52-211.53)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Normal Airway</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Abnormal Airway</td>
<td>4.15 (2.28-7.54)</td>
<td>&lt;0.001</td>
<td>0.48 (0.14-1.68)</td>
<td>0.25</td>
</tr>
<tr>
<td>No Hypoxia (&gt;94%)</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mild Hypoxia (90-94%)</td>
<td>3.54 (1.73-7.24)</td>
<td>&lt;0.01</td>
<td>2.10 (0.69-6.35)</td>
<td>0.19</td>
</tr>
<tr>
<td>Hypoxic (&lt;90%)</td>
<td>22.3 (8.94-55.64)</td>
<td>&lt;0.001</td>
<td>7.15 (1.77-28.94)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Bradycardic (&lt;60)</td>
<td>13.46 (4.84-37.37)</td>
<td>&lt;0.01</td>
<td>21.73 (4.40-107.23)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Normal (&gt;60 - &lt;90)</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mild Tachycardia (90-100)</td>
<td>1.00 (0.32-3.13)</td>
<td>0.99</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Tachycardic (&gt;100)</td>
<td>7.76 (3.86-15.60)</td>
<td>&lt;0.01</td>
<td>9.90 (3.44-28.45)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>No Hypotension (&gt;100)</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mild Hypotension (90-99)</td>
<td>2.06 (0.58-7.32)</td>
<td>0.27</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Hypotension (&lt;90)</td>
<td>4.18 (1.44-12.15)</td>
<td>&lt;0.01</td>
<td>1.50 (0.29-7.82)</td>
<td>0.63</td>
</tr>
<tr>
<td>0 Other Injuries</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1 Other Injury</td>
<td>2.58 (1.26-5.30)</td>
<td>&lt;0.05</td>
<td>2.18 (0.68-7.06)</td>
<td>0.19</td>
</tr>
<tr>
<td>2+ Other Injuries</td>
<td>4.75 (2.08-10.87)</td>
<td>&lt;0.001</td>
<td>3.39 (0.72-15.91)</td>
<td>0.12</td>
</tr>
</tbody>
</table>
3.2 Results – Optimal Model Derivation

Backwards elimination of all independent variables included in the models derived from multiple logistic regression was performed by sequentially removing the variables with the largest P values until a final, fully significant (P = <0.05) set of mortality predictors was elucidated, shown in Table 5. This refined model adjusted for age >50, GCS <14, hypoxia, bradycardia and tachycardia had 522 observations, seven degrees of freedom and a BIC of 215.96, compared to a BIC of 228.79. The BIC difference between the complete and refined model is > 10, indicating very strong evidence that this refined model best fits the data.¹

| Table 5 – Backwards Eliminated Predictors of Mortality |
|------------------|------------------|------------------|
| Independent Variable | Adjusted Mortality - OR (95% CI) (n=522) | P Value |
| Age > 50           | 3.80 (1.21-11.89) | <0.05 |
| GCS 9-13           | 6.54 (2.30-18.60) | <0.01 |
| GCS 3-8            | 41.60 (14.97-115.59) | <0.01 |
| Hypoxic (<90%)     | 7.36 (2.20-24.57) | <0.01 |
| Bradycardic (<60)  | 11.29 (2.90-43.96) | <0.01 |
| Tachycardic (>100) | 5.20 (2.23-12.12) | <0.01 |

For the purpose of making our results comparable to other reports of TBI mortality predictors in the literature we transformed the analysis to report on predictors of survival to hospital discharge. This comparison was only relevant for hypoxia (<90%), which had an adjusted odds ratio of survival to hospital discharge of 0.14 (0.04-0.45).

3.3 Results – Hypoxia and Mortality in Moderate/Severe TBI

One hundred and fifty-two patients with moderate or severe TBI were enrolled, 28.9% of these patients died. Of these 152 patients 43 were hypoxic with an spO2% of <=94% recorded. 53.5% of these hypoxic patients died, while only 19.3% of the non-hypoxic patients died. Hypoxia was further stratified to <=94% and <90% and compared with non-hypoxic patients (Table 6). Mortality was higher among hypoxic moderate/severe TBI patients. If the spO2% was <=94% mortality was 34.2% higher and 46.1% higher if spO2% was <90%; substantially more than the 25% difference we anticipated. Logistics were unable to support enrollment of the original sample size; 200 moderate/severe TBI patients with at least 70 being hypoxic. However, this study had 97% power to detect the mortality differences of 34.2% and 46.1% among the 152 moderate/severe TBI patients that were enrolled. (calculated in Stata 12.2 software).

| Table 6 – Crude Mortality of Moderate/Severe TBI Patients Stratified by Hypoxia |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Survivors       | >94%            | <=94%           | >=90%           | <90%            | Total           |
| Survivors       | 88              | 20              | 102             | 6               | 108             |
| Deaths          | 21 (19.3%)      | 23 (53.5%)      | 31 (22.3%)      | 13 (68.4%)      | 44 (28.9%)      |
| Total           | 109             | 43              | 133             | 19              | 152             |

Difference 34.2%  Difference 46.1%
4. Discussion

Through recruitment and analysis of a prospective cohort of acute TBI patients cared for at KUTH A&E this study described clinical and demographic characteristics and determined the most important predictors of mortality in this population.

Prognosis is important in any clinical setting but perhaps even more important when clinicians must make decisions about where to direct scarce resources in order to have the greatest chance of a positive outcome for patients.

Among acute TBI patients we identified a significantly higher adjusted odds of in-hospital mortality when compared to all TBI patients if a patient was older then age 50, suffered a moderate or severe TBI, was hypoxic (<90% spO2), bradycardic (<60 heart rate) or tachycardic (>100 heart rate). Despite increasing recognition of the value of prognostic models in TBI few aimed to identify a simple set of in-hospital mortality predicting characteristics able to be determined upon initial patient assessment in a resource limited setting.\(^1\) Many prognostic models used an outcome of mortality at 6 months after the injury, include only moderate to severe TBI patients and do not include patients in LMIC making comparison of our results challenging.\(^2\)\(^3\)\(^4\)\(^5\)\(^6\)\(^7\)

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4.1 Study strengths and limitations

While the focus of this analysis was limited to identification of mortality predictors in this population of TBI patients in a resource limited setting, the study itself represents the most comprehensive effort we are aware of to describe the medical care that was and was not delivered in A&E to these patients. Data collected as part of this study establish a baseline for KUTH leadership and educators to compare future findings against and determine the successes and failures of quality improvement measures. Comparison of the data collected in this study with that from the KUTH A&E triage register highlights the limitations of triage registers as data sources and can help future investigators to avoid pitfalls associated with use of triage register data.

The primary limitation of this analysis is the small number of patients enrolled, and the lack of diversity in their characteristics (23 hypoxic patient <90%, 19 hypotensive patients <90 mmHg). Additionally, these findings from a single center; an urban, teaching hospital setting in East Africa, have limited generalizability to other LMIC. Finally, our results show that hypoxia and heart rate alterations are associated with worse outcomes but it remains unclear if mortality could be improved after intervention. While the rates and timeliness of interventions were collected as part of this study the numbers were insufficient to include analysis of any impact.

4.2 Comparable Studies

The largest and most rigorous study of TBI patients from LMIC is the Medical Research Council-Corticosteroid Randomization After Significant Head Injury (MRC-CRASH). This study included 10,008 adult (>14 years) patients presenting with a GCS of <15 who presented within 8 hours of their injury. The primary outcome of death was assessed at the time of hospital discharge or 14 days, whichever came sooner. Seventy five percent of patients came from LMIC and they found the predictive value of their models to differ between LMIC patients and those from high-income countries. The most basic model to predict mortality in 7,412 LMIC TBI patients included age, GCS, pupil reaction and major extra-cranial injury (defined as an Abbreviated Injury Score (AIS) of >=3 or "any injury requiring hospital admission on its own").8

Age was assessed only after the age of 40 years and they reported an odds ratio for mortality of 1.47 (1.40-1.54) for every 10 years increase over age 40. Our study found an odds ratio for mortality of 3.80 (1.21-11.89) for any age over 50 years. MRC-CRASH had a mean age among LMIC patients of 35.8 (SD 16) which was similar to our study which found a mean of 31 (SD 11.8).

GCS starting at a score of 14 had an odds ratio of mortality of 1.39 (1.35-1.42) for each number it decreased in value. Our study approached GCS differently reporting odds ratios of death for moderate TBI (GCS 9-13) of 6.54 (2.30-18.60) and severe TBI (GCS<8) of 41.60 (14.97-115.59).

Major extracranial injury in MRC-CRASH had an odds ratio of mortality of 1.15 (0.99 to 1.34) while our study did not find other severe injuries to be predictive of mortality after adjustment. In both our study and MRC-CRASH assessment of other injuries was a somewhat subjective process, and injuries like chest trauma requiring tube thoracostomy had the same value in the analysis as an ankle fracture that required surgical intervention.

For all predictors compared between this study and MRC-CRASH the 95% confidence intervals are much larger in our study due to our comparably small sample size (672 vs 7,412). The overall mortality in MRC-CRASH was 20.7% compared to our study with 9.23%. However our study differed by including GCS 15 patients; 453 of them (67.4% of the total 672) and only 6 deaths (1.32% mortality). Unfortunately MRC-CRASH did not collect physiologic data like heart rate or oxygen saturation so we cannot compare our findings of bradycardia, tachycardia and hypoxia as excellent predictors of mortality.

4.3 Heart Rate and Hypoxia in Traumatic Brain Injury

There is very little published in the literature regarding heart rate and the association with TBI mortality. We found that heart rates <60 (11.29 (2.90-43.96)) and >100 (5.20 (2.23-12.12)) were independent adjusted predictors of mortality in all levels of TBI. A retrospective analysis of trauma patients in Los Angeles County in the United States found increased adjusted mortality at the heart rate thresholds of <50 (OR 4.70
(3.24-6.83)) and >110 (OR 1.69 (1.38-2.09)). The Los Angeles study included 11,977 patients, studied only moderate-severe TBI and evaluated ranges of heart rate by tens to find the levels that predicted mortality. Additionally, they differed by not limiting their patients to adults as we did in this study (we excluded patients <18 years from this analysis). One potential reason for this apparent discrepancy between the literature and our findings of a strong relationship between high and low heart rates and mortality in TBI is that heart rate is actually a surrogate for the severity of TBI or severity of other severe injuries. Cushing’s triad; hypertension, bradycardia and an irregular or diminished respiratory rate is an indicator of elevated intracranial pressure and considered a sign of impending cerebral herniation. Similarly, tachycardia is thought to be a marker of severe injury and hypovolemia in trauma, and an earlier indicator of a life threatening situation then hypotension. Perhaps heart rate in our study is measuring aspects of generally life threatening situations that we did not measure.

We searched PubMed titles and abstracts for the terms TBI, hypoxia, mortality and LMIC and no search results returned. Removing LMIC from the search string returned 42 results but only 4 studies were in humans in the hospital setting. Two studies used mortality at six months as an outcome and a third defined hypoxia as a

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ratio of Partial Arterial Oxygen pressure to the Fraction Inspired Oxygen (PaO2/FiO2) of <200.\textsuperscript{14} One study, an analysis of TBI patients in the Trauma Audit and Research Network (TARN) from the United Kingdom, shared enough similarities with our approach as to have comparable results.\textsuperscript{15} This analysis was limited to 802 patients who spent at least three days admitted to the hospital and whom arrived with a head AIS of \( \geq 3 \). Their outcome was survival to hospital discharge and they reported the odds ratio of survival for each predictor so we transformed our analysis accordingly. Using the same definition of hypoxia (spO2 <90\%) this study found an adjusted odd ratio of survival to be 0.27 (0.13-0.57) compared to our finding of 0.14 (0.04-0.45). Reference and citation searching was able to uncover several more reports of the impact of hypoxia on mortality in moderate/severe TBI but these were also challenging to compare with our findings. Two studies measured hypoxia using PaO2 measured on an arterial blood gas\textsuperscript{16} \textsuperscript{17}, another measured hypoxia with spO2 but reported mortality at 3 months\textsuperscript{18} and two more studied hypoxia in the prehospital setting.\textsuperscript{19} \textsuperscript{20}

A section of our results specifically reported the crude difference in mortality seen for different levels of hypoxia among moderate/severe TBI patients. We emphasized these findings in order to show that our study was adequately powered to detect the difference in outcomes that we found, despite our inability to include enough patients to fulfill the original sample size calculation. Without adjustment for other factors that we found to impact mortality these findings have limited value to a clinician trying to determine the actual mortality predictive power of hypoxia in their patients.

4.4 *Triage Registers as Data Sources*

Rigorous quality control methods were employed that support the validity of our results. Research Assistants (RAs) identified as many as 157 injured patients who should at least be suspected of having a TBI that were not captured by the triage registers. To the best of our knowledge less than 2% of eligible acute TBI patients failed to be included in this cohort, and we found minimal difference between enrolled and missed patients (Figure 1). It is important to appreciate the limitations of this triage register data as the chief complaint is often recorded at the time of triage, and not after a full assessment has been completed. Additionally, these data reflect all patients that presented to A&E, not only patients with acute injuries being evaluated for the first time at KUTH. Our study identified head injury patients using a standard definition but each member of the A&E care team completing the triage register utilized their own personal means of determining which patients had a head injury. Finally, this critique of triage register data will improve future quality improvement efforts that may consider using
the triage register as a data source. This practice is commonly employed in low resource settings to understand patient populations and could easily lead to selection bias and inadvertent omission of large groups of patients from studies.\textsuperscript{21} \textsuperscript{22} \textsuperscript{23}

### 4.5 Implications for policy and practice

Data from this study is important for assessment of current local care practices and as an addition to the very limited amount of data from LMICs that is currently available in the literature. Recently, a review of the literature published in the World Journal of Neurosurgery searched Medline and a reference analysis from 1980 to 2010 for English language, original data relating to the epidemiology, initial assessment, in-hospital care of follow-up/rehabilitation of patients with head injuries in LMICs. Only 12 papers met their inclusion criteria, with only one paper from a low-income country (Nepal) and with South Africa representing the only Sub-Saharan African country included.\textsuperscript{24} These findings from a single center in an urban, teaching hospital setting in East Africa are not generalizable to all LMICs but given the scarcity of available data they represent an important contribution to the literature.

4.6 Implications for further research

There are no shortage of calls for a greater focus on research aimed at understanding the epidemiology of injury and improving injured patient outcomes in the developing world.\textsuperscript{25-27} This study initiates the process in Rwanda, establishing a baseline for assessments of care provided to TBI patients and describing the epidemiology of this population. Further, this work helps to develop the capacity for future clinical research in this LMIC through collaboration with local partners and institutions whom ultimately conceived the project. Results have been utilized locally in developing an evidence based clinical practice guideline for A&E clinicians. We determined a small, easily obtained set of patient characteristics associated with increased mortality that can be assessed during a triage process. These findings should be tested for their predictive value in other LMIC and Sub-Saharan African populations as well as other clinical settings within Rwanda.

4.7 Challenges

This study initially employed four RAs to complete patient screening, enrollment and initial data collection in A&E. Two months into this study one of the RAs was dismissed from her position. The remaining RAs elected to work more hours instead of taking on additional staff, preserving consistency in training and experience among

\textsuperscript{25} Wisborg T, Montshiwa TR, Mock C. Trauma research in low- and middle-income countries is urgently needed to strengthen the chain of survival. Scand J Trauma Resusc Emerg Med. 2011; 19:62.
\textsuperscript{27} Ivers, Rebecca, Mohit Bhandari, and Robyn Norton. "A call to research: Documenting the non-fatal outcomes of injury." Injury 45.6 (2014): 921-922.
study staff members. During her time with the study the RA who was dismissed enrolled 12.1% of the total patients. Data from her subset of patients were compared to the other RAs and there was no statistically significant difference between the groups.
5. Conclusion

Head injuries comprise a large group of patients cared for at KUTH A&E. This study investigated the demographic and clinical characteristics of this population and identified a set of factors associated with mortality. Additionally, we collected a broad set of data that describes the care currently being provided to these patients, establishing a baseline for quality improvement efforts.

Age greater than 50 years, an initial GCS of <14, bradycardia < 60 bpm, tachycardia >100 bpm, and hypoxia <90% spO2 are all significant predictors of in-hospital mortality. These five characteristics are relatively simple to assess in patients during initial triage and could be utilized to develop an early warning system that prioritizes care for these patients. Future research should be conducted to test the performance of these mortality predictors in other Rwandan clinical settings and in TBI populations in other LMICs.
Appendix A

CHUK Traumatic Brain Injury (TBI) Enrollment/Data Collection Form

Study ID: [ ]

1st RA Name: [ ]

Date of injury: [ ]

Start time: [ ]

End time: [ ]

2nd RA Name: [ ]

Date: [ ]

Start time: [ ]

End time: [ ]

Injured Patient Selection

Mark all that apply:

- ○ Signs of head trauma
- ○ Report hit by head
- ○ Sleepy or confused
- ○ Headache

OPatient refused observation

OStaff say not TBI patient

REMEMBER TO EVALUATE EVERY INJURED PATIENT AND COMPLETE AN ENTRY IN THE PATIENT REGISTER EVEN IF PATIENT IS EXCLUDED FROM THE STUDY.

Airway:

- ○ Snoring
- ○ Gurgling
- ○ Blood/secrections
- ○ Normal
- ○ Other_____

OObserved: Ambulance

ODoctor

OUnknown: Nurse

OTurned on side: [ ]

ODid not turn

OObserved: Ambulance

ODoctor

OUnknown: Nurse

OSuffocated: [ ]

ODid not suffocate

OObserved: Ambulance

ODoctor

OUnknown: Nurse

OOral/nasal airway: [ ]

ODid not place

OObserved: Ambulance

ODoctor

OUnknown: Nurse

ODone before CHUK

OIntubated: [ ]

ODid not intubate

OObserved: Ambulance

ODoctor

OUnknown: Nurse

ODone before CHUK

Observations

Mode of Arrival:

- ○ Ambulance
- ○ SAMU
- ○ Other vehicle
- ○ On foot
- ○ Other_____

OObserved: Ambulance

ODoctor

OUnknown: Nurse

Patient Arrival Time:

- ○ Observed: Ambulance
- ○ Dossier: Doctor
- ○ Unknown: Nurse

First Nurse Time:

- ○ Observed: Ambulance
- ○ Dossier: Doctor
- ○ Unknown: Nurse

First Doctor Time:

- ○ Observed: Ambulance
- ○ Dossier: Doctor
- ○ Unknown: Nurse

Breathing:

- ○ Auscultation: [ ]

- ○ Did not auscult

- ○ Observed: Ambulance

- ○ Dossier: Doctor

- ○ Unknown: Nurse

- ○ Did not give

- ○ Observed: Ambulance

- ○ Dossier: Doctor

- ○ Unknown: Nurse

- ○ Oxygen: [ ]

- ○ Did not give

- ○ Observed: Ambulance

- ○ Dossier: Doctor

- ○ Unknown: Nurse

Circulation:

- ○ Eval pulses: [ ]

- ○ Did not eval

- ○ Observed: Ambulance

- ○ Dossier: Doctor

- ○ Unknown: Nurse

- ○ IV started: [ ]

- ○ Did not start

- ○ Observed: Ambulance

- ○ Dossier: Doctor

- ○ Unknown: Nurse

- ○ IV fluids given: [ ]

- ○ Did not give

- ○ Observed: Ambulance

- ○ Dossier: Doctor

- ○ Unknown: Nurse

- ○ Given before CHUK

GCS: Circle the doctors assessment

<table>
<thead>
<tr>
<th>Time</th>
<th>Time</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Eyes Open

- ○ Spontaneously
- ○ In response to pain
- ○ None

Verbal Response

- ○ Confused
- ○ Confused
- ○ Confused
- ○ Confused
- ○ Confused

Motor Response

- ○ Good Comprehends
- ○ Limbs
- ○ Limbs
- ○ Limbs
- ○ Limbs

Deficit:

- ○ Mannitol given: [ ]

- ○ Cervical Collar: [ ]

- ○ Placed before CHUK: [ ]

- ○ Placed Properly

- ○ Not placed properly

- ○ Did not place

- ○ Convolutions: [ ]

- ○ Medication given: [ ]

- ○ No convulsions: [ ]

Draw a square around your assessment

- ○ Observed: Dossier
- ○ Doctor

- ○ Observed: Dossier
- ○ Doctor

- ○ Observed: Dossier
- ○ Doctor

- ○ Observed: Dossier
- ○ Doctor

- ○ Observed: Dossier
- ○ Doctor

- ○ Unknown: Nurse

- ○ Unknown: Nurse

- ○ Unknown: Nurse

- ○ Unknown: Nurse

- ○ Unknown: Nurse
### Vital Signs

<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature</th>
<th>Heart Rate</th>
<th>Respiration</th>
<th>Blood Pressure</th>
<th>Oxygen Saturation</th>
<th>Blood Sugar</th>
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<tbody>
<tr>
<td>------</td>
<td>-------------</td>
<td>------------</td>
<td>-------------</td>
<td>----------------</td>
<td>-------------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>

*If a vital sign was not taken at the time, mark an X in the box.*

### History

**Cause of Injury:**
- ☐ Road traffic crash
- ☐ Car truck
- ☐ Motorcycle
- ☐ Wore helmet
- ☐ No helmet
- ☐ Unknown
- ☐ Bicycle
- ☐ Wore helmet
- ☐ No helmet
- ☐ Unknown
- ☐ Bus
- ☐ Pedestrian hit
- ☐ Unknown
- ☐ Other:
  - ☐ Fall
  - ☐ Assault
  - ☐ Explosion
  - ☐ Unknown
  - ☐ Observed
  - ☐ Ambulance
  - ☐ Dossier
  - ☐ Doctor
  - ☐ Unknown
  - ☐ Nurse

**Patient age:** ☐

**Patient sex:** ☐ M ☐ F

**Alcohol Use:**
- ☐ Yes
- ☐ No
- ☐ Unknown

**Transferred to CHUK:**
- ☐ Yes
- ☐ No

**Has insurance:**
- ☐ Yes
- ☐ No
- ☐ Unknown

**Facility name:**

### Disposition

<table>
<thead>
<tr>
<th>Time patient left triage:</th>
<th>O A&amp;E 9</th>
<th>O A&amp;E 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>O A&amp;E 8</td>
<td>O A&amp;E 3</td>
<td></td>
</tr>
<tr>
<td>O A&amp;E 7</td>
<td>O A&amp;E 2</td>
<td></td>
</tr>
<tr>
<td>O A&amp;E 5</td>
<td>O A&amp;E 1</td>
<td></td>
</tr>
<tr>
<td>O NSG/RNC</td>
<td>CHUK ward 7</td>
<td></td>
</tr>
<tr>
<td>O ICU</td>
<td>O PACU</td>
<td></td>
</tr>
<tr>
<td>O Triage/waiting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Other:**

### Orders

- ○ Chest x-ray: ACRIK
- ○ Skull x-ray: ACRIK
- ○ No chest x-ray: ACRIK
- ○ No skull x-ray: ACRIK
- ○ Observed: Ambulance
- ○ Dossier: Doctor
- ○ Unknown: Nurse
- ○ Done before CHUK: ACRIK
- ○ Done before CHUK: ACRIK
- ○ Pelvis x-ray: ACRIK
- ○ Abd US: ACRIK
- ○ No pelvis x-ray: ACRIK
- ○ No Abd US: ACRIK
- ○ Observed: Ambulance
- ○ Dossier: Doctor
- ○ Unknown: Nurse
- ○ Done before CHUK: ACRIK
- ○ Done before CHUK: ACRIK
- ○ CBC lab: ACRIK
- ○ Type & screen lab: ACRIK
- ○ No CBC: ACRIK
- ○ No type & screen: ACRIK
- ○Observed: Ambulance
- ○ Dossier: Doctor
- ○ Unknown: Nurse
- ○ Done before CHUK: ACRIK
- ○ Done before CHUK: ACRIK
- ○ CT Brain: ACRIK
- ○ CT Body: ACRIK
- ○ No CT Brain: ACRIK
- ○ No CT Body: ACRIK
- ○ Observed: Ambulance
- ○ Dossier: Doctor
- ○ Unknown: Nurse
- ○ Done before CHUK: ACRIK
- ○ Done before CHUK: ACRIK

**Doctor called:**
- ☐

**Did not call:**
- ☐

**In dossier:**
- ☐

**Not in dossier:**
- ☐

**NSG team arrives in A&E:**
- ☐

**To see patient:**
- ☐

**Did not arrive in A&E:**
- ☐

**No Consult:**
- ☐

### Neurosurgery Consult

**Other Severe Injuries**

If the patient dies in A&E, during your observation complete this section. Ask the doctor if there are injuries other than TBI that require the patient to stay in the hospital or have surgery.

- Neck: ☐ Yes ☐ No
- Back: ☐ Yes ☐ No
- Chest: ☐ Yes ☐ No
- Abdomen: ☐ Yes ☐ No
- Arms: ☐ Yes ☐ No
- Legs: ☐ Yes ☐ No
- Pelvis: ☐ Yes ☐ No
- Skin: ☐ Yes ☐ No

### Other Severe Injuries

**Neck:**
- ☐ Yes
- ☐ No

**Back:**
- ☐ Yes
- ☐ No

**Chest:**
- ☐ Yes
- ☐ No

**Abdomen:**
- ☐ Yes
- ☐ No

**Arms:**
- ☐ Yes
- ☐ No

**Legs:**
- ☐ Yes
- ☐ No

**Pelvis:**
- ☐ Yes
- ☐ No

**Skin:**
- ☐ Yes
- ☐ No

### Notes

- ○ FOLLOW UP - mark here if patient was discharged before follow up on the next day was able to be performed

41
### CHUK Traumatic Brain Injury (TBI) Patient Follow-Up Form

Hospital day #0 is the date of enrollment, begin this form on hospital day #1. Update the form every day. On the day of discharge make sure that the bottom, final section is completed.

<table>
<thead>
<tr>
<th>Patient Location</th>
<th>Hospital Day</th>
<th>RA/SC Name:</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A&amp;E 9</td>
<td>O&amp;A 4</td>
<td>Triage/waiting</td>
<td>TBI Surgery</td>
</tr>
<tr>
<td>A&amp;E 8</td>
<td>O&amp;A 3</td>
<td>ONSG/RNC</td>
<td>Other surgery</td>
</tr>
<tr>
<td>A&amp;E 7</td>
<td>O&amp;A 2</td>
<td>ICU</td>
<td>PACU</td>
</tr>
<tr>
<td>A&amp;E 5</td>
<td>O&amp;A 1</td>
<td>CHUK ward 7</td>
<td>Discharged</td>
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<tr>
<td>Other:</td>
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</table>

**Date:**

**Time:**

**Glasgow Outcome Score (GOS):**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>5</td>
<td>Good Recovery</td>
</tr>
<tr>
<td>4</td>
<td>Moderate Disability</td>
</tr>
<tr>
<td>3</td>
<td>Severe Disability</td>
</tr>
<tr>
<td>2</td>
<td>Persistent Vegetative State</td>
</tr>
<tr>
<td>1</td>
<td>Death</td>
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</tbody>
</table>

**Study ID:**

Code from Dossier Number

Notes:

**Hospital Day #2**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

<table>
<thead>
<tr>
<th>Score</th>
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<tr>
<td>3</td>
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<tr>
<td>2</td>
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<td>1</td>
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Notes:

**Hospital Day #3**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

<table>
<thead>
<tr>
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<td></td>
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Notes:

**Hospital Day #4**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

<table>
<thead>
<tr>
<th>Score</th>
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Notes:

**Hospital Day #5**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

<table>
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Notes:

**Hospital Day #6**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

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<thead>
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Notes:

**Hospital Day #7**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

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<thead>
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Notes:

**Hospital Day #8**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

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<td></td>
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</table>

Notes:

**Hospital Day #9**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

<table>
<thead>
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<tbody>
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Notes:

**Hospital Day #10**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

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<thead>
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Notes:

**Hospital Day #11**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

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Notes:

**Hospital Day #12**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

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Notes:

**Hospital Day #13**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

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<thead>
<tr>
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Notes:

**Hospital Day #14**

**Date:**

**Time:**

**RA/SC Name:**

**Location:**

**GOS:**

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Notes:
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<tbody>
<tr>
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<td>Patient</td>
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</tr>
<tr>
<td>Time:</td>
<td>Location:</td>
<td>O4 O1</td>
</tr>
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<td>Notes:</td>
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<table>
<thead>
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<th>GOS: 03</th>
</tr>
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<tbody>
<tr>
<td>Date:</td>
<td>Patient</td>
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</tr>
<tr>
<td>Time:</td>
<td>Location:</td>
<td>O4 O1</td>
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<table>
<thead>
<tr>
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<th>GOS: 03</th>
</tr>
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<tbody>
<tr>
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<td>Patient</td>
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<tr>
<td>Time:</td>
<td>Location:</td>
<td>O4 O1</td>
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<tr>
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<tr>
<td>Time:</td>
<td>Location:</td>
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<td>Date:</td>
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<tr>
<td>Time:</td>
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<tr>
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<td>O4 O1</td>
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<td>Notes:</td>
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</table>

**Final Information at Discharge or Death**

<table>
<thead>
<tr>
<th>Hospital Events</th>
<th>Date</th>
<th>CT Brain Results</th>
<th>Other Severe Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBI Surgery #1:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>TBI Surgery #2:</td>
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<tr>
<td>TBI Surgery #3:</td>
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<tr>
<td>TBI Surgery #4:</td>
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<tr>
<td>TBI Surgery #5:</td>
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<tr>
<td>Other Surgery #1:</td>
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<td>Hospital Discharge:</td>
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<tr>
<td>Death:</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

O Mark if discharge was delayed because patient could not pay

**Notes:** It is helpful to write a short description of the patient's time in the hospital and to describe any delays like waiting for surgery, if the patient refused discharge, or if doctors did not assess patients regularly.
Bibliography


MacLeod, Jana BA, et al. "A comparison of the Kampala Trauma score (KTS) with the revised Trauma score (RTS), Injury Severity Score (ISS) and the TRISS method in a Ugandan Trauma registry." *European Journal of Trauma* 29.6 (2003): 392-398.


